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PROCEEDINGS OF THE NASA/MIT WORKSHOP ON AIRLINE SYSTEMS ANALYSIS

WATERVILLE VALLEY, NEW HAMPSHIRE
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Joseph F. Vittek
Editor

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Joseph F. Vittek
Workshop Director

INTRODUCTION

The recent renaming of the NASA Office of Advanced Research and Technology as the Office of Aeronautics and Space Technology emphasizes the new stress being placed on aeronautical research by the Federal government in general, and NASA in particular. Aeronautical research at NASA now engages 5,300 people with an annual budget of $110 million dollars and addresses such problems as:

- Major reductions in aircraft noise, particularly by developing a very quiet short-haul aircraft.
- Improved automated air traffic control
- Encouragement of development of vehicles for both high- and low-density short-haul markets.
- Development of an experimental approach to test and verify not only technical concepts, but also market characteristics, social benefits and the like.

Research and development are essential to the solution of current problems, as they always have been. They are also essential if the full potential of civil aviation is to be realized. However, it must be recognized that neither today's nor tomorrow's problems are solely technological. Solutions will involve not only traditional applications of the physical sciences but also the techniques of economic analysis and the social sciences. Technological advances are subject to a variety of institutional constraints which can be categorized as regulatory, legal, financial, social, attitudinal and the like. All of these factors must be examined and are an essential part of both the problems and their solutions.

Although it is realized that NASA's role in seeking solutions to these problems is essentially technical, it is imperative that the technologist be familiar with the additional constraints that the social and legal systems impose on technical designs. As an example, future aircraft engines must not only provide more thrust, but they must do so economically and quietly.

The purpose of the summer workshop was to provide a background and insight into these non-technical areas for NASA personnel who will be involved in both the direction and implementation of the technical programs to ensure end products that are acceptable to the market place and the public in general. As was stated in the CARD study:

> "... the scope of civil aviation research and development should be expanded to increase emphasis on nonphysical sciences such as economics and sociology."

The workshop consisted of a two-week series of lectures and discussions by leading academic government and industry personnel in the field of flight transportation, covering the interface between technology and the remaining aspects of the air system.

The workshop was held at Waterville Valley, New Hampshire. This site was chosen, because it is away from the normal business setting, thus freeing participants from the daily interruptions of their office routines and offering them a fresh setting in which to immerse themselves in the subject material.

The presentations, as reported here, are not compiled chronologically but rather they are grouped according to major topic and also from the more basic to the more advanced within each topic. This is done so as to give the reader the proper background and continuity (see Table of Contents).

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DEVELOPMENT OF THE AIR TRANSPORT INDUSTRY

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July 10, 1972

Abstract

The presentation will focus on the major developments in the U.S. scheduled air transport industry both domestic and international, together with a brief history of the European air transport system. The role and formulation of the U.S. Civil Aeronautics Board, International Civil Aviation Organization, and International Air Transport Association will also be covered.

The early development of the commercial air transport industry was made possible through government financial support, although this support varied in nature and degree from country to country. In Europe most of the research and development in early aviation was undertaken in one way or another for defense purposes. In the United States, since the transportation of mail had always been the function of the government, public funds were justified to develop the system. Even the "bush-pilots" in Canada were somewhat dependent on government support. In general, this financial aid consisted of air mail payments, grants for offering service on certain routes, outright monetary gifts, aircraft development costs, extremely low interest loans to purchase aircraft and special depreciation allowances. It was assumed that these supports would be temporary and that eventually the industry would become self-supporting.

Prior to the first World War, the United States lagged behind Europe in the development of aircraft, with France considered the pioneer in design and production of early heavier-than-air aircraft. According to one source[1], at the beginning of the first World War, France had 1400 airplanes, Germany 1000, Russia 800, Great Britain 400, and the United States 23. One explanation for this is the amount of military aviation budget for each of these countries. For example, by 1913 the military aviation budget in France had reached almost 7.5 million dollars, while the figure for the

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[1] CAB Publication - Reference 1. Page 204

United States was closer to $125,000.[2]

Although the history of the commercial air transport industry can be traced back to 1905; apart from some of the experimental flights and routes, regularly scheduled air services were not offered until 1918 in the U.S. and 1919 in Europe. In general, the development of the industry focused on the transportation of mail in the United States and passengers in Europe. The U.S. mail service was inaugurated on May 15, 1918 on the New York-Washington route using army equipment and personnel and five months later the air transport part of the service was taken over by the Post Office Department. The fleet consisted mostly of war-surplus aircraft with some new aircraft specially built for the Post Office Department. By December the service was offered in the New York - Chicago market and within two years transcontinental air mail service was in operation between New York and San Francisco with the airplane flying during the day only. In Europe, after the war, England, France and Germany, all within a few months of each other, started scheduled air services. In Germany Deutsche Luft Reederei began operating a passenger service in February 1919 between Berlin and Weimar via Leipzig;[3] in France Farman Airlines started scheduled operations on the Paris-London and Paris-Brussels routes; and in England, Aircraft Transport and

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[2] Miller and Sawers - Reference 2. Page 9.

[3] Davies - Reference 3. Pages 11-20.

Travel offered scheduled service in August on the London-Paris route.

The fleets of these early airlines consisted mostly of single and twin-engined bombers which were modified to carry passengers. The British and the French used the early biplanes with capacity ranging from four to twelve seats, while the Germans used the Junker monoplanes. These aircraft had very limited payload capacity, cruising speed and range. By the mid-twenties these early carriers had upgraded the fleets to tri-motors and development was underway for radial air cooled engines which were more powerful and more efficient.

Since the transportation by air crossed national frontiers, a need arose for establishing some principles of international law regarding aerial navigation and a state's sovereignty over its airspace. The Aeronautical Commission of the Peace Conference held in Paris in 1919, established the basic rule of international law regarding commercial aviation. This law stated that every nation has complete and exclusive sovereignty over the airspace above its territory. Although, the United States did not ratify this convention, the Pan American convention signed in Havana in 1928 agreed to most of the principles of the Paris convention. Also in 1919, six European nations, Denmark, England, Germany, Holland, Norway and Sweden, jointly created an organization called the International Air Traffic Association, the predecessor of the present International Air Transport Association. The initial functions of the organization were to clarify international aviation law and to standardize aviation technology. The main aim of the member airlines was to standardize the conditions and facilities of air travel between their countries.

The mid-1920's represented a period of consolidation in Europe. In many cases the government made consolidation and sometimes partial state ownership a necessary condition for subsidy. For example, Imperial Airways was incorporated in England by merging four separate companies. The Civil Air Transport Subsidies Committee (Hambling Committee) organized in 1923 recommended that the existing four carriers should be merged into one Imperial Airways, partially government owned, which received a total subsidy of one million pounds, spread in decreasing amounts over a ten year period.

Expansion to other countries and continents was largely a result of the European countries expanding operations within their colonial empires. The Belgians, for example, set up services in the Congo in 1920. Since the Treaty of Versailles restricted the Germans from manufacturing aircraft and operating any German international airline, they followed a strategy of setting up local operations in various countries around the world, beginning with South America. The objective was to initially develop local airlines in as many countries as possible and eventually to connect them with a trunk service operating from Germany. Using this strategy, Germany set up local lines in South America, Eastern and Central Europe, and eventually Persia and China.

Other countries to realize the potential of air transportation were often the ones with poor communication due to natural barriers such as forests, rivers, and mountains, creating a situation for the establishment of air services. For the most part, though, these countries had no aviation industry and exploited some tie with those nations who did in order to obtain aircraft for their air services. In Australia, mail service was started in 1919 on the west coast between Perth and Derby by West Australian Airways. The following year Qantas started the mail service in the east. By the early twenties, similar service was started in Canada, Japan, Latin America, Middle East and South Africa.

In the U.S., while business was not too successful over short distances, great opportunities existed for long-haul transportation of the mail. This was well demonstrated by the time savings produced in an experimental flight from San Francisco to New York taking about 34 hours. By 1924 the transcontinental flight time had further been reduced when the operation had been extended to include night service. The introduction of more reliable and durable engines, radio communication and navigational aids significantly improved the reliability of airline operations. Although there had been a number of early attempts at regular air passenger service in the United States, it was not until 1925 that service was offered on a year-around basis on the Los Angeles-San Diego route. The 120 mile trip took an hour and a half and cost $17.50 one-way or $26.50 round trip. From here on, the passenger traffic began to grow rapidly and by 1930, the passenger traffic in the United States was about equal to the rest of the world taken together. In Europe, Deutsche Lufthansa was the leading airline in 1930 having carried well over 100,000 passengers. In France in the same year, four airlines put together had carried less than fifty percent of the passenger traffic carried by the German carrier.

The significant passenger traffic growth resulted in the development of larger capacity aircraft. For a long time, however, aircraft speed remained around 100 miles per hour. Although, up until the late twenties, Europe had maintained the lead in aircraft development, the United States took over this leadership in a relatively short period. While the total number of aircraft produced in the United States in the year 1924 amounted to approximately 60, the number increased to about 5,500 during 1929. The U.S. leadership in aircraft development began with the Ford Tri-motor of 1926, continued with the Boeing 247 and received world acknowledgement in 1935 with the DC-3. The DC-3 had a capacity of 21 passengers and a speed of almost two hundred miles per hour. This aircraft revolutionized the air transport industry. Due to its much lower direct operating costs, the carriers were able to lower the fares and increase traffic. Miller and Sawers show that by the end of 1941, almost 800 DC-3's were delivered and over half of these were delivered to the airlines.

The Post Office Department in the U.S. operated the mail flights until 1927 in spite of the fact that protests were heard from the railroads in the early twenties regarding governmental competition in the transportation of mail. As a result of these protests the Air Mail Act of 1925 (Kelly Act) was passed to encourage commercial aviation and to transfer the air mail transportation operation to private carriers on the basis of competitive bids. Initially the contracts were awarded for four-year periods. Under competitive bidding the most significant contracts were awarded to Boeing Air Transport for the San Francisco-Chicago route and to National Air Transport for the New York-Chicago route. The transcontinental route was linked by about a dozen feeder routes such that almost every major city in the United States was linked on the air mail system.

The problem in the United States during this time period was that the mail revenues were too low to justify capital expense for better equipment. Poor equipment, on the other hand, resulted in poor service which in turn led to even lower revenues. Part of the unwillingness of the carriers to invest in new equipment resulted from the fear of losing mail contracts and the lack of adequate passenger traffic. The carriers needed some government backing and the public needed assurance that air transportation was safe, fast and within their means.

There were four major factors which encouraged the development of the U.S. air transport industry at this very critical time. First, the Air Commerce Act of 1926 initiated the development by the federal government of civil airways, navigational aids, and provided for the regulation of safety. This Act, therefore, relieved the private carriers from heavy investments in ground facilities for air navigation. Second, Charles Lindbergh's transatlantic flight proved to be very timely in stimulating the early development of the air passenger market. Third, the Daniel Guggenheim Fund enabled an experiment to operate a "model airline" to encourage the development of passenger traffic, which was sometimes considered as a financial liability. Fourth, the Kelly Act was amended to include provisions whereby the original four year mail contracts could be extended to ten years, thereby promoting increased investment in the industry.

During this time period, most of the airlines in the world were still dependent on government subsidies. Again according to the research of Miller and Sawers, the French airlines received the highest amount of government financial support. In 1928 only ten percent or so of the airline revenues came from commercial operations. In Germany Lufthansa's commercial operations accounted for roughly 30 percent of the total income. The data on the exact amount of subsidy by country are not readily available. Estimates are available, however, for the development costs of the air mail transportation system in the United States. According to Warner's[4] research, the United States government paid roughly ten million dollars for developing the early transport system. This estimate is based on a total government expenditure of roughly $17.5 million for the nine year period from 1918 to 1927, while Warner estimated the income for this period to be roughly $7.5 million based on the real value of inventory and capital items in hand and the receipts for postage during the nine year period.

In the summer of 1927, Juan Trippe, who was connected with Colonial Airways at the time, learned that the Post Office Department was considering an air mail contract between Key West, Florida and Havana, Cuba. There were two carriers in operation in Florida, Pan American and Florida Airways and neither of these two companies had the necessary financial backing or the equipment to negotiate the contract for the transportation of mail between Cuba and the United States. Although Pan American had acquired a contract from the Cuban government to fly the mail between the U.S. and Cuba, the company did not, however,possess the landing rights.

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4. Warner - Reference 4. Page 29

Trippe flew over to Havana and negotiated an exclusive flying permit between the U.S. and Cuba, ensuring that only Pan Am could operate on this route.

In 1928, the Foreign Air Mail Act was passed authorizing the Postmaster General to award contracts for the transportation of mail by air to foreign countries and territorial possessions of the United States. The carrier selected to offer foreign air mail services was Pan American. Since Pan American had already acquired the necessary landing privileges in other Latin American countries, virtually all of the foreign air mail contracts were awarded to the company at the highest rate permissible under the Act.

Initially the U.S. government did not negotiate the development of the international routes with these Latin American nations. Pan American on its own initiative went ahead and made private agreements with these foreign nations for landing rights in their country and since Pan American was not in a position to offer exchange landing rights, the agreements were made without reciprocal landing rights in the United States. With mail payments authorized by the Foreign Air Mail Act of 1928, and with exclusive landing rights, Pan American showed rapid development.

Although passenger travel was growing fairly rapidly by the end of the twenties, prior to 1929, there was no uniform law regarding the rights of the passengers, ownership of freight, or liability of the carriers. In 1929, an International Diplomatic Conference on Private Air Law was held in Warsaw, Poland to establish the law regarding the liability of the airlines in international air transportation, towards their passengers and cargo in the event of an accident. The result of this was the Warsaw Convention, which initially limited the carriers' liability to $8,300 for each passenger. The limit on the liability was doubled by the Hague Protocol of 1955 and further increased to $75,000 by the Montreal Agreement of 1966.

In the United States, the Air Mail Act of 1925 was once again amended in 1930 (now called the McNary-Watres, or Watres Act). This Act authorized the exchange of air mail contracts for air mail route certificates with further authority to extend or consolidate routes. Furthermore, the Act authorized payment for the transportation of mail based on space available and distance flown rather than the mail load carried.

It has been said that the Postmaster General, Walter Brown was the chief planner of the Watres Act. He wanted to restructure the industry from a random assortment of short unconnected mail routes to a stable integrated nationwide airline system. He intended to expand passenger services and establish a self-sufficient air transport industry. His plan was to set up three major transcontinental routes coordinated and integrated with several feeder routes. Brown felt that the smaller companies were under capitalized and nearly all of them completely dependent upon the government contracts for their survival. He was convinced that the solution was to eliminate competitive bidding and to use the mail pay to support the carriers whom he considered strong enough to contribute to the development of commercial aviation.

He was able to achieve this by first awarding mail contracts to the lowest bidder who showed a daily operation for a period of at least six months over a route of 250 miles in length and, secondly, through extension or consolidation of routes which in his opinion were in the public interest. The provision providing the substitution of mail contracts for ten-year route certificates had already been in existence. The extension and consolidation provision allowed the establishment of major transcontinental routes. Finally, the form of payment represented an indirect subsidy which enabled the carriers to purchase and operate larger aircraft and develop the passenger market. Mail contracts were not necessarily awarded to the lowest bidder because there was no guarantee that the lowest bidder would be able to survive the cut-throat competition. However, cases when a contract was given to a larger carrier over a smaller carrier the larger carrier was obliged to buy out the smaller carrier at a "fair" price.

Somewhat similar developments were taking place in Europe. For example, the Empire Air Mail Scheme which included provisions that all mail dispatched to or from those parts of the British Commonwealth served by Imperial Airways would automatically be carried by air. This scheme enabled Imperial to intensify the services and capacity it offered in the knowledge that much of its payload was guaranteed. On this basis, Imperial Airways introduced faster aircraft with more frequent service. This program provided the carrier with substantial subsidy for development in addition to reimbursement for the costs of transporting mail.

During early 1933, charges were made against Brown for collusion, illegal administration and unfair mail awards. A special investigating committee was set and hearings began in September 1933. Although during the investigation it became clear, among other things, that almost all of the mail contracts were awarded to three carriers, some writers claim that the investigation did not probe deeply into the causes of Brown's actions or the sincerity of his national plan. The result of the investigation was that the President cancelled all mail contracts held between the Post Office Department and the private carriers. The Army Air Corps was asked to fly the mail. Severe weather and flying over unknown routes caused some fatal accidents with about a dozen deaths in the first few weeks. As a result of this the transportation of the mail was curtailed and finally came to a standstill in June, 1934.

The Air Mail Act of 1934 set up a threefold control of the air transport industry in the United States. The air mail contracts were to be awarded by the Post Office Department. The Interstate Commerce Commission was put in charge of setting "fair and reasonable" rates for the transportation of air mail and the Bureau of Air Commerce in the Department of Commerce was made responsible for the regulation of safety. Under this Act, mail contracts were to be awarded on the basis of competitive bidding. Furthermore, the carriers involved in the previous "collusion" charges could not be awarded the contracts, a stipulation which caused the carriers to change their corporate names. In addition, the Act made holding companies illegal and, therefore, separated the historical affiliation between the major airlines and the aircraft manufacturers. Finally, the Act also established a five-man Federal Aviation Commission to study and recommend future aviation policy for the Federal Government. The most important recommendation of this commission was that a single independent agency should be created to regulate civil aviation.

Meanwhile, on the international scene, the determination of landing rights at foreign ports was still the responsibility of the carrier, and Trippe with his position secure in Cuba, had been negotiating exclusive landing rights from the governments of the other Latin-American nations. A decision was made to offer flying boat services based out of Miami and this became the gate-way to the Caribbean and Latin America. The use of flying boats had two definite advantages: First, whereas airports were scarce, sheltered bodies of water were plentiful; and second, the flying boats seemed to provide a measure of safety in case of a forced landing at sea.

Pan American expanded very aggressively through outright purchase of local airlines or companies if it proved necessary commercially and/or legally. For instance, having won rights to the Caribbean, Pan American proceeded to expand service to the west coast of South America and to Argentina. This was achieved through the formation of Pan American-Grace Airways, Inc., (Panagra) of which Pan American held 50 percent of the stock and W. R. Grace, the steamship company held the other 50 percent of the stock. The firm W. R. Grace and Company ran ships, banks, warehouses, stores, and dominated almost the entire economy on the west coast of South America. From the political and economic points of view, this proved to be a great asset for Pan Am's expansion. There were certain other advantages to the formation of Panagra, for example, the Grace Line steamers provided the radio weather service needed for air transportation. Similar acquisitions of airlines gave Pan American a dominance in Latin America.

Negotiations for the North Atlantic route had begun as early as 1929 resulting in preliminary agreements to offer service twice a week between the United States and England. However, the British insisted that Pan American could not offer the service until such time when a British carrier could also offer similar service. Since the British did not possess an appropriate commercial aircraft capable of flying the North Atlantic, service was delayed. In the meantime, Trippe involved himself with establishing service on the Pacific. Survey flights were made as early as 1931. While the northern Great Circle route (Seattle-Alaska-Siberia-Japan) required landing permission from Russia and Japan, the central-Pacific route contained fueling points which were American possessions. The mid-Pacific route linked San Francisco and Manila via Hawaii, Midway, Wake and Guam. In October 1935, Pan American received the trans-Pacific mail contract for service from San Francisco to Manila (Philippines). The service was extended to passengers in 1936 and in 1937 the route was expanded to Hong Kong. By 1940, Pan Am had also expanded its trans-Pacific route from Hawaii to New Zealand and Australia.

On the U.S. domestic scene, the air transport industry was passing through a state of ruinous competition. Some carriers were submitting ridiculously low bids to obtain the air mail contracts and routes. Many of the smaller carriers could not bid against the giants, and public investment was beginning to shrink. Legislation was needed to financially stabilize the industry by providing control of competition, assurance of the operation of the carrier, and an end to the confusion of responsibility through the establishment of a single regulatory agency.

The Civil Aeronautics Act of 1938 placed the development, regulation and control of air carriers under the jurisdiction of a single independent administrative body later known as the Civil Aeronautics Board. This Act broadened the scope of safety regulation and subjected the airlines to economic regulation. The regulation of the industry was performed with "public interest" and "public convenience and necessity" as main considerations. The major functions of the CAB were to approve passenger fares, freight and mail rates, certificate carriers, monitor competition, and approve mergers and subsidies.

Under the "grandfather" clause of the Civil Aeronautics Act of 1938, 16 remaining airlines were given permanent certificates of convenience and necessity for routes which each of them possessed at the date of adaptation of the Act. The Board also certificated the Railway Express Agency as an indirect air carrier with exemptions from the economic provisions of the Civil Aeronautics Act. The nonscheduled carriers were not required to have certificates of public convenience and necessity and were also exempt from economic regulation by the Board.

Pan American introduced the first regular scheduled mail service on the Atlantic in May 1939, between New York, Lisbon and Marseilles. One month later a similar mail service was offered to England via Newfoundland and Ireland and in July of 1939 passenger service was opened to both countries. The transatlantic crossing took approximately 29 hours using the Boeing 314 flying boat. The British began a similar service in August. Initially, the passenger fare was set at $375 one way or $675 round trip.

By 1940, the U.S. government's policy towards exchanging landing rights had changed. The landing privileges on international airports were to be negotiated by the Department of State and subject to presidential approval. The CAB was to decide as to which United States carrier should be authorized to operate the negotiated routes. This, in essence, put an end to Pan American's monopoly on negotiating and operating exclusive landing rights.

With the beginning of World War II, Pan American's projected expansion came to a halt. The U.S. government took over the transatlantic operations with Pan American and American Export Airlines being the sole operators. Regular schedules were maintained on the Atlantic and the Pacific. Furthermore, a lot of the aircraft belonging to the U.S. domestic airlines were either purchased or leased by the government. With very few aircraft left in their hands, the carriers were forced into more efficient operations and greater utilization from their fleet on restricted routes which received service. Most of the airlines began to show profit during the war years due, basically, to high load factors, high utilization of equipment and elimination of discount fares such as for round trips and those offered to credit card holders.

During the War normal airline operations were curtailed throughout Europe due to shortage of equipment or enemy action.

Passenger traffic dropped to about a third of the level achieved in 1939. Britain's air transport industry felt a very severe impact. The routes of BOAC had to be restructured completely: the Empire Route had to by-pass Europe and the North Atlantic service was discontinued while the carrier concentrated in keeping open critical lines of communication. The airlines of Allied countries were cooperative in transporting government officials, military personnel and supplies. In Germany Lufthansa's commercial operations were ended abruptly.

The War was responsible for the rapid technical and operational development of transport aircraft. Many refinements were introduced to the aircraft which were in existence prior to the War. Aircraft introduced during the War period such as the DC-4 and the Lockheed Constellation possess higher payload capacity, range and speed. Other areas where refinements were introduced rapidly included radio communication, navigational aids, instrument flying and airport facilities.

Towards the end of the war, many nations were interested in formulating a universal international air transport policy with regard to commercial air rights and in establishing rules governing technical and navigational aspects. In 1944, at the invitation of the United States, 54 nations sent their representatives to the Chicago Conference to formulate universal international air transport policy for international travel and commerce. Due to the conflicting interests of the various nations present at the conference, an agreement was not reached to provide a means for exchanging commercial rights to fly in and out of independent nations. Basically, there were two conflicting views-- one of relatively complete competitive freedom desired by the U.S. having the aircraft, experience, and finances to dominate such a state of affairs; and the other of rather heavily regulated operations supported by most other nations in their poor economic state following the War and fearing just such a U.S. dominance from which they might never escape.[5] The British wanted to set up an international agency to control capacity, frequency and fares. The routes were to be assigned through bilateral agreements. The Americans, on the other hand, agreed that the routes should be negotiated through bilateral agreements, but the international agency should perform a consultative function only with respect to economic regulation. Instead they suggested, the agency should be restricted to control the technical side of the air transportation.

The outcome of the Conference was an establishment of the International Air Services Transit Agreement and the Provisional International Civil Aviation Organization (PICAO). The former agreement allowed civil aircraft of the signatories to (a) fly across another nation's territory (if the nation was a participant to the agreement) without landing and (b) land for non-commercial purposes. The function of PICAO was to coordinate the activites of the nations signing any agreement made at the Chicago Conference.

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5. See Robert Thornton - Reference 5

This organization was also to act as an arbitrator in case of conflicts between the various member states. PICAO, however, did not possess any economic powers to be applied to the international air transport industry.

In 1945, the International Air Transport Association (IATA) was formally established at Havana, Cuba. This organization superseded the original one formed in 1919. Unlike the old organization, the principal function of the new IATA was to control rates on international routes. There are no provisions for controlling capacity or frequency. The extent of capacity was to be negotiated in the bilateral agreements. In addition, some of the functions of the old IATA were still to be performed by the new IATA. The two most important provisions in the functioning of IATA with regard to controlling fares are: (1) a proposed tariff has to be approved unanimously by all the members (2) the approved tariff is still subject to the approval of the aeronautical agency of each of the member nations, which would be affected by the proposed tariff.

Since the Chicago Conference did not result in an agreement to decide on a means of exchanging commercial rights, representatives from Great Britain and the United States met in Bermuda in 1946 to exchange operating rights between the two nations. The Bermuda Agreement resulted in the famous "five freedoms" of the air. The first two freedoms were essentially agreed at the Chicago Conference, namely to fly across and to land for non-commercial purposes in another nation's territory. The remaining freedoms are: to disembark passengers and cargo in a foreign country which originated in the carrier's home country; to pick up passengers and cargo from a foreign country destined for the carrier's home country; to transport passengers and cargo from one foreign country to another foreign country. The freedom classification is based on the origin and destination of the passenger and the nationality of the airline and not the passenger. For instance, a Canadian in London boarding a flight to Rome is a third freedom on a British carrier, fourth freedom on an Italian carrier and fifth freedom on a U.S., Canadian or a French carrier.

Most countries were in favor of the Bermuda type of agreement for exchanging international traffic rights for commercial civil aviation. The terms of the original Bermuda Agreement between the United Kingdom and the United States are fairly liberal. For example, the agreement did not include provisions for restricting frequencies or number of carriers of either country. Since then, however,the policies of countries have changed. For instance, in 1966, a special bilateral agreement was signed between the U.S. and the U.S.S.R. to provide service between New York and Moscow. This agreement is different in format from the usual Bermuda type, since it contains provisions on the number of frequencies that may be operated between the two countries as well as a designation of the carrier which may operate these flights.

In international operations, a country may sometimes designate two or more national carriers to offer parallel services on a given route. The United States has authorized this type of designation on the North Atlantic. London is served, for example, by National, Pan Am, TWA, and Seaboard, the all-cargo carrier. The decision for multi-designation on an international route involves many factors, such as density of the route, the extent of traffic generated by each country, the market share of the carriers of each country, fifth freedom traffic, national interest, etc. While some of these factors are market related and based on simple economics, others are of a political nature and as such very difficult to evaluate.

After the War, Pan American was a strong promoter of the "chosen instrument" concept. Under this concept, all international services were to be operated by a single carrier. Again the concept involves many factors such as prestige, defense, public interest, competition with subsidized carriers, the value of the market, etc. In the United States, the Civil Aeronautics Board, however, favored competition. As early as 1942, American Export Airlines (a shipping company) was awarded a temporary certificate to offer transatlantic service. The Board justified this by saying that an additional carrier would improve the service and serve as a yardstick for comparison of costs. Soon after the war, Pan American was given further competition when another U.S. carrier, TWA, and a number of foreign flag carriers were authorized to offer scheduled service on the North Atlantic.

With expansion of routes, excess capacity, and heavy investment committed in larger and faster aircraft, the U.S. domestic air transport industry was facing economic crisis in 1948. The scheduled carriers were facing another problem, that of competition from the nonscheduled carriers which came into existence at the end of the War. These nonscheduled operations were started by ex-military personnel who purchased the war-surplus aircraft. The Board exempted these nonscheduled carriers from the economic regulation to carry passengers and/or property in the case of domestic operations and property only in the case of international operations on selected heavy traffic routes. The Board's exemption was based on the assumption that the service provided by these carriers would supplement the scheduled carriers. In order to improve the economic situation of the industry, the Board authorized high mail rates. This was supplemented by larger passenger traffic growth due to the introduction of lower fares, partly a result of the economics of larger and faster aircraft and partly due to management initiative in introducing differential pricing mechanisms such as coach-type service and family fare plans.

The other line of development in the aviation industry after the War, was the air freight. Although, in the United States the history of air freight dates back to 1930 when many companies made arrangements with the Railway Express Agency to transport packages on regularly scheduled flights, it was not until 1945 that all-freight airlines came into existence. In 1947, the Board permitted ten all-cargo carriers to offer scheduled air freight transportation on a non-certificated basis. By 1949, six of these had declared bankruptcy and the remaining four were issued temporary certificates of public convenience and necessity to perform scheduled service.

There are four other types of U.S. air carriers which need some explanation. First, there were carriers such as Alaska and Hawaiian Airlines which were located in the U.S. overseas territories. Since Hawaii and Alaska did not enter the Union until 1959, and for other reasons of special operating rights with respect to other U.S. airlines, these carriers were not classified under the category of domestic. Even today they are classified as Intra-Alaska or Intra-Hawaii carriers and both carriers possess the Board's permanent route certificates. Secondly, after the War, there was yet another category of carriers called the intrastate carriers. The operations of these carriers were restricted to within state borders and regulated by the state's Public Utilities Commission. These carriers were exempt from the Board's regulations. Third, in 1952, the CAB authorized a group of small irregular carriers to offer service between communities not served by scheduled airlines to points receiving scheduled airline service. These carriers, called the air-taxi operators or commuter carriers in their scheduled form, offering service with aircraft weighing less than 12,500 pounds were also exempt from the Board's Economic Regulations.

The fourth category of carriers consisted of the helicopter air service operators. The Helicopter Air Service Program started in the United States after the War with subsidies to helicopter carriers in a few major cities for the carriage of mail. Until 1953, the three United States helicopter carriers carried no passengers at all and their sole source of transport revenue was from mail. In the early years the subsidy exceeded overall transport revenues, but as passenger traffic increased, it passed subsidy levels by 1964. The subsidy was completely cut off by the end of 1965 and the major trunk airlines were persuaded to supply financial aid to the helicopter carriers. Since most of the helicopter passengers were airline connecting passengers, the rationale for this action lay in offering better services for the airline passengers with the costs to be borne by the profits of the trunkline industry.

In Europe, BEA and Sabena made significant inroads in the development of helicopter service. BEA started the scheduled helicopter passenger service in 1950. Over the years, many routes were tried on an experimental basis and most of these proved to be unprofitable because of excessive costs. Although Sabena was far more successful in its helicopter passenger service, the carrier had to curtail the operations for economy and other non-market reasons. The year 1958 was a boom year when, due largely to the Brussels World Fair, the helicopter services carried over 50,000 passengers and an additional 65,000 sightseeing passengers over Brussels.[6]

By October of 1951, ten domestic trunk carriers had gone off federal subsidy. For those still receiving subsidy, the CAB announced that a separation should be made between service mail payments and subsidy mail payments. For the Big Four trunks -- American, Eastern, TWA, and United, the Board established a domestic service mail rate of 45 cents per ton-mile. Four years later the Board developed a uniform service mail rate structure called "multi-element rate formula." This was a two part rate structure consisting of a line haul charge per mail ton-mile and a terminal charge per pound of mail enplaned, varied according to the class of station served.

In Europe, after the war, the air transport industry grew very rapidly. Most of the route network consisted of pairs of airlines enjoying third and fourth freedom rights and even today

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6. World Airline Record - Reference 6, page 205.

there are usually only two dominant airlines on any given city-pair. Until about 1950, there was heavy competition between the two carriers. This was considered wasteful rivalry and was gradually eliminated and replaced on many routes by a system of commercial agreements between the airlines, generally known as pool agreements. Pool agreements generally tend to reduce competition and provide the carriers with high equipment and personnel utilization as well as high load factors. Economics can result through more uniform scheduling instead of "bunching" flights at peak demand periods. It is claimed by some that pooling agreements provide the passenger with a more uniform service at a lower price. This is debatable. The terms of the agreement can include sharing of revenue, capacity, costs, and can also include joint marketing studies, promotion and sale, etc. The extent of the agreement varies from carrier to carrier and the agreements are usually tied to the national agreements between the respective countries. According to the Edwards Report[7], BEA for example, earns roughly 60 percent of its total revenue from commercial agreements. These agreements are not necessarily restricted to intra-European operations. For instance, the "Kangaroo" route which links England with India and Australia is operated through a tripartite agreement between BOAC, Qantas and Air India. The

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7. Edwards Report - Reference 7. Page 95.

distribution of revenue is based on a sophisticated formula which takes into account traffic on the various segments as well as the connecting traffic at various points.

These pool agreements generally apply only to the third and fourth freedom traffic. Within Europe fifth freedom traffic is generally limited. There is yet another type of traffic called cabotage. This refers to the transportation of passengers by a foreign carrier between two cities in the territory of one state or its dependencies. For instance, BOAC carrying passengers originating at New York to Los Angeles would be referred to as cabotage traffic. Another example of this would be for Pan Am to carry traffic originating in London to Bermuda. The German internal service operated by foreign carriers is sometimes confused with cabotage traffic; here however, the peace treaty which followed West Germany regaining its sovereignty prohibited Lufthansa from offering service to West Berlin and this service was offered by Air France, BEA and Pan Am. This is not cabotage traffic. However, there were some other routes within West Germany which were operated by the foreign carriers, which was cabotage and is now practically non-existent.

A large number of the scheduled airlines, with the exception of the United States air carriers, are partially or wholly owned by their governments. The extent of government ownership can range from a small percentage as in the case of Finnair (about 6 percent) to a complete control as in the case of BOAC, Qantas, Air Canada, Air India, etc. Presently, out of the 107 IATA member carriers, 37 are completely privately-owned and forty are completely state-owned. Table 1 shows the extent of state ownership for the IATA member carriers.

The reasons for public ownership vary from political philosophy to market related factors. In England, for example, one reason for nationalization of the airlines was that these carriers were unable to compete with the subsidized foreign carriers. The size of the carrier is usually not the reason for public ownership; it is also important to keep in mind that private ownership, in the case of an international airline still involves government participation for at least two reasons. First, the carrier can prove to be a very useful element of national defense, and second, the carrier needs the government to negotiate bilateral agreements with other nations for landing rights.

Some analysts have attempted to find the relationship between government ownership and profitability. So far there is no conclusive evidence that government ownership leads to inefficient operations, lower profitability, etc. In fact, several government owned airlines have consistently shown profitable operations. In most cases, complete or partial public ownership also does not imply that these carriers exist solely to provide social services, carry the national flag, receive protection from competition and pay very little attention to the cost of providing the service.

TABLE 1

Extent of State Ownership

IATA Member Carriers

Number of Carriers	Percent State Ownership
37	0
9	1 - 49
13	50 - 89
8	90 - 99
40	100
TOTAL 107	

Source: Interavia November 1971 - Reference 8.

In many cases the nationalized airlines are eventually expected to pay their own way.

Joint ownerships are quite common in the airline industry. For example, in 1946, TWA acquired a 35 percent common stock interest in the Greek Company, Technical and Aeronatuical Exploitations, in exchange for financial and technical assistance. In the same year, BEA held 30 percent interest in Alitalia. There are many reasons for holding financial interests in other airlines. These can range from pure commercial investment reasons to obtaining feeder traffic, developing new routes, and establishing an outlet for retired aircraft.

The establishment of airlines in many of the smaller or less developed countries was strongly influenced by non-economic or non-market factors. In many cases, the airlines were supported by the government for reasons such as national prestige and national defense. On the economic grounds, these international services are usually justified for such reasons as earning foreign exchange and developing tourism. In many cases the development of these airlines was enhanced significantly by the foreign aid through agencies such as the United States Export-Import Bank, ICAO, World Bank, A.I.D., etc. The United States, for instance, has provided low interest loans to purchase United States manufactured aircraft. Some of the European countries have also provided similar sort of aid in the past. Besides financial aid, the airlines of these less developed nations have been given support in areas such as pilot training, technical services, management consultation, etc. The benefits gained by the nations providing aid and the airlines providing support have been mentioned previously.

By the mid-1950's, the airline industry in the United States could be considered as established. In 1955, the CAB granted permanent certificates of public convenience and necessity to the local carriers. Two years later, the CAB was authorized to guarantee loans to assist carriers to purchase flight equipment. The amount of loan was limited to 5 million dollars per carrier and maximum of 90 percent of the loan could be guaranteed. The following year, new legislation was introduced permitting the subsidized air carriers to retain profits from the sale of flight equipment on the conditions that the profits were reinvested in new equipment within a reasonable period of time.

The Federal Aviation Act of 1958 amended and replaced the Civil Aeronautics Act of 1938. The safety rule making function was transferred to the newly created Federal Aviation Agency, while the regulation of civil aircraft accidents still remained the responsibility of the Civil Aeronautics Board. Parallel developments in streamlining the regulatory aspects of air transportation were taking place in many other countries of the world. For instance, Britain's Civil Aviation (Licensing) Act of 1960 established the Air Transport Licensing Board to approve applications for operating licenses and regulate domestic fares in the United Kingdom.

The type of regulation applied to the airlines in the United States should not be taken as typical. For instance, the Australian civil air transport policy has been quite unique. Presently the Australian airline industry is basically made up of three airlines: Qantas, a public-owned carrier operating international services only, and two competitive domestic airlines, a private corporation called Ansett Airlines and a government-owned carrier called Trans-Australia Airlines. Under the Civil Aviation Agreement of 1957 and the Airlines Equipment Act of 1958, the government not only controls competition, but exercises a tight control on the commercial management decisions. For example, neither TAA or Ansett can purchase a new aircraft without the specific approval of the government, while each carrier is also supposed to inform the other of its decisions to purchase new equipment. The approval is granted if the regulatory authority considers that the new equipment will not result in excess capacity or produce a competitive edge for one of the carriers. In case of excess capacity, the authority can force the carrier(s) to review their fleets.

Although, research and development of the jet engine was well under way during and even prior to World War II, it was not until 1952 that the public was offered commercial jet service by BOAC (which unfortunately had to be withdrawn shortly after for technical reasons.) In 1956 the Russians introduced the TU-104. The year 1958 is, however, referred to as the "jet revolution" year when Pan American introduced the Boeing 707 on the North Atlantic, in October 1958, three weeks after BOAC introduced the second version of their jet, the DeHavilland Comet 4. For almost a full year there were no other competitors on the North Atlantic with jet aircraft until September and November of 1959 when QANTAS and TWA introduced the Boeing 707's. On the domestic side, National Airlines was the first to offer jet service in the United States, on December 1958, the carrier offered jet service on the New York-Miami route with a B-707 leased from Pan American Airways. A month later American put in a 707 on the transcontinental route, TWA entered the market in March, and United introduced the DC-8 in September of 1959 on this route.

Up to this point, the emphasis has been upon scheduled services, domestic and international, however of increasing importance has been the development of mass travel on non-scheduled or charter services due to the lower fares relative to scheduled services.

The scheduled air services have catered to this demand through excursion fares and other forms of differential pricing, however the lower costs obtainable through non-scheduled air travel have resulted in a tremendous growth in this form of air transportation.

The growth of non-scheduled air carriers started after World War II on both sides of the Atlantic, dependent largely upon the carriage of military cargo and troops for their survival. However before long the European carriers began to vigorously promote civilian commercial operations, in particular the inclusive tour charter. In an inclusive tour charter, a travel agent produces a "complete package" containing air travel, hotel accommodations, ground transportation, etc. and by arranging schedules to ensure full plane loads, the operators are able to offer packages at a considerably lower price compared to the price of air travel on scheduled carriers. By opening the air travel market to the lower income groups, the charter operators were able to achieve tremendous growth rates.

Prodded by the tremendous demand and realizing the economic importance of tourism, the European States formulated a Multilateral Agreement on Commercial Rights of Non-Scheduled Air Services in Europe at Paris in 1956. This agreement greatly facilitated the growth of inclusive tour travel between the 19 signatories, while attempting to protect their scheduled services.

The low price of the ITC's allowed the lower income workers in Northern Europe to holiday in the sunny South, with air travel to and from the resorts making such a vacation possible within the short time periods available to them. A number of combining factors meant that the United States was much slower in responding to this development and ITC's were not permitted until the mid-sixties while military charters still represent a significant proportion of the supplemental carriers' revenue.

Similar to the scheduled carriers, the United States charter carriers are owned privately. In Europe, although the charter operators are not owned directly by the state, many of them are owned by the national carrier which in turn is partially or wholly owned by the state. This is a critical issue regarding competition not only between charter operators and scheduled airlines in Europe, but between United States scheduled and European scheduled carriers. In the United States, scheduled airlines have not been allowed to own subsidiaries which offer charter services, although they may do so themselves.

Interesting agreements such as these were not always set up in Europe. A different, but interesting agreement was formed by the major airlines in the United States. In 1959, six U.S. carriers, American,Capitol, Eastern, Pan American, TWA and United entered into an agreement called the Air Carrier Mutual Aid Pact.

This agreement provides for financial assistance in case of a strike. The arrangement calls for payment to the struck carrier of any increased "windfall" revenues which they receive as a result of handling the struck carrier's business less the additional expense of handling such increased traffic. In addition, more recently the CAB has allowed some carriers to cooperatively restrict capacity on certain routes.

In general the United States policy reflected free trade. This has been made fairly clear in the various reports on the U.S. international air transport policy released in 1963 and 1970. The policy was essentially non-protectionist, promoting reasonable rates and equal opportunities for U.S. carriers in route exchanges with foreign nations, and opposing arbitrary capacity restrictions. Other significant recommendations were to retain a balance of U.S flag competition on the North Atlantic, have more than one U.S. international air carrier and oppose pooling agreements with foreign carriers.

In Europe, cooperative agreements regarding maintenance and spare parts had begun as early as 1958, with the introduction of jet aircraft. Initially SAS and Swissair signed an agreement to coordinate equipment policy and pool resources in terms of operating workshops and technical organizations. By 1969, the agreement had been extended to include two other carriers, KLM, and UTA, to form the KSSU group. Under the new program, KLM was to provide airframe maintenance for the B-747 and SAS was responsible for the engine maintenance. This type of cooperation provides the carrier with a small fleet with the advantages of a large fleet.

One other form of cooperative agreement which is significant is the concept of "blocked-space" agreement. Under this concept, a developing carrier with insufficient funds to invest in a large fleet and to minimize the financial risk involved in purchasing aircraft, can block space on another line to be sold under its corporate identity. For example, in 1969 Austrian Airlines entered into a pool agreement with Sabena to offer service on the North Atlantic. Under this scheme, Sabena operated a daily B-707 flight from Vienna to New York via Brussels. Austrian Airlines blocked half of the cargo capacity for its use and paid Sabena half the operating costs of the flight, and a fee for each passenger handled. The flag carrier of Portugal, TAP, had negotiatied a similar blocked space agreement with Alitalia in 1966 to offer service between Lisbon and New York.

The mid-sixties not only set the pace for jet operations, but also began to focus on the supersonic aircraft. Pan American, BOAC, and Air France placed firm orders for the Concorde supersonic aircraft. Besides these three international air carriers, a U.S. domestic carrier, Continental Air Lines, also placed an order for three Concorde aircraft. In the meantime, two airframe manufacturers and two engine manufacturers undertook the design studies on the U.S. SST for the Federal Aviation Agency. The major portion of the cost of research and development was to be borne by the United States Federal Government. Boeing and General Electric were selected to design the United States SST. This team won the competition but the project was abandoned in 1971 for political, environmental, and socio-economic reasons.

The mid-sixties once again witnessed a further streamlining of the transportation planning process in the United States. The Department of Transportation was created to provide total transportation planning, policy guidance and protection of public interest with the aim of achieving an integrated national transportation system based on economic criteria and not modal preferences. Prior to this organization, there were numerous uncoordinated modally oriented transportation agencies with virtually non-existent common goals. These agencies were generally unstructured and without sufficient authority to develop a national transportation system effectively. The Department was given the responsibility of coordinating transportation programs, providing transportation leadership, cooperating and coordinating transportation projects with federal, state, and local government agencies, and identifying prodigious transportation problems.

Parallel efforts took place in Canada, where the National Transportation Act of 1967 created the present Canadian Transport Commission to coordinate the development, regulation and control of the total transportation system; and in the United Kingdom where the Civil Aviation Authority (CAA) came into being in April of this year (1972) with much the same powers but for aviation only. The functions of these Agencies are somewhat similar to those of the United States Department of Transportation as well as the Civil Aeronautics Board.

In this paper most of the attention has been devoted to the development of the air passenger transportation industry. Although the growth of air cargo has been very significant in the past, its contribution to the total revenue of the carriers is still fairly small. On the average, for all scheduled airlines taken together, approximately ten percent of the revenue is derived from air cargo. According to one report[8] less than one half of a percent of the total cargo moves by air. The same report estimates that if the bulk cargo such as oil, coal minerals, etc, is excluded then the share of cargo transported by air increases to almost four percent. In the past a large part of the air cargo has been emergency cargo. The stable cargo has in the past been restricted to goods of high value, fragility and perishability.

The most crucial factor in air cargo is, of course, the cost. It is now a generally accepted fact that roughly half of the cost of handling cargo is on the ground: loading, unloading, storing, documentation, etc. Recently, effort has been focused on reducing these ground handling costs. For instance, according to one detailed study,[9] a typical international shipment requires the preparation and processing of an average of 46 documents of which nine involve the carrier directly.

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8. Interavia - Reference 8.
9. Committee on International Trade Documentation - Reference 9.

Efforts to reduce ground handling costs in the past have been in the areas of containerization, computerized documentation systems, etc. Another critical and unfortunately unsolved problem is in the area of rates. So far no carrier or government agency has been able to set rates which take into account adequately, the cost, the value and the market elements of air cargo. The solutions to these problems will expand the air cargo market and its contribution to the total revenue of the air transport industry.

Although direct subsidy is non-existent with major airlines, indirectly the airlines are still aided a great deal by the governments. In most cases, the full cost of navigational and terminal services is still not recovered from the air carriers, but supported by national and regional governments. Since the Chicago Conference of 1944, much work has been done by ICAO to try to coordinate and standardize the charges made for airport and their facilities are open to use by anyone, the governments have had much trouble distinguishing between the services offered to different users. As a consequence, it is debatable whether the airlines have paid their full way on the ground or in the air.

Recently more accurate allocation of airports and navigational costs have become critical issues. In Europe, for example, an organization called Eurocontrol operates navigational facilities in the upper airspace and makes a charge for such services. In the United States the Airport and Airways Development Act of 1970 imposed new and increased aviation user charges to be used for expansion and improvement of the airport and airway system. In addition, some airports have sought to meet their costs through "head taxes" levied on arriving and/or departing passengers. Recently, an agreement was reached in the United States to prohibit such state and local airport head taxes.

During this relatively short period of roughly sixty years, the progress in the commercial air transport industry has been spectacular. In 1970, over 300 million passengers were carried by the scheduled international and domestic carriers belonging to IATA. Today, the operating revenue of the United States airline industry is about ten billion dollars. We can expect even greater progress with the forthcoming supersonic age and the increasing growth of tourism with its mass travel implications.

References

1. U.S. Civil Aeronautics Board, "Handbook of Airline Statistics". 1969 Edition.

2. Ronald Miller and David Sawers, "The Technical Development of Modern Aviation", Routledge & Kegan Paul Limited, London. 1968.

3. Davies, R.E.G. "A History of the World's Airlines", Oxford University Press, England, 1964.

4. Warner, E.P., "The Early History of Air Transportation", Norwich University, Northfield, Vermont, November 21, 1937.

5. Thornton, Robert L., "International Airlines and Politics". University of Michigan, Ann Arbor, Michigan, 1970.

6. World Airline Record, Road Cap and Associates, 7th Edition, 1972.

7. British Air Transport in the Seventies: Report of the Committee of Inquiry into Civil Air Transport, London, May 1969.

8. Interavia, January 1971, "Air Cargo - The Sleeping Giant".

9. National Committee on International Trade Documentation, "Paperwork or Profits $? in International Trade," 1971. Report by International Trade Documentation and Department of Transportation.

THE ROLE OF THE FEDERAL GOVERNMENT IN THE DEVELOPMENT OF THE U.S. AIR TRANSPORTATION SYSTEM

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Abstract

A review of the roles of the various federal agencies in the regulation, control, and development of the Air System, with major emphasis on the Department of Transportation (Office of the Secretary, Federal Aviation Administration, and National Transportation Safety Board) and the Civil Aeronautics Board.

The Federal Government plays a central role in the development, finance and operation of the United States Air Transportation System. Figure 1 shows some of the functional relationships between the Government and the other major institutions that are parts of the system. Although local and state governments play a minor role (through the imposition of local taxes or participation in airport ownership and management), the national government is the primary source of political influence and legal control.

Figure 2 shows the government organizations that impact the air system and how they fit into the federal structure. The United States Constitution is the ultimate source of all authority. It allocates governmental functions between the Courts, the Congress and the President. In turn, the legislative and executive branches create and appoint personnel to the independent agencies which are in essence a fourth branch of government - the administrative branch. Each branch interacts with the others, and each plays a particular role.

THE ROLE OF THE COURTS

The Courts are not involved in the day-to-day affairs of the air system. Their major function is the supervision of other governmental bodies through the judicial settlement of disputes as they arise. In addition to the resolution of conflicts involving the federal government, the Courts settle litigation between the other institutions that make up the system - the users, manufacturers, airlines, etc. Judicial decisions may have major impact and long range policy implications, but since they only arise when parties bring particular disputes before the Courts, one cannot say that these decisions play a decisive or prominent role in shaping air transportation.

THE ROLE OF THE LEGISLATURE

Under Article I, Section 3 of the Constitution, the Congress has the power to regulate commerce among the states. Therefore, the legislature is the major source of air system policy. However, Congress, like the courts, does not participate in the day-to-day affairs of the system. Rather, through legislation, it establishes policy and delegates the implementation of that policy to executive or independent agencies. Through Congressional hearings, it periodically reviews the impact of its legislation and will make modifications only when necessary.

Perhaps the most important function of Congress is the control of appropriations sought by the operating agencies. In this way, the legislature can exert pressure on both the administrative and executive bodies that are charged with policy implementation.

General Accounting Office (GAO)

The General Accounting Office is an independent agency in the legislative branch of the government established to assist the Congress in controlling the receipt, disbursement and application of public funds. In general, the audit authority of the GAO extends to all departments and agencies of the Federal Government. Through audits, the GAO monitors the ways in which agencies are discharging their financial responsibilities, the efficiency of operations and program management, and whether Government programs are achieving the purposes intended by Congress. This monitoring activity also extends to state and local governments, quasi-governmental bodies and private organizations when they receive or administer federal funds.

By law, federal agencies are required to pay on presentment bills for freight and transportation services furnished by carriers subject to the Interstate Commerce of Federal Aviation Acts. These payments must be made even if not audited. The GAO monitors these transactions, and is responsible for determining the propriety of the rates and classifications billed, recovering overcharges and settling transportation claims brought for or against the government.

THE ROLE OF THE PRESIDENT

Article II, Section 1 of the Constitution vests the executive power of government in the President. In addition, the President has specific authority and responsibility covering a large range of topics conferred by statute. In general, he is charged with the implementation of federal policy, which he performs both through the Executive Office of the President and the Executive Departments.

The Executive Office

Many special and general purpose agencies are administratively grouped into the Executive Office. They provide various services and functions to assist the President in his administration and executive duties. Several of these agencies can have major impact on the air system.

Council on Environmental Quality -- The Council was established by the National Environmental Policy Act of 1969 to formulate and recommend national policies to promote and improve the quality of the environment. Its recommendations on aircraft noise and pollution could have great influence on the future of air transportation.

Domestic Council -- Through ad hoc project committees set up to deal with both broad program areas and specific problems, the Domestic Council formulates and coordinates domestic policy recommendations to the President. It assesses national needs and coordinates the establishment of national priorities, recommends integrated sets of policy choices and provides a rapid response to Presidential needs for policy advice on pressing domestic issues. The Council also maintains a continuous policy review of on-going programs.

National Aeronautics and Space Council (NASC) -- Created along with NASA by the National Aeronautics and Space Act of 1958, the NASC is composed of the Vice President, the Secretaries of State, Defense and Transportation, the Administrator of NASA, and the Chairman of the Atomic Energy Commission. An Executive Secretary administers the affairs of the Council assisted by a small staff.

The functions of NASC are to advise and assist the President regarding policies, plans and programs in aeronautics and space. The Council develops comprehensive programs for such activities and fixes the responsibilities of the agencies involved.

Office of Management and Budget (OMB) -- OMB is the President's financial watchdog. It also provides valuable interagency coordination and review. In the financial area, OMB assists the President in improving the efficiency and economical conduct of Government services, and in the preparation and formulation of the budget and fiscal programs. It supervises and controls the administration of the budget. OMB also conducts research into new modes of administrative management.

In the area of interagency review, OMB clears and coordinates departmental positions on proposed legislation and monitors the progress of activities so that the work programs of all the executive agencies may be coordinated and so that Congressional appropriations can be expended in the most economical manner with the least overlap and duplication of effort.

OMB also promotes and coordinates Federal and other statistical services, and plans and develops information systems to monitor program performance.

Office of Science and Technology (OST) -- OST assists the President in the development of technical programs and evaluating and coordinating technical activities to assure that science and technology are used most effectively in the general welfare. Specific tasks include the assessment of selected scientific and technical developments and programs and the evaluation of their impact on national policies. OST also maintains close relations with the Nation's scientific and engineering communities so they will continue to participate in the strengthening of the national technology base.

Special Commissions -- Special boards, committees and commissions are created from time to time for special purposes and administratively report to the Executive Office of the President. Some examples are:

Export Administration Review Board
Federal Safety Council
President's Science Advisory Committee
Aviation Advisory Commission

These commissions are composed of experts from industry and government with full-time staff support. Generally, they undertake a specific important task, and are dissolved when their work is completed.

The Executive Departments

The Department of Agriculture -- In addition to its more traditional duties, the Department locates, operates and administers airports in the national forest; contracts for aerial services such as seeding, spraying and fire fighting; and through participation in CAB proceedings, the Department seeks to secure adequate air service for its forests. The Department also operates inspection and quarantine stations for plants and animals at airports of entry and assures the humane treatment of animals moving in interstate commerce by air.

The Department of Commerce -- Through the United States Travel Service, the Department encourages foreign travel to the United States, and controls the export of aircraft and related equipment. It also disseminates technical data abroad and encourages U.S. businesses to seek foreign contracts.

Through the Bureau of the Census and the Coast and Geodedic Survey, the Department provides population and geographic data essential for airport siting and planning. Through the National Weather Service, the Department provides the weather information vital to aircraft operations.

The Department of Defense (DOD) -- The role of the DOD in the development of the air system cannot be minimized. Through technology spin-off, DOD projects have provided the scientific and technical base for many major developments in civil aviation. In addition to the technology spin-offs, it is a prime source of trained aviation personnel who have completed military service.

The DOD is also a customer for air services. It contracts with carriers for the movement of its personnel and equipment and thus provides a major source of income to them, particularly the supplementals. In connection with its purchases of air services, the DOD appears before the CAB in matters relating to military tariffs.

Department of Health, Education and Welfare -- The Department provides quarantine functions at airports of entry to protect against the import of contagious human diseases and to enforce interstate quarantine and health regulations.

Department of Housing and Urban Development (HUD) -- HUD provides funds for regional and urban planning including research on zoning, land-use planning and airport planning. It can finance studies of urban access problems, but research on rapid mass transit to airports is primarily performed by the Urban Mass Transit Administration.

The Department of the Interior -- The Department controls the use of airports in national parks, monuments and recreational areas. Through participation in CAB proceedings, the Department attempts to ensure adequate service to these areas as well as for the Pacific Trust Territories which it helps administer.

The Department of Justice -- The Department has several functions that directly relate to the air system. First, through the Immigration and Naturalization Service, it maintains offices at airports of entry to monitor the transit of aliens and foreign nationals. Second, Justice enforces nondiscriminatory practices in the air industry by prosecuting violations. Third, Justice provides enforcement when needed for the rules of air safety such as transport of dangerous items and interference with the pilot. Finally, the Justice Department takes an active role in merger proceedings before the Civil Aeronautics Board and enforces anti-trust laws against manufacturers and suppliers. The Civil Aeronautics Act of 1938 exempts the air carriers subject to the Act from the anti-trust laws and substitutes CAB supervision. However, the other institutions in the air system are subject to prosecutions for anti-trust violations.

The Department of Labor -- The major role of the Labor Department is in the enforcement of policies on minimum wages, limitations on hours of work and the employment of minorities. It also provides statistical information on employment and sponsors some limited vocational and training programs.

Department of State -- The State Department is primarily involved in the international aspects of air transportation, particularly as they affect United States manufacturers and carriers. Through the Agency for International Development (AID) it explores the potential for air transportation systems in underdeveloped countries. State promotes international agreements on air traffic control and airspace standards and facilitates cooperation for international weather data collection and dissemination.

The State Department issues passports and visas for travel to and from the United States. Through the Office of the Deputy Assistant Secretary for Transportation and Telecommunications, the Department formulates policy recommendations and negotiates foreign air transportation agreements.

The Treasury Department -- Two bureaus of the Treasury affect the air system. The Bureau of the Customs conducts all customs operations at airports of entry to the United States. The Bureau of Internal Revenue establishes depreciation policies that affect the purchase of aircraft, and sets the policy for taking deductions for business travel. The latter can affect the use of corporate aircraft and the overall volume of travel.

The Postal Service -- The Postal Service is one of the airlines' largest customers. Although mail rates for certified carriers are set by the Civil Aeronautics Board, the Postal Service has a great deal of control over the amount and timing of airmail movements.

In addition, the Postal Service can negotiate contracts with third level carriers to carry mail to small communities not receiving regular certificated air service. These postal contracts are of major importance to the small operator.

THE ROLE OF THE INDEPENDENT AGENCIES

The independent agencies are created by Congress to perform a particular duty defined in the authorizing statute. Normally, members of the agency are appointed by the President with the advice and consent of the Senate, and once appointed, remain in office either for their specified term or until they resign. Although there is removal power, it can only be exercised if the agency member is guilty of major misconduct in office.

So once the agency is established and its members appointed, in theory it is independent of the other branches of government. However, the President can exert great political pressure, and one can assume that members appointed by the President in office may favor his ideas and policies. Likewise, Congress exerts pressures through financial and budget appropriations and through the threat of amending or revoking the statutory authority that originally set up the agency. The Courts also exert some control over agency action by review of decisions on appeal.

The distinction between members of an agency and agency staff must be made clear. All the independent agencies have staff to perform day-to-day functions and support agency members. In many organizations, the staff may perform research and make policy recommendations. It may even appear as an independent party in agency proceedings. However, recommendations of the staff are not binding on the agency members who make the actual decisions. For example, it is not uncommon for the Civil Aeronautics Board Staff to take positions that are completely contrary to the final decision of the Board members.

Environmental Protection Agency (EPA) -- To date, the EPA has not had major impact on the air system, deferring most environmental matters involving aviation to the Federal Aviation Administration. However, there are indications that this may not hold true in the future. EPA has a variety of research, monitoring, standard-setting and enforcement activities related to noise and chemical pollution abatement and control. It is logical that these activities will in some way be extended to aviation if a truly systematic attack is to be made on environmental problems. Whether the EPA assumes some of these roles itself, or merely serves as an advisor and consultant to the FAA, it will play an important role in air system development.

Equal Employment Opportunity Commission (EEOC) -- The Commission has two purposes: (1) to end discrimination based on race, color, religion, sex or national origin in the hiring, promotion, firing, wages, testing, training, apprenticeship and all other conditions of employment; and (2) to promote voluntary action programs by employers, unions and community organizations to put equal employment opportunity into actual operation. The Commission participates in the investigation and enforcement of actions arising from unlawful discrimination.

Export-Import Bank -- The Bank aids in the financing and export of commodities from the United States to foreign countries. It supplements rather than competes with private financing and plays a major role in the foreign sale of aviation hardware. A more complete description of its functions can be found elsewhere in these proceedings.

Federal Communications Commission (FCC) -- The FCC is charged with the frequency management of telecommunications activities. In particular, it licenses and regulates radio broadcasts for aviation and emergency purposes.

Federal Mediation and Conciliation Service -- The Service assists parties to labor disputes where the industry affects interstate commerce, to settle such disputes through mediation and conciliation. The Service possesses no law enforcement authority, but depends wholly on persuasive techniques. Whenever in its judgement, a dispute threatens to cause a substantial interruption of interstate commerce, the Service can offer its services either on its own incentive or at the request of one or more of the parties. The Service is involved with all industries auxiliary

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to the airlines including manufacturers or concessionaries, but does not take an active role in disputes involving the airlines, since they are covered by the Railway Labor Act.

General Services Administration (GSA) -- The GSA manages the property (and records) of the government, including the construction and operation of buildings, procurement and distribution of supplies, disposal of surplus property, traffic and communications management, stock piling of strategic and critical materials and the creation, preservation and disposal of records.

In particular, the GSA manages the government's Transportation and Communications Service (TCS) which performs traffic management for civil executive agencies. The TCS represents these agencies in negotiations with carriers and in hearings of regulatory bodies. It also develops policies, procedures and regulations for the procurement and utilization of transportation services.

Interstate Commerce Commission (ICC) -- The ICC participates with the CAB in establishing air cargo pickup and delivery zones. It has also developed a policy with the CAB, to limit or prevent transmodal transportation systems and intermodal ownership and control of transportation companies.

National Aeronautics and Space Administration (NASA) -- NASA's primary programs in aeronautics are managed by the Office of Aeronautics and Space Technology and the research centers assigned to it. The efforts include research and advanced technological development of aircraft and associated electronics. The primary centers are:

> Ames Research Center - Research in the configuration, stability, structure and guidance and control of aircraft (and space vehicles).
>
> Flight Research Center - Research in extremely high performance aircraft and spacecraft, including flight operations, flight systems and structural characteristics of the vehicles.
>
> Langley Research Center - Research in structures and materials for subsonic and supersonic flight.
>
> Lewis Research Center - Research in power plants and propulsion.

NASA's work and interest in these areas has expanded rapidly during the past few years and this trend is expected to continue.

National Labor Relations Board (NLRB) -- Most of the private institutions involved in the air system are covered by the various provisions of the National Labor Relations Act as amended, with the major exception being the airlines themselves which are covered by the Railway Labor Act. The two major functions of the NLRB are to conduct secret ballot elections among employees to determine whether or not they wish to be represented by a labor organization, and to prevent and remedy unfair labor practices by employers or labor organizations.

Through its regional offices, the NLRB can issue complaints in unfair practice cases, seek settlements of unfair practice charges, obtain compliance with Board orders and court judgements and petition for injunctions to prevent or remedy unfair practices.

National Mediation Board -- The Board was created by a 1934 amendment to the Railway Labor Act. Its jurisdiction was later extended to carriers by air engaged in interstate commerce or under a mail contract. The purposes of the act are to avoid interruption to commerce, to ensure the rights of employees to organize and to provide for the prompt settlement of disputes.

The principle duty of the Board is to mediate differences between the transportation companies and their employees arising from attempts to reach agreements on rates of pay, rules on employee working conditions and the like. The Board also settles disputes among employees concerning what unions should represent them.

National Science Foundation (NSF) -- The major role of NSF is to strengthen research and education in the sciences in the United States. Many of the projects undertaken are transportation oriented. Through the award of grants and contracts to universities and other nonprofit institutions, NSF encourages research in vital areas.

Securities and Exchange Commission (SEC) -- The SEC guards against fraud in the issuance and sale of securities in interstate commerce or through the mails. It operates primarily by requiring the submission of certain factual data before the stock can be registered, and periodical data submissions thereafter. It does not guarantee the accuracy of the data filed, but it makes those guilty of fraudulent representations liable for civil or criminal penalties. The SEC also has the power to obtain court orders enjoining acts or practices that could defraud investors or otherwise violate the law.

THE DEPARTMENT OF TRANSPORTATION

There are two federal agencies that merit particular attention: the Department of Transportation (DOT), an executive department of the President; and the Civil Aeronautics Board (CAB), one of the independent agencies.

The DOT is a major institutional factor in the air system. Both through the Office of the Secretary and the Federal Aviation Administration, DOT is involved in policy determination, system analysis and operational problems associated with air service. Through the FAA and the National Transportation Safety Board (which is loosely tied to the DOT for administrative purposes), the Department plays a major role in air safety.

Figure 3 shows the organization of DOT as of 1971. The administrations listed on the bottom line are the operating administrations of the Department. All other functions are collectively said to be in the Office of the Secretary of Transportation (OST).

The Office of the Secretary -- Within OST, the Secretary and the Under Secretary are responsible for overall planning, direction and control of the Department. There are several Assistant Secretarials who play a major role in air system policy development.

Assistant Secretary for Environment and Urban Systems - Through its concern for environmental matters, the Assistant Secretary's office influences noise and chemical pollution policy and airport planning.

Assistant Secretary for Policy and International Affairs -- The Assistant Secretary is responsible for international and domestic transportation policy, objectives and system planning. He directs programs of international technical cooperation, including technical support to developing countries. A comprehensive transportation data information retrieval system is also being developed in this section of the Department.

Assistant Secretary for Systems Development and Technology -- Scientific and technological research and development in transportation systems, safety, noise abatement and technical policy inspect are under the management of the Assistant Secretary. He also provides overall management for the Transportation Systems Center in Cambridge, Massachusetts which is charged with performing and managing projects in advanced systems and technological research and development in all transportation disciplines.

The Federal Aviation Administration (FAA) -- The FAA is primarily concerned with safety and the operational aspects of air transportation, as compared with the Civil Aeronautics Board's economic responsibilities. The Administration is more involved with the day-to-day aspects of the system than any other governmental body. It is charged with the promotion of safety and development of the system; achieving efficient use of the air space; and promoting the national airport system. In addition, the FAA is responsible for the development and operation of air traffic control and air navigation systems for both civilian and military usage.

One of the Administration's most important functions is safety regulation. It issues and enforces rules, regulations and standards for aircraft manufacture, maintenance and operation; for the certification of airmen; and for the certification of airports used by carriers under CAB economic control. The FAA also installs and maintains air navigation facilities, communication equipment and electronics needed for control towers and air traffic control centers. The safe and efficient management and utilization of the navigable airspace is one of the Administration's primary objectives.

The FAA provides a system for the registration and recording of the nationality and ownership of aircraft, engines, propellers and appliances, and performs research and development tasks needed to fulfill its statutory responsibilities. The National Aviation Facilities Experimental Center in Atlantic City, New Jersey is maintained as a facility necessary for the experimental phases of research tests.

In addition to other tasks too numerous to mention, the FAA administers programs to identify the type and costs of airports required for a national airport system and provides funds to assist in airport systems planning and airport master plan development. It also administers the Aviation Trust Fund, making grants for runway and taxiway construction on a matching funds basis with airport operators.

The National Transportation Safety Board (NTSB) -- The NTSB, although administratively attached to the DOT, is autonomous in its functions with its own statutory responsibilities and executive authority. The DOT Act of 1966 specifically states that the Board in the exercise of its functions, powers and duties shall be independent of the Secretary and the other officers of the Department. It is required to directly report to Congress annually on the conduct of its duties and make appropriate recommendations for legislation. The NTSB has responsibility for determining the causes of surface accident as well as air. On the air side, it investigates accidents (except where it delegates such investigation to the FAA), determines probable cause and reports all facts and circumstances. It also conducts special studies and makes recommendations for aviation safety and accident prevention.

THE CIVIL AERONAUTICS BOARD

Figure 4 shows the organizational structure of the CAB. The Board itself is composed of the five members shown at the top of the chart. All other offices and positions provide staff support to the Board and its activities.

The Board was created by the Civil Aeronautics Act of 1938 and continued by the Federal Aviation Act of 1958. It has broad responsibility for the encouragement and development of civil aviation. Unlike the Interstate Commerce Commission (ICC), the CAB is charged to both regulate the industry and promote its development at the same time. This often leaves the Board in a dilemma as to which goal should be predominant. For example, when a fare increase is requested, the Board must balance the cost to the consumer against the carrier's needs for more capital.

The Board's five members are approved for staggered six-year terms, and no more than three may be from the same political party. The President annually designates one member as Chairman and another as Vice-Chairman. Board activities can be roughly grouped as follows:

> Route Authorizations - The Board through the grant of certificates of public convenience and necessity, authorizes domestic carriers to perform domestic and/or foreign air service between designated points. It also issues permits to foreign carriers to provide air transportation between the United States and foreign countries and authorizes the navigation of foreign aircraft in the United States for other purposes.
>
> Fares - The Board has authority over the tariffs, rates and fares charged for civil air transportation. The carriers initiate the rates and the Board oversees and approves them. The Board also authorizes and pays subsidies for service to communities where traffic does not cover the cost of service.
>
> Inter-Carrier Relationships - The CAB passes on mergers, agreements, acquisitions of control and interlocking relationships involving air carriers. It also supervises unfair competitive practices of carriers or ticket agents.
>
> Reports - The Board requires regular financial and operating reports to be filled by the Carriers. It also specifies the accounting and bookkeeping practices and procedures to be used in preparing the required information.
>
> International - The CAB serves as an advisor to the Department of State in foreign negotiations for new or revised air routes and services.

Board decisions in all domestic areas are subject only to court review, and not that of any executive department or agency. Decisions granting or affecting certificates for overseas and foreign air transportation require Presidential approval.

The Board's Office of Consumer Affairs has recently increased in importance. This office is maintained to assist air travelers, shippers, and others interested in air transportation. It processes complaints arising from the use of air service and attempts to arrange voluntary solutions between members of the industry and the public.

SUMMARY

There are over 30 federal agencies that can affect the development, operation and control of the air transportation system. Because of the many complex roles the government plays, it is impossible to understand our air system without understanding how intimately private and public institutions are related. What might appear to be a simple management decision may involve complicated regulatory and policy issues that could have major unforeseen impact on the overall operation and efficiency of air transportation. One must understand the complexities of the federal role to truly predict the effects of decisions on the system as a whole.

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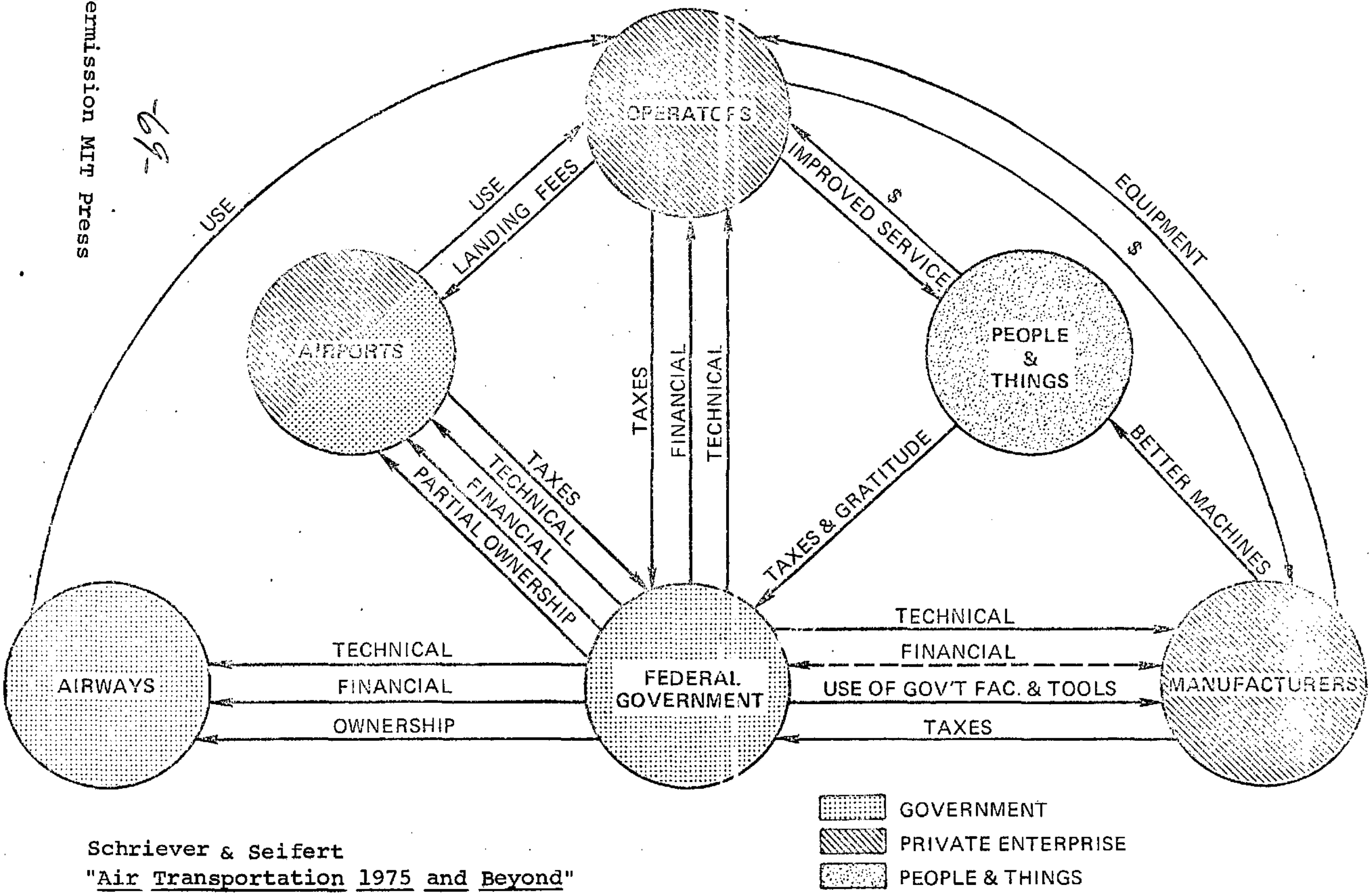
FIGURE 1



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"Air Transportation 1975 and Beyond"

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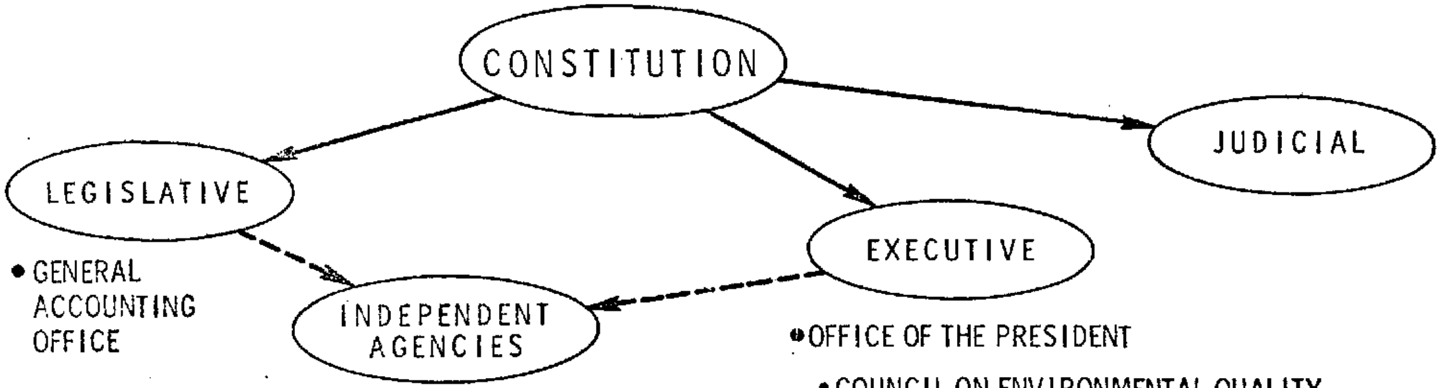

- GENERAL ACCOUNTING OFFICE

- CIVIL AERONAUTICS BOARD
- ENVIRONMENTAL PROTECTION AGENCY
- EQUAL EMPLOYMENT OPPORTUNITY COMMISSION
- EXPORT-IMPORT BANK
- FEDERAL COMMUNICATIONS COMMISSION
- FEDERAL MEDIATION
- CONCILIATION SERVICE
- GENERAL SERVICES ADMINISTRATION
- INTERSTATE COMMERCE COMMISSIONS
- NATIONAL AERONAUTICS SPACE ADMINISTRATION
- NATIONAL LABOR RELATIONS BOARD
- NATIONAL MEDIATION BOARD
- NATIONAL SCIENCE FOUNDATION
- SECURITIES AND EXCHANGE COMMISSION

- OFFICE OF THE PRESIDENT
  - COUNCIL ON ENVIRONMENTAL QUALITY
  - DOMESTIC COUNCIL
  - NATIONAL AERONAUTICS AND SPACE COUNCIL
  - OFFICE OF MANAGEMENT AND BUDGET
  - OFFICE OF SCIENCE AND TECHNOLOGY
  - SPECIAL COMMISSIONS
- EXECUTIVE DEPARTMENTS
  - AGRICULTURE
  - COMMERCE
  - DEFENSE
  - HEALTH, EDUCATION AND WELFARE
  - HOUSING AND URBAN DEVELOPMENT
  - INTERIOR
  - JUSTICE
  - LABOR
  - STATE
  - TRANSPORTATION
  - TREASURY
- POSTAL SERVICE

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FIGURE 2

DEPARTMENT OF TRANSPORTATION

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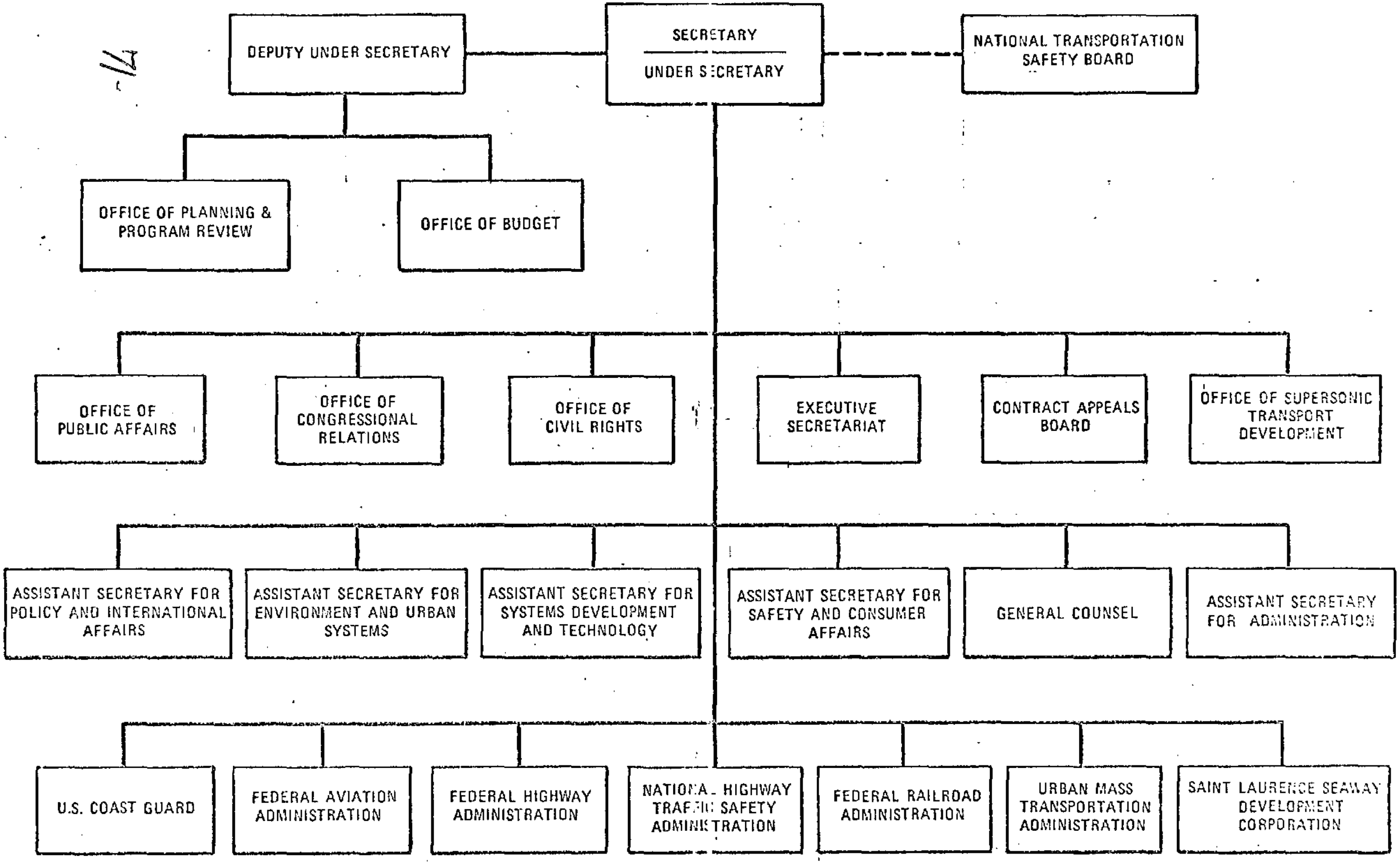

FIGURE 3

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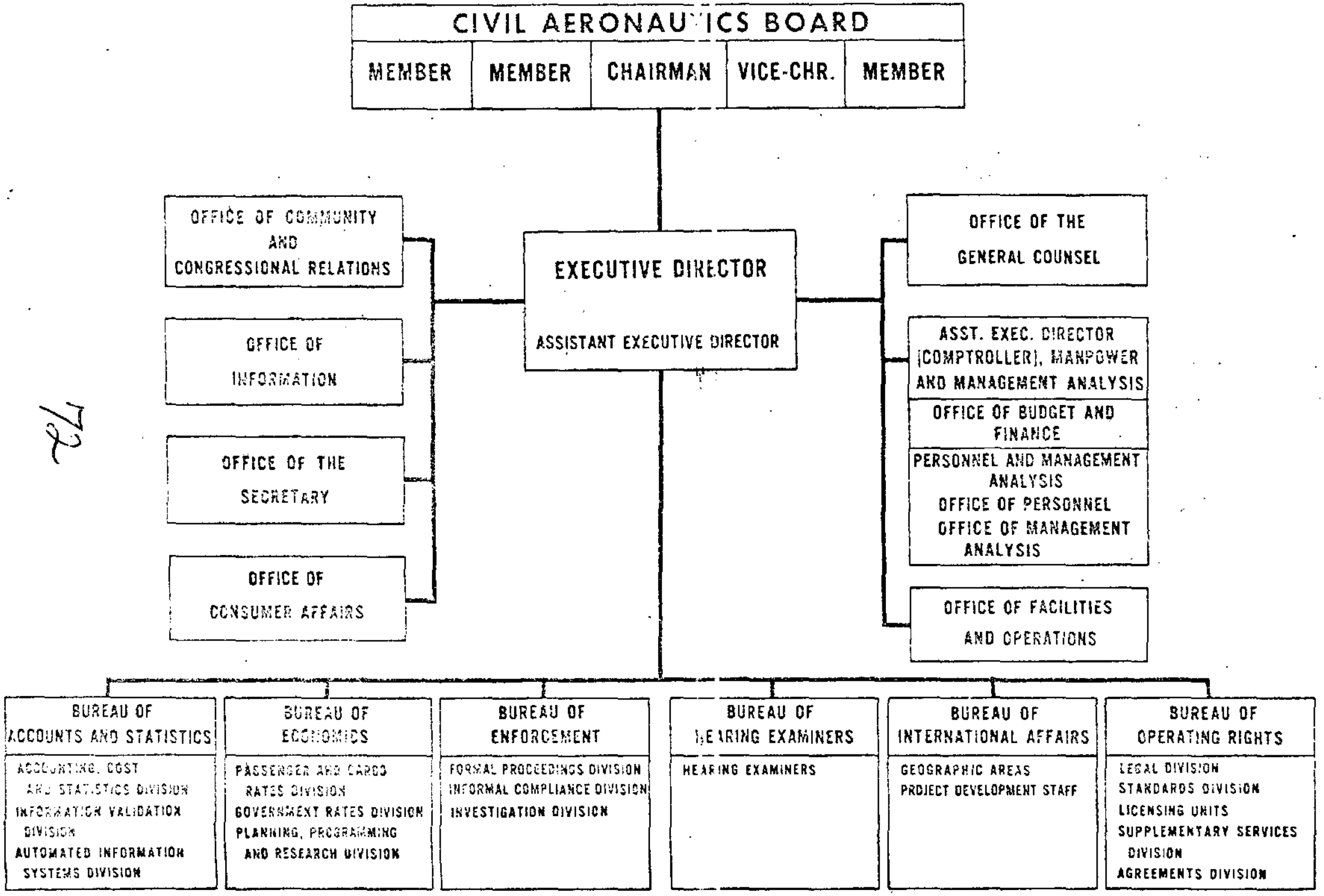

CIVIL AERONAUTICS BOARD
MEMBER
MEMBER
CHAIRMAN
VICE-CHR.
MEMBER
OFFICE OF COMMUNITY AND CONGRESSIONAL RELATIONS
OFFICE OF INFORMATION
OFFICE OF THE SECRETARY
OFFICE OF CONSUMER AFFAIRS
EXECUTIVE DIRECTOR
ASSISTANT EXECUTIVE DIRECTOR
OFFICE OF THE GENERAL COUNSEL
ASST. EXEC. DIRECTOR (COMPTROLLER), MANPOWER AND MANAGEMENT ANALYSIS
OFFICE OF BUDGET AND FINANCE
PERSONNEL AND MANAGEMENT ANALYSIS
OFFICE OF PERSONNEL
OFFICE OF MANAGEMENT ANALYSIS
OFFICE OF FACILITIES AND OPERATIONS
BUREAU OF ACCOUNTS AND STATISTICS
ACCOUNTING, COST AND STATISTICS DIVISION
INFORMATION VALIDATION DIVISION
AUTOMATED INFORMATION SYSTEMS DIVISION
BUREAU OF ECONOMICS
PASSENGER AND CARGO RATES DIVISION
GOVERNMENT RATES DIVISION
PLANNING, PROGRAMMING AND RESEARCH DIVISION
BUREAU OF ENFORCEMENT
FORMAL PROCEEDINGS DIVISION
INFORMAL COMPLIANCE DIVISION
INVESTIGATION DIVISION
BUREAU OF HEARING EXAMINERS
HEARING EXAMINERS
BUREAU OF INTERNATIONAL AFFAIRS
GEOGRAPHIC AREAS
PROJECT DEVELOPMENT STAFF
BUREAU OF OPERATING RIGHTS
LEGAL DIVISION
STANDARDS DIVISION
LICENSING UNITS
SUPPLEMENTARY SERVICES DIVISION
AGREEMENTS DIVISION

FIGURE 4

An Analysis of Airline Costs

Lecture Notes for MIT Courses

16.73 Airline Management and Marketing

Robert W. Simpson
Flight Transportation Laboratory, MIT

NASA-MIT Summer Workshop on Air Transportation
Waterville Valley, New Hampshire
July 1972

1.0 Introduction

Unlike most forms of public transportation, there is a good body of data describing the costs of providing air transportation services for U.S. domestic airlines. The source of this data is monthly and quarterly reports by US carriers to the CAB using the Uniform System of Accounts and Reports (Form 41). The existence of this data has made it possible for the air transport industry to study the costs of providing service and to introduce new, lower cost methods and equipment in a rational manner.

Historically, costs have been divided into two main categories : Direct Operating Costs, those directly associated with a transport aircraft's operation; and Indirect Operating Costs which are those not directly associated with an aircraft, but rather with an airline and its ground operations.

There are several formula for estimating direct operating costs. A common standard for turbine transports is the ATA 67 formula used by manufacturers to compare transport aircraft (Reference 3).

There is no standard formula for indirect operating costs although they represent roughly one half of the total operating cost and cannot be ignored in any study of air transportation systems. They must be constructed by the analyst for the airline system he is studying using whatever data is available. For new forms of air transportation this is a major difficulty.

The system of accounts used by air carriers to submit their costs to the CAB does not recognize the existence of direct and indirect groupings. It has its own classification scheme which we shall now briefly describe.

U.S. airlines are required to submit to the CAB on a quarterly basis their operating expenses, among other financial statistics, in accordance with the economic regulations of the CAB Uniform

System of Accounts and Reports (Form 41). The accounting provisions are different for route vs. supplemental carriers. Within the route carriers, domestic trunks and locals (Group III) are again distinguished from third level carriers (Groups I and II).

Each cost item in Form 41 is given a four-digit account number. The first two digits designate more general classifications. They are referred to as the functional classification. The last two digits are more detailed breakdowns. They are referred to as the objective classifications. A fifth digit, appended as a decimal, has been assigned for internal control by the CAB. It subdivides the objective classifications.

We include in here, for reference purposes, brief excerpts of the official definitions of the Functional classifications. Full descriptions of the Functional and Objective classifications can be found in Reference 4.

> 5100 Flying Operations
>
> This function shall include expenses incurred directly in the in-flight operation of aircraft and expenses attaching to the holding of aircraft and aircraft operational personnel in readiness for assignment to an in-flight status.
>
> 5200 Direct Maintenance
>
> This function shall include the costs of labor, materials and outside services consumed directly in periodic maintenance operations and the maintenance and repair of property and equipment of all types and classes, regardless of the location at which incurred.

5300 Maintenance Burden.

This function shall include all overhead or general expenses used directly in the activities involved in periodic maintenance operations and the maintenance and repair of property and equipment of all types and classes, including the cost of direct labor, materials and outside services used in the maintenance and repair of property and equipment.

5500 Passenger Service.

This function shall include all expenses chargeable directly to activities contributing to the comfort, safety and convenience of passengers while in flight and when flights are interrupted.

6100 Aircraft Servicing.

This function shall include the compensation of ground personnel and other expenses incurred on the ground incident to the protection and control of the in-flight movement of aircraft; scheduling or preparing aircraft operational crews for flight assignment; landing and parking aircraft; visual inspection, routine checking, servicing and fueling of aircraft; and other expenses incurred on the ground incident to readying for arrival and take-off aircraft.

6200 Traffic Servicing.

This function shall include the compensation of ground personnel and other expenses incurred on the ground incident to handling traffic of all types and classed on the ground subsequent to the issuance of documents establishing the air carrier's responsibility to provide air transportation. Expenses attributable to the operation of airport traffic offices shall also be included in this subfunction; expenses attributable to reservations centers shall be excluded. It shall include expenses incurred in both enplaning and deplaning traffic as well as expenses incurred in preparation for enplanement and all expenses subsequent to deplanement.

6300 Servicing Administration.

This function shall include expenses of a general nature incurred in performing supervisory or administrative activities relating solely and in common to functions 6100 Aircraft Servicing and 6200 Traffic Servicing.

6500 Reservations and Sales.

This function shall include expenses incident to direct sales solicitation, documenting sales, controlling and arranging or confirming aircraft space sold, and in developing tariffs and schedules for publication. It shall also include expenses attributable to the operation of city traffic offices.

6600 Advertising and Publicity.

This function shall include expenses incurred in creating public preference for the air carrier and its services; stimulating development of the air transport market; and promoting the air carrier or developing air transportation generally.

6800 General and Administrative.

This function shall include expenses of a general corporate nature and expenses incurred in performing activities which contribute to more than a single operating function such as general financial accounting activities and other general operational administration which are not directly applicable to a particular function.

7000 Depreciation and Amortization.

This function shall include all charges to expense to record losses suffered through current exhaustion of the serviceability of property and equipment due to wear and tear from use and the action of time and the elements, which are not replaced by current repairs, as well as losses in serviceability occasioned by obsolescence, supersession, discoveries, change in popular demand or action by public authority. It shall also include charges for the amortization of capitalized developmental and preoperating costs, and other intangible assets applicable to the performance of air transportation.

2.0 The Art of Cost Estimation

Before we describe in greater detail a classification system for airline costs, it is necessary to make a few observations on the nature of cost estimation. It is very much dependent upon the judgement of the cost analyst who must correctly apply the available data according to a given purpose or objective. To be correct, the cost analyst must understand the operations of the airline, and how the activities of the airline are measured, as well as how the costs are incurred and recorded.

The data source is usually a cost accounting process. This provides data on the cumulated expenses in various categories over a time period like a quarter, or year, and must be correlated by the analyst with cumulated measures of airline activity which he deems to be causing this expense. Different analysts will correlate a given cost with different measures of activity, or the same analyst may even use different activity measures in analyzing costs for different purposes.

2.1 Cost Functions

Here we shall attempt to provide an analytical framework for cost estimation to show some of its difficulties. We shall introduce the abstract concept of a cost function.

Cost functions attempt to relate the cost of some operation to the various component activities related to the operation. We may denote a cost function as $C_i(\bar{x},t)$

where C_i is the cost function for operation i, (dollars)
t is time variable
x is a vector of activity variables $(x_1, x_2, x_3,..x_n)$

Thus a cost function provides a time history of the cost of operation i as a function of the activities which are deemed to cause it. We rarely know with any confidence such an analytical expression for any cost function.

Typical measures of activity for airline operations are listed below:

P - passengers originated (or enplaned)
D - aircraft departures
RH - revenue aircraft block hours
RM - revenue aircraft miles
RPM - revenue passenger miles
ASM - available seat miles
RTM - revenue ton miles
ATM - available ton miles
R - revenue dollars

These are cumulative measures for the airline system over some time period similar to the cumulated expense and one expects that any cost function would be montonic if expressed in terms of these measures (i.e. the cumulated cost never decreases as the cumulative measures of activity increase.)

However, analysts commonly use ratios to "average" these cumulative measures, as an index of activity levels. Some of the common ratios are listed below:

$\bar{P} = \frac{P}{D}$ = average passengers per departure

$\bar{D} = \frac{RM}{D}$ = average aircraft stage length, or hop length

$\bar{d} = \frac{RPM}{P}$ = average passenger trip length (or hop length).

$\bar{T}_b = \frac{RH}{D}$ = average aircraft block time

$\bar{r} = \frac{R}{P}$ = average ticket price per passenger

$\overline{LF} = \frac{RPM}{ASM}$ = average passenger load factor

$\overline{LF} = \frac{RTM}{ATM}$ = Average overall ton-mile load factor

Cost functions will generally be "joint" functions of the activity variables, i.e. more than one variable is causing the expense in a certain category. Analysts generally find it necessary to represent the cost as a "separable" function, or to ignore the "jointness" and represent the costs as a function of a single activity variable. Thus, our general cost function is separated into components,

$$C_i(x_1,x_2) = C_i^1(x_1) + C_i^2(x_2)$$

where commonly only one component is said to exist.

The art of cost estimation occurs precisely at this point. The cost analyst must choose the form of the cost function he believes to exist. Having done so, he returns to the "science" of econometrics to use linear or non-linear multiple regression techniques to determine the coefficients and parameter which give a "best fit", or "best correlation" between the observed cost data, and the observed activity data. The analyst postulates cause and effect, and a circumstance of a good correlation does not verify his postulate, although this is often hopefully stated by inexperienced analysts. A result of good correlation is necessary, but not sufficient to verify this postulate.

2.2 Marginal and Unit Costs

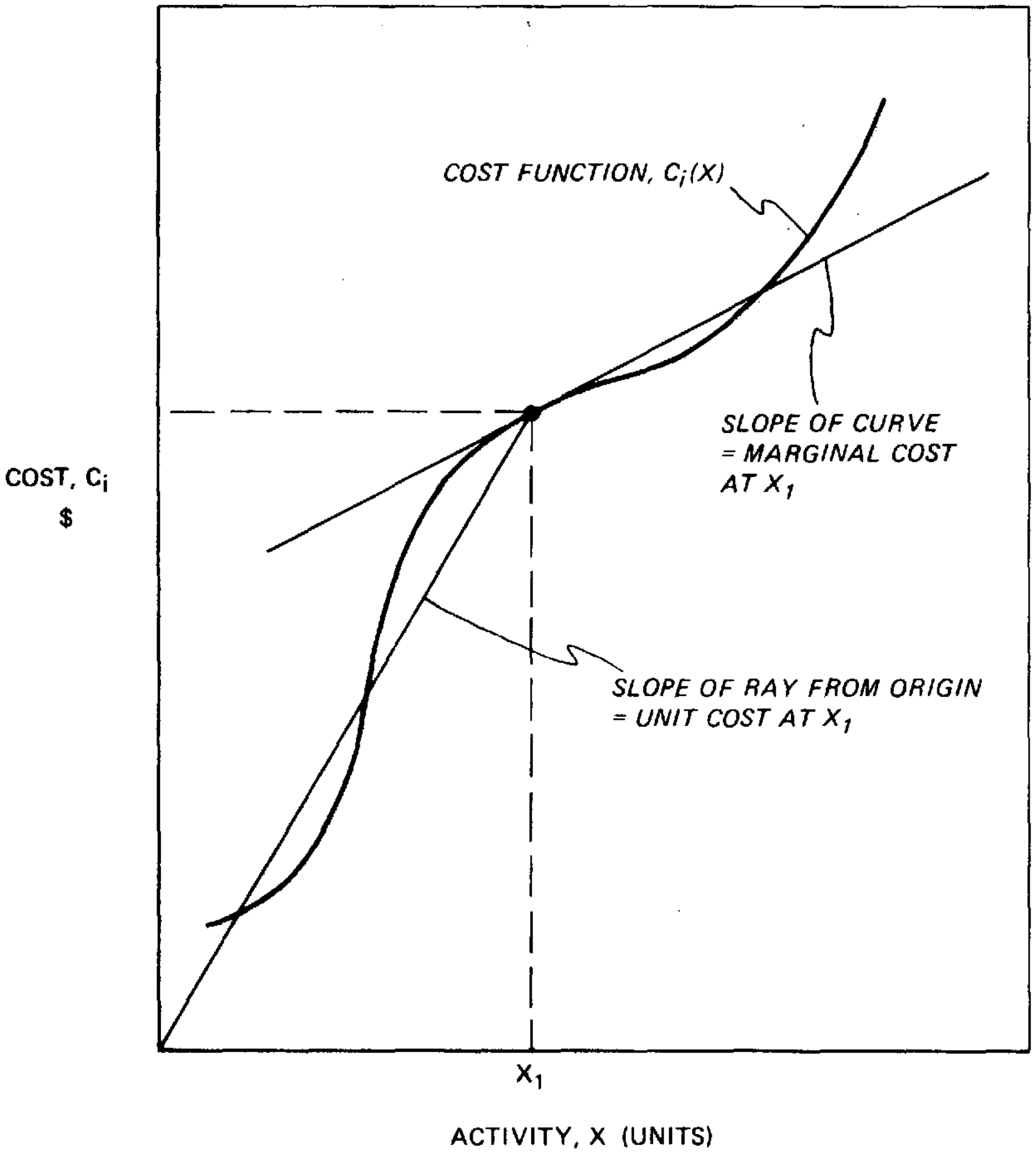
If we assume that we have a single component cost function, we can plot it against its activity variable as shown by figure 1. In this case, we may take the ratio of the cost to its activity at any point to form a "unit cost". Its value corresponds to the slope of the line from the origin to the cost curve as shown in figure 1, and obviously varies as the scale of operations changes, i.e. the unit cost is a function of x.

$$\text{Unit Cost} = c(x) = \frac{C(x)}{x}$$

There is another cost corresponding to the actual slope of the cost curve at any point. This is called the "marginal cost" and is also a function of the activity variable x.

$$\text{Marginal Cost} = c'(x) = \frac{\partial C(x)}{\partial x}$$

Figure 1 A SINGLE COMPONENT COST FUNCTION

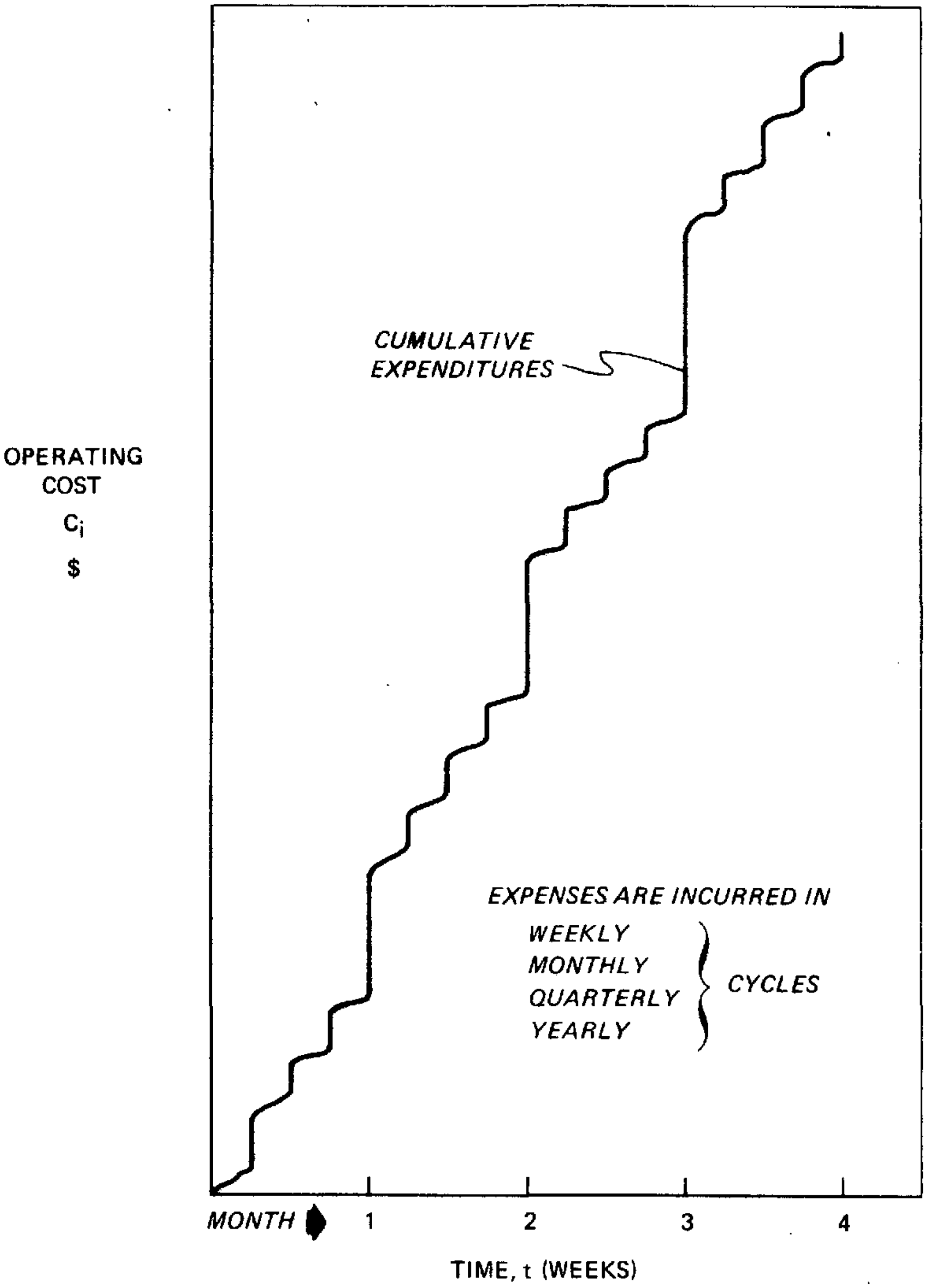


In general marginal costs do not equal unit costs.

The marginal costs also exist for a general cost function, and if known, would tell us the rate of change of cost as any activity variable is changed. If the general cost function is separable, then unit costs can exist for each component of the cost function. Notice that the unit costs represent an "average cost per unit", and thus are sometimes called average costs. We shall avoid that usage here, and refer to them as unit costs.

In a similar manner, costs may be plotted against time as shown in figure 2. The unit cost becomes the "long term" cost, while "short term" rates of expense may be determined by taking the slopes over shorter periods of time. Given a time frame for a cost analysis, the analyst regards short term costs as "variable" costs, and long term costs as "fixed" costs. The distinction of variable and fixed costs may also apply to other activity measures used in a given cost analysis, where only a certain portion of the costs are considered to be variable. Yet another cost concept is the distinction made between "sunk" and "recoverable" costs , where a large expense or investment made at some point in time is classified as to whether or not it could be recovered in some fashion.

Figure 2 VARIATION OF COST OVER TIME



3.0 Categorization of Airline Costs

We shall follow the categories of costs developed in reference 1, where:

a) Direct Operating Costs are designated Flight Operating Costs

b) Indirect Operating Costs are divided into two categories;

   1) Ground Operating Costs
   2) System Operating Costs

c) System Non-operating Costs are also identified.

Table 1 shows the major categories of this new cost structure. Instead of just direct and indirect categories, there are now four major categories. Table 2 gives a detailed breakdown of the operating cost categories showing a percentage of total operating costs for US domestic trunk airlines for each category and sub-category. Table 2 also indicates the time frame for the expense and some arbitrary allocations of the cost. A brief explanation of this cost categorization is given below:

a) Flight Operating Costs

These are usually known as direct operating costs, and are defined here to coincide with the definition used in reference 2, so that document can be used as a source of data. There is one exception where rental and flight insurance costs listed under Direct Flying Operations are transferred to a category called Flight Equipment Ownership. Flight Operating Costs are usually allocated against the flying hours of the airline fleet. Note that cabin crew expenses and interest costs of debt associated with aircraft ownership are not included, even though they are major cost items. On the other hand, a maintenance burden is included covering general administrative and overhead expenses for the airline maintenance shops.

b) Ground Operating Costs

This is a new group of costs which might be called direct ground operating costs. These costs are incurred at the station in handling passengers and aircraft, and are directly incurred

Table 1

A Breakdown of Airline Expenses

A. Flight Operating Costs - (FC)
- A.1 Direct Flying Operations
- A.2 Flight Maintenance
- A.3 Flight Equipment Ownership

B. Ground Operating Costs - (GC)
- B.1 Reservations and Sales
- B.2 Traffic Servicing
- B.3 Aircraft Servicing

C. System Operating Costs - (SC)
- C.1 System Promotional Costs
- C.2 Svstem Administrative Costs
- C.3 Ground Maintenance
- C.4 Ground Equipment Ownership

D. Total Operating Costs - (TOC) = Sum of A + B + C

E. System Non-Operating Costs - (SNC)
- E.1 Interest and Debt Expense
- E.2 Taxes

TABLE 2 - BREAKDOWN OF AIRLINE OPERATING COSTS

A = Allocation Frame
x = Expenditure Frame

	Allocation Transform	% TOC (1970)	Time Frame for Expenditure					
			$/ Pax.	$/ Dep.	$/ Hr.	$/ Mo.	$/ Yr.	$/ Rev.
A. FLIGHT OPERATING COSTS		55.7			A			
1. Direct Flying Operations		26.5			A			
Flt. Crew	Hrs./Mo.	13.5			A ←	x		
Fuel, Oil		13.0			x			
Other		-			A			
2. Flight Maintenance		15.5			A			
Direct Airframe + Other	Hrs./Dep.	4.6		x →	A,x			
Direct Engines	Hrs./Dep.	4.4		x →	A,x			
Burden	Hrs./Year	6.5			A ←		x	
3. Flight Equipment Ownership		13.6			A			
Depreciation Airframe + Other	Hrs./Year	8.2			A ←		x	
Depreciation Engines		1.7			A ←		x	
Obsolescence & Deterioration		0.4			A ←		x	
Flt. Equipment Rental		3.2			A ←		x	
Flt. Insurance		0.4			A ←		x	
B. GROUND OPERATING COSTS		23.8	A	A				
1. Reservations & Sales		8.3	A					
Personnel	Pax./Mo.	3.2	A ←			x		
Commissions	(Rev./Pax.)$^{-1}$	3.9	A ←					x
Other		1.2	A					
2. Traffic Servicing		8.2	A					
Personnel	Pax./Mo.	5.5	A ←			x		
Rentals	Pax./Year	0.7	A ←				x	
Other		1.1	A					
3. Aircraft Servicing		7.3		A				
Personnel	Dep./Mo.	4.0		A ←		x		
Landing Fees		2.0		x				
Other		1.2		A				
C. SYSTEM OPERATING COSTS		20.3						A
1. Promotional Costs		12.6						A
Passenger Flight Service	Rev./Pax., Rev./Mo.	10.2	x →			→ x →		→ A
Advertising & Publicity		2.4						x
2. Administrative Costs	Rev./Mo.	4.3				x →		→ A
3. Ground Maintenance		1.5						A
4. Ground Equipment Ownership	Rev./Year	1.9					x →	→ A

in providing the complete transportation service. They are best allocated against passengers enplaned, and aircraft departures although other allocations may be useful. Station administative costs are not listed here, but included as a system administrative expense later.

c) System Operating Costs

These costs are the old indirect operating costs remaining after ground operating costs are removed. They are not directly associated wtih supplying the transportation service, and are more of the nature of a system overhead expense. For example, Promotional costs are those spent to increase system revenues, and includes the onboard passenger service expenses of food and cabin crew. Administrative expenses are those of a general management of corporate nature for the complete airline system (except maintenance administration). The maintenance and ownership of ground property and equipment are minor categories included for completeness. System Operating costs may be allocated in an overhead manner against dollars of revenue.

d) Total Operating Costs

The sum of the above costs is called total operating cost.

e) System Non-Operating Costs

This is a new group of costs not normally considered by the old DOC-IOC breakdown. They are not associated with the operations of the compnay, but rather with its corporate existence. The interest expenses associated with corporate debt are substantial, and since most of the airline debt can be associated with new flight equipment, can be related to Flight Equipment Ownership for some analysis purposes. The taxation expenses are associated with corporate profit declaration, and is difficult to separate from the corporation.

The following sections will describe these cost categories in more detail.

4.0 Flight Operating Costs - FC

This grouping of costs is more generally known as "Direct Operating Costs". We shall use the basic definitions of the CAB source document (reference 2) with some minor rearrangements as described previously. These costs are long term, average costs for operating an aircraft. For shorter term operations, various categories of the costs should be dropped. For example, ownership costs, and maintenance burden costs are commonly deleted since they are long term costs spread over several years.

As indicated by Table 2, Flight Operating Costs are roughly 55% of total operating costs.

4.1 Flight Operating Costs per Block Hour, FC_{HR}

The basic cost measure for transport aircraft is the flight operating cost per block hour, FC_{HR}. It is a constant, independent of trip distance for a given aircraft and airline, and therefore provides a simple, useful description for comparing different aircraft in airline service

Another simple measure which is not widely used, but which is useful for comparing aircraft of different capacity is the flight operating cost per seat-hour, FC_{SHR}

$$FC_{SHR} = \frac{FC_{HR}}{Sa}$$

where Sa = available seats

A set of typical values of these measures for US transport aircraft is given in Table 3. Notice that FC_{SHR} varies between 4 to 6 \$/seat hour for both jet and turboprop transports, and that the helicopter costs are much higher.

A more detailed breakdown of these hourly costs is shown in Table 4 for the Boeing 727-100 in domestic service in 1969. The total cost

TABLE 3

Operating Costs Per Hour, Costs Per Seat Hour 1969

Aircraft Type A) Domestic Trunks	Fleet Size	Cost/Hr. ($)	Seats[1]	Cost/Seat Hr. ($)	Average Stage (miles)
B707-100	17	810.59	128	6.33	884
B707-100B	91	774.87	128	6.05	1156
B720	45.1	701.02	120.7	5.85	827
B720B	65.7	669.98	116	5.76	721
DC8-20	43.7	728.60	132.8	5.48	1180
DC8-50	43.3	691.00	134.5	5.14	936
DC8-61	35.5	754.76	196.2	3.85	1033
B727-100	275	564.46	95.6	5.90	508
B727-200	144.2	684.55	125.3	5.45	517
DC-9-30	132.4	439.63	89.3	4.93	298
DC-9-10	67.4	444.59	68.4	6.55	296
BAC-111-400	25.9	554.70	64	8.65	214
Electra	40	526.85	82.7	6.37	187
B-737	86.3	457.56	96.2	4.75	231
B) Local Service					
DC-9-30	50.7	396.64	96.5	4.10	230
CV-580	103.3	256.7	50.7	5.07	118
FH-227	47.1	227.26	44.6	5.09	109
C) Helicopters					
S-61	8	340.7	23.5	14.50	18
V-107 (1968)	4.3	575.3	24.6	23.60	13
C) STOL					
DHC-5 Twin Otter (Est.)		100.00	19	5.25	-

---

[1] Seats are averaged over aircraft miles performed in 1969.

Table 4

Flight Operating Costs per Block Hour for Boeing 727-100[1]

1.	Direct Flying Operations	- 283.63		
	-Flt. Crew		144.91	144.91
	-Fuel Oil		138.72	138.72
2.	Flight Maintenance	- 158.45		
	-Direct Airframe & Other		48.85	48.85
	-Direct Engine		43.00	43.00
	-Burden		66.30	
3.	Flight Equipment Ownership	- 122.15		
	-Depreciation Airframe & Other		69.77	
	-Depreciation Engines		14.46	
	-Obsolescence and Deterioration		1.78	
	-Flight Equipment Rental		26.75	
	-Flight Insurance		9.39	
4.	Long-Term Average Costs		564.46	
5.	Short-Term Average Costs (less Burden, Ownership Costs)			375.48

---

[1] Yearly average for Domestic Operations, 1969, 274 Aircraft in service from CAB Operating Cost and Performance Report, August 1970.

of 564 \$/hour is distributed roughly equally between crew, fuel, maintenance, and ownership. Thus, the sub-category, "Direct Operatio made up of fuel and crew accounts for roughly 50%, while the other two sub-categories are each 25%. If maintenance burden, and ownership costs are dropped, a short term or monthly operating cost of 375 \$/hour is obtained. A breakdown of hourly costs for the first six months of 1971 is given in Table 5 for various types of current transports and individual airlines. The costs vary quite widely. For the Boeing 727, they range from 593 to 856 \$/block hour with an average of 665 \$/block hour for this period. This range is due to factors such as wage rates, fuel cost variations, varying maintenance programs, and varying depreciation scheduled. The variation is significant enough to invalidate the use of any standard formula such as the ATA67 DOC formula when studying the operations of a particular airline system, or for return on investment calculations.

In recent years there has been a marked rate of increase of Flight Operating costs due to inflationary factors. Reference 5 is a good source of the trends in operating cost for jet transport aircraft in domestic service. Table 6 is extracted from it to show the effects of inflation on the flight operating costs for the Boeing 727. With this rate of growth in costs, it is necessary to also specify the year in studying the operations of the industry, or a given airline system.

The hourly operating cost FC_{HR} for a transport aircraft must be related to its hourly productivity, P_{HR} as measured in available seat miles per hour, or available ton miles per hour. A plot of FC_{HR} against available ton miles per hour is shown in figure 3 for aircraft in domestic trunk and local airline service for the year 1968. The flattening of the trend curve indicates a relative improvement in flight operating costs as productivity increases.

If we divide the hourly operating costs by the productivity measured in available ton-miles per hour, we obtain a value of DOC, direct operating cost in terms of dollars per available ton mile. A

TABLE 5

First Six Months of 1971

(Dollars per Block Hr.)	Total Block Hours	DIRECT EXPENSES				Maint. Burden	Total Aircraft Expense
		Flying Operations	Direct Maint.	Deprec. & Rentals	Total		
Boeing 727							
United	214,550	356	76	137	569	82	651
Eastern	186,238	349	99	120	568	74	642
American[1]	157,712	349	98	134	581	106	687
TransWorld	101,153	353	80	165	598	102	700
National	61,419	310	97	130	537	56	593
Braniff	59,041	329	103	125	557	40	597
Northwestern	58,529	340	68	230	638	34	672
Continental	38,523	345	106	101	552	72	624
Northeast	34,010	347	115	178	640	86	726
Pan American	29,225	392	123	196	711	131	842
Western	9,159	346	95	203	644	37	681
Alaska	8,527	428	162	196	786	42	828
Airlift	5,194	376	154	179	709	42	751
Frontier	5,058	361	168	179	708	61	769
Allegheny	3,355	457	64	264	785	71	856
727 Average	971,693	349	93	144	586	79	665
Douglas DC-9							
Delta	143,573	235	55	102	392	49	441
Eastern	132,576	270	74	108	452	55	507
Allegheny	46,901	271	71	107	449	43	492
Air West	31,307	278	100	123	501	27	528
Continental	30,427	221	89	94	404	62	466
Southern	24,950	236	94	111	441	26	467
Ozark	24,344	241	95	132	468	27	495
TransWorld	22,610	291	80	143	514	91	605
Texas Int'l.	22,410	236	92	115	443	29	472
North Central	21,403	254	75	113	442	44	486
Northeast	19,071	263	92	120	475	71	546
Hawaiian	8,515	305	116	211	632	59	691
Caribair	3,529	418	150	237	805	56	861
DC-9 Average	531,616	255	76	113	444	49	493
Boeing 737							
United	72,953	339	62	116	517	72	589
Western	40,688	264	110	105	479	43	522
Piedmont	17,820	254	78	95	427	39	466
Frontier	15,558	251	124	148	523	47	570
Aloha	4,593	300	120	189	609	77	686
Wien Consl.	3,635	401	114	190	705	74	779
737 Average	155,247	301	86	118	505	58	563
BAC 111							
American	21,068	269	81	216	566	91	657
Mohawk	13,632	250	76	94	420	52	472
Braniff	13,588	211	90	86	387	40	427
111 Average	48,288	247	82	145	474	66	540

Table 5 (continued)

(Dollars per Block Hr.)	Total Block Hours	DIRECT EXPENSES				Maint. Burden	Total Aircraft Expense
		Flying Operations	Direct Maint.	Deprec. & Rentals	Total		
Boeing 747							
Pan American	37,862	818	156	647	1621	164	1785
TransWorld	29,917	634	239	510	1383	134	1517
American	21,254	698	294	695	1687	132	1819
United	16,052	838	218	600	1656	180	1836
Northwest	15,566	724	131	519	1374	71	1445
Delta	7,312	880	165	493	1538	197	1735
Continental	6,103	803	421	377	1601	72	1673
Eastern	4,319	768	536	1995	3299	51	3350
National	3,420	810	256	561	1627	148	1775
Braniff	1,760	1051	312	687	2050	48	2098
747 Average	143,565	758	226	626	1610	137	1747
Douglas DC-8							
United	177,331	462	88	204	754	96	850
Delta	77,463	420	102	176	698	110	808
Eastern	54,238	488	158	230	876	112	988
National	36,425	410	122	106	638	67	705
Flying Tiger	31,725	538	134	229	901	82	983
Seaboard	19,169	477	126	214	817	45	862
Braniff	13,461	490	97	270	857	38	895
Airlift	8,562	551	159	387	1097	43	1140
American	6,133	517	131	318	966	61	1027
Pan American[1]	3,596	741	311	31	1083	14	1097
DC-8 Average	428,103	465	112	202	779	91	870
Boeing 707							
TransWorld	196,514	434	89	170	693	97	790
Pan American[1]	170,538	480	99	194	773	124	897
American	167,564	434	83	184	701	99	800
Northwest[1]	46,417	450	84	242	776	51	827
Continental	22,417	463	142	173	778	109	887
Braniff	17,830	449	137	162	748	58	806
Western	10,056	540	121	162	823	47	870
Alaska	645	415	144	159	718	28	746
Airlift	210	260	236	223	719	72	791
707 Average	632,191	451	94	185	730	100	830
Boeing 720							
Western	47,147	391	139	179	709	55	764
United	41,331	428	73	153	654	85	739
Continental	13,056	338	136	130	604	104	708
Pan American	10,238	420	112	192	724	126	850
American	9,850	392	126	387	905	169	1074
Northwest	9,011	379	80	341	800	47	847
Braniff	8,530	392	204	77	673	116	789
720 Average	139,163	398	116	187	701	85	786
Convair 880							
TransWorld	31,882	413	132	190	735	143	878
Delta	29,361	381	135	48	564	143	707
880 Average	61,183	398	134	121	653	143	796

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[1] Data for Trans Caribbean included with American.

plot of this value is shown in figure 4, and clearly demonstrates the superiority of the more productive aircraft in terms of unit costs.

4.2 Flight Operating Costs per Trip

The hourly cost, FC_{HR} is a basic and convenient cost measure for transport aircraft. A more precise formulation for analytic purposes is provided by the trip cost measures; FC_{AT}, flight operating cost per aircraft trip, and FC_{ST}, flight operating cost per seat trip.

Flight Cost per aircraft trip, FC_{AT} always turns out to be a linear function of distance, d.

$$FC_{AT} = c_1 + c_2 \cdot d$$

so that knowledge of the two coefficients c_1 and c_2 is sufficient to accurately describe the cost performance of any transport aircraft. Because the variation of fuel costs is not proportional to block time, and since fuel costs may vary with the particular climb-cruise schedule used for a given aircraft, it is not possible to simply multiply the hourly costs by the block time to obtain a precise measure of trip costs.

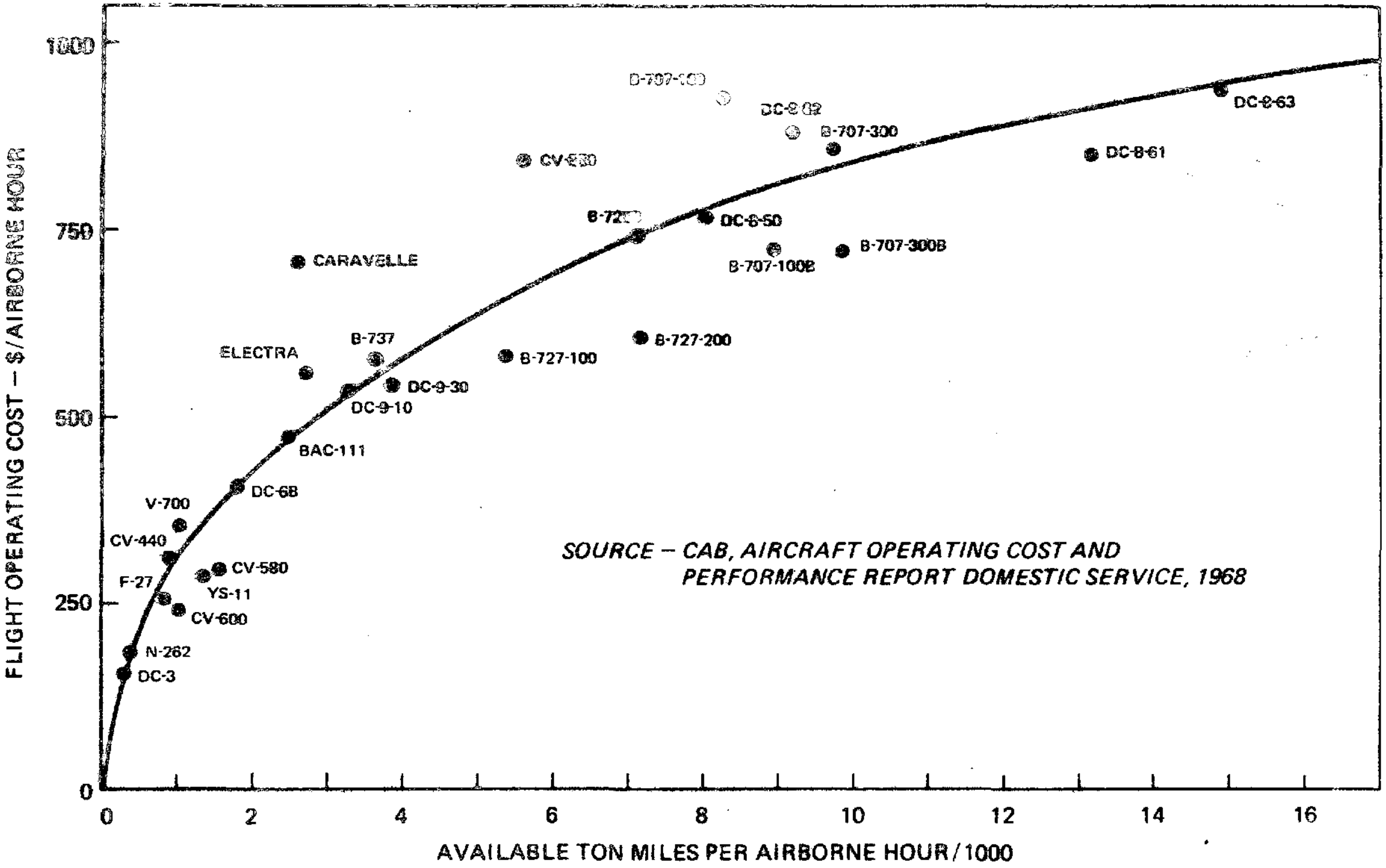
For purposes of determining minimum cost flight plans, where varying climb-cruise profiles and schedules may be used, it is sometimes useful to represent trip costs in the following form:

$$FC_{AT} = \text{Time Costs} + \text{Fuel Costs}$$

where the time costs are computed using a short term hourly cost for crew, maintenance, and perhaps ownership, and fuel costs are computed for a given mission profile.

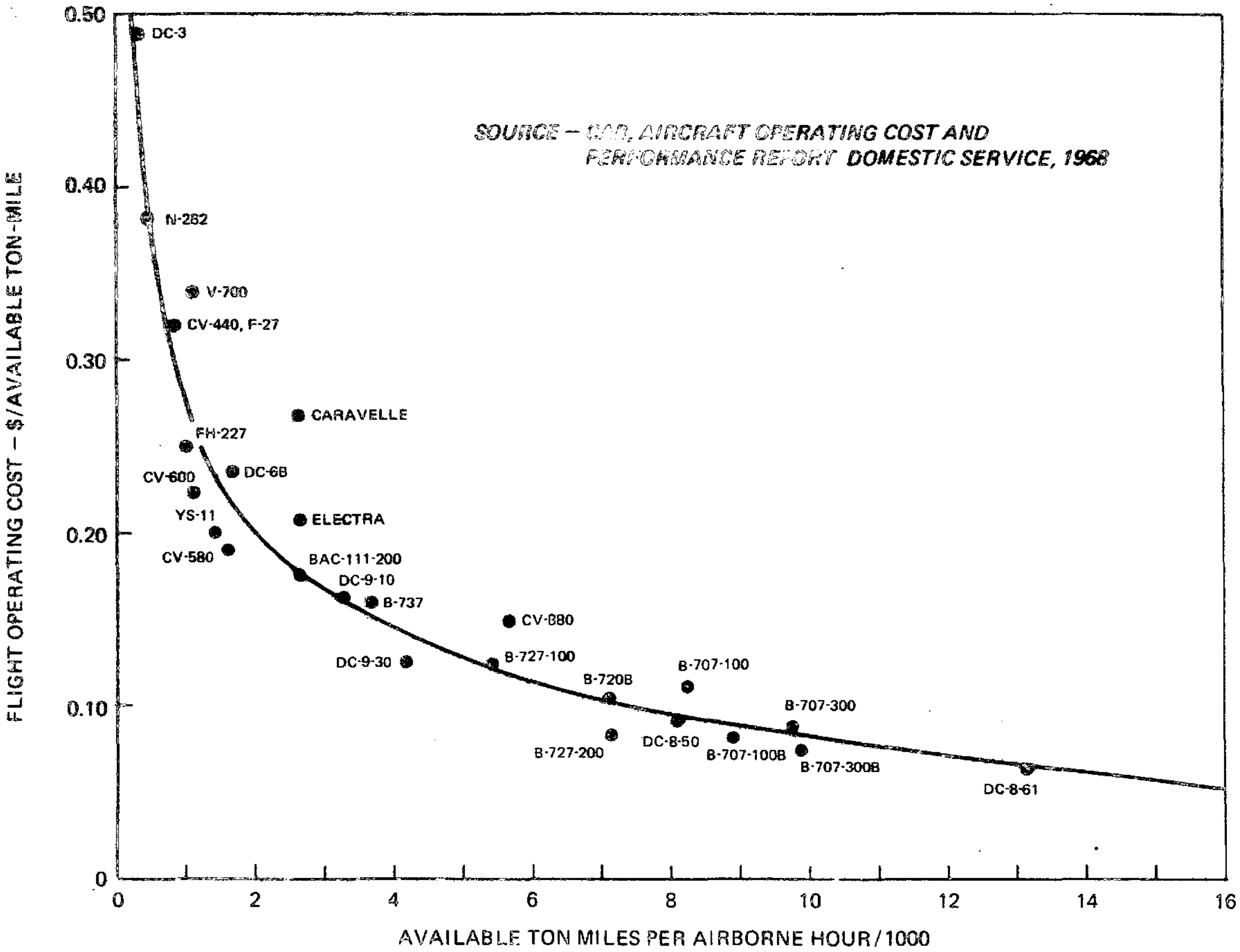
It is useful to also define the trip costs per available seat FC_{ST}. Since Sa, the available seats is not constant after design range, this cost measure will have a linear form up to design range, and a non-linear variation after design range. The traditional DOC curves can be derived from FC_{ST} by dividing by the trip distance. The variation

Figure 3 FLIGHT OPERATING COST PER HOUR VERSUS HOURLY PRODUCTIVITY



SOURCE – CAB, AIRCRAFT OPERATING COST AND PERFORMANCE REPORT DOMESTIC SERVICE, 1968

Figure 4 FLIGHT OPERATING COSTS PER AVAILABLE TON MILE VERSUS HOURLY PRODUCTIVITY



SOURCE – CAB, AIRCRAFT OPERATING COST AND PERFORMANCE REPORT DOMESTIC SERVICE, 1968

Table 6

Trends in Flight Operating Cost per Block Hour, B-727 Domestic

Year	Flying Operations		Maintenance $	Ownership $	Total FC_{HR} $
	Crew	Fuel			
1964	108	121	121	161	512
1965	121	129	147	139	539
1966	128	127	171	138	566
1967	123	130	159	121	535
1968	133	132	152	121	539
1969	140	141	143	130	556
1970	160	146	168	147	622

of these cost curves with trip distance is shown in Figure 5 for the B727 in domestic service in 1969. Notice the strong variation in the unit costs measure, DOC, before it flattens out around full design range.

4.3 Average Flight Costs

Suppose we have an aircraft operating over a given set of trips (or hops, or stages) within an airline system. We want to compute measures of average flight operating costs over this set of trips.

If there are N trips with n(x) trips at a particular distance, x, then we may denote a probability density function, $f(x) = \frac{n(x)}{N}$ to describe the distribution of trip distances within the set of trips.

The average trip distance, $\overline{d}$, is given by

$$\overline{d} = \int_0^\infty x \cdot f(x) \cdot dx$$

where $$1.0 = \int_0^\infty f(x) \cdot dx$$

Now, the flight operating costs per trip can be expressed as a linear function of trip distance, x

$$FC_{AT} = c_1 + c_2 \cdot x$$

The average flight cost per trip, $\overline{FC}_{AT}$, becomes

$$\overline{FC}_{AT} = \int_0^\infty (c_1 + c_2 x) \cdot f(x) \cdot dx$$

$$= c_1 + c_2 \cdot \overline{d}$$

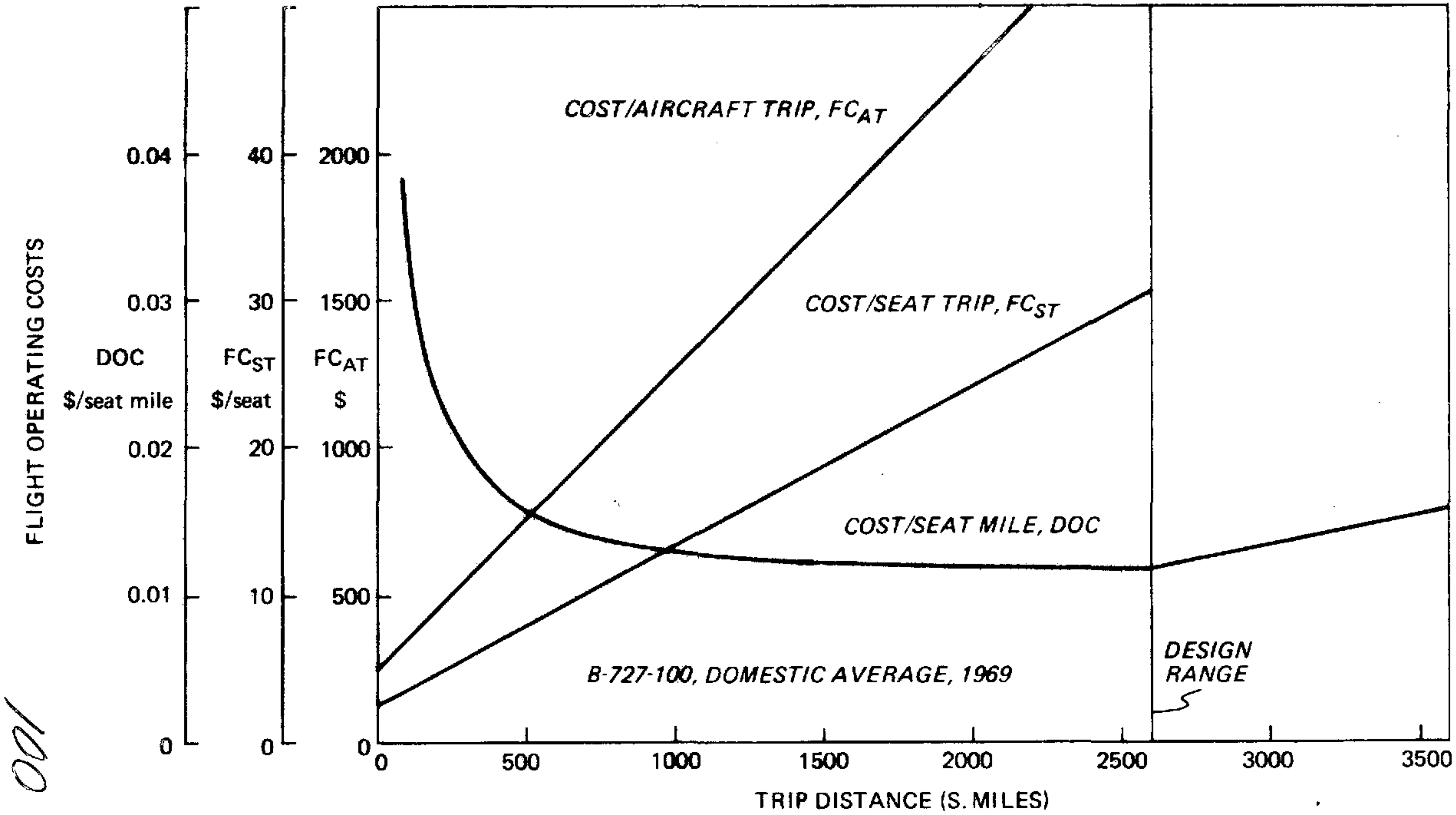
i.e., the average flight cost per trip is exactly the flight cost at the average trip distance.

Now, the total flight operating cost over the set of trips, FC is given by:

$$FC = N \, \overline{FC}_{AT}$$

and the total mileage of the set of trips, M;

Figure 5 VARIATION OF FLIGHT OPERATING COSTS WITH TRIP DISTANCE



$$M = N \cdot \overline{d}$$

so that the average flight operating cost per seat mile (if we assume that S seats are available on all trips) becomes:

$$DOC_{AV} = \frac{FC}{M} = \frac{N \cdot \overline{FC}_{AT}}{N \cdot \overline{d} \cdot S} = \frac{c_1 + c_2 \cdot \overline{d}}{\overline{d} \cdot S}$$

$$= \frac{1}{S} \left[\frac{c_1}{\overline{d}} + c_2 \right]$$

$$= DOC\ (\overline{d})$$

i.e., the average direct operating cost over the set of trips is exactly the direct operating cost at the average distance.

These two properties are a result of the linear form of trip costs with trip distance.

Notice, however, that if we average DOC values over a set of trips, we do not get the value of DOC_{AV} since DOC(x) is non-linear in x;

$$\overline{DOC} = \frac{1}{S} \int_0^{\infty} \left[\frac{c_1}{x} + c_2 \right] \cdot f(x) \cdot dx$$

so $\overline{DOC} \neq DOC(\overline{d}) \neq DOC_{AV}$

The value $\overline{DOC}$ is a useless quantity, and it is a mistake to compute it. The useful quantity is $DOC(\overline{d})$, the direct operating cost at the average trip distance.

5.0 Ground Operating Costs

This group of operating costs are incurred on the ground in preparation and termination of the trip. They are zero-distance, or "terminal" costs as opposed to "line-haul" costs, although it may be argued that there is more preparation for a longer haul trip.

As indicated by Table 2, Grand Operating Costs are roughly 25% of total operating costs, broken down into roughly equal categories of 8% each for reservations and sales, traffic servicing, and aircraft servicing. A particular airline would use its own costs over the system, or perhaps for each station in its system. Notice that these costs are relatively independent of the type of aircraft

5.1 Measures of Airline Activity

Statistics on measures of activity for domestic airlines for the last quarter of 1970 are given in Table 7. Some selected activity indices are also presented.

While more detailed cost allocations may often be made using various appropriate measures of airline activity, here we shall allocat ground operating costs against passengers originated, and aircraft departures performed for the complete domestic industry. There may be significant variation from these unit costs for a particular airline or station.

5.2 Ground Operating Costs per Passenger, GC_p

For reservations and sales, the unit cost for the last quarter of 1970 is 4.96 \$/passenger originated. For traffic servicing, it is 4.80 \$/passenger originated. The total is defined as ground operating cost per passenger,

$$GC_p = 9.76 \text{ \$/passenger}$$

5.3 Ground Operating Costs per Aircraft Departure, GC_D

The costs per aircraft departure cover the arrival of the plane (and its landing fees), its servicing, and its start up and departure. Dividing the costs reported for the last quarter of 1970 by the number departures gives a unit cost value

$$GC_D = 178.30 \text{ \$/aircraft departure}$$

TABLE 7. ACTIVITY MEASURES, DOMESTIC AIRLINE INDUSTRY

(last quarter, 1970)

Activity Measures

RPM $= 22.76 \times 10^9$ revenue passenger miles

P $= 29.0 \times 10^6$ revenue passenger originated

RTM $= 2.97 \times 10^9$ revenue ton miles

RH $= 0.993 \times 10^6$ revenue aircraft block hours

D $= 0.720 \times 10^6$ revenue aircraft departures

R $= 1.50 \times 10^9$ revenue dollars

Indices of Activity

$\bar{d}$ = 784 (s. miles) - average passenger trip length

$\bar{p}$ = 40.3 (passengers) - average passengers per departure

$\bar{r}$ = 51.7 (dollars) - average ticket price

$\bar{T}_b$ = 1.37 (hours) - average block hours per departure

$\bar{R}$ = 2083 (dollars) - average aircraft revenue per departure

6.0 System Operating Costs

This group of costs is a system wide set of costs of an overhead nature. It is rougly 20% of total operating costs as may be seen from Table 2. Promotional costs are roughly one half of this group, with the remainder split equally between general and administrative and the costs of owning and maintaining ground equipment.

While these costs may be allocated against a variety of airline activity measures, here we shall simply allocate against the revenue dollar as an overhead costs. Again, note that these costs are independent of the types of aircraft used in the airline system.

6.1 System Operating Costs, SC

Using the data for the domestic industry for the last quarter of 1970 once again, we obtain the following costs in terms of dollars per dollar of revenue:

Promotional Costs -	
Passenger Service	- 0.112
Advertising	- 0.025
TOTAL	0.137
General and Administrative	- 0.043
Ground Equipment	
Maintenance	- 0.015
Ownership	- 0.019
TOTAL	0.034

Combining these expenses, we form an overall system cost SC,

$$SC = 0.220 \qquad \$/\text{revenue dollar}$$

7.0 Trip Costs

We now combine the Flight Operating Costs and the Ground Costs and the Ground Costs per aircraft departure to form a cost per aircraft trip, TC_{AT};

$$TC_{AT} = FC_{AT} + GC_D$$

Also, we shall define the trip costs per available seat;

$$TC_{ST} = FC_{ST} + \frac{GC_D}{S_a}$$

$$= FC_{ST} + GC_{ST}$$

where GC_{ST} = ground operating costs per seat departure.

These trip cost measures combine the aircraft related costs; Flight Operating Costs, and Aircraft Servicing costs. The trip cost per available seat, TC_{ST}, is useful for comparison with fares or yields in a later section.

For example, if we use the industry averages for 1970 for a Boeing 727-100;

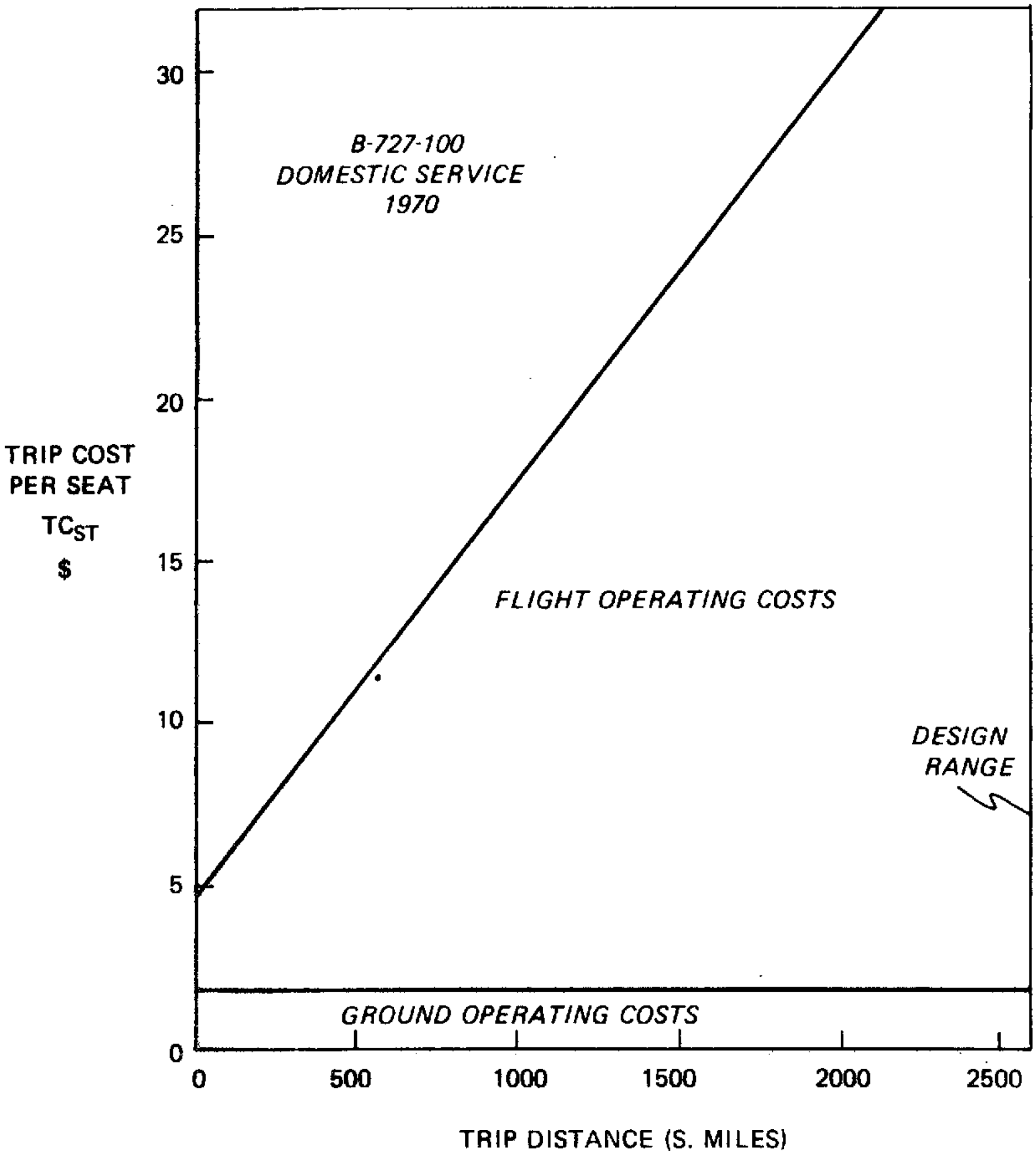
$FC_{ST} = 2.85 + .0121d$ $/seat trip

$GC_{ST} = \frac{178.30}{96} = 1.86$ $/seat departure

Therefore, $TC_{ST} = 4.71 + .0121d$

The variation of trip costs with distance is shown by figure 6. Notice that the ground operating costs are small compared to flight operating costs, and that the cost levels seem very low, e.g. the cost per seat for a 1000 mile trip is only $16.80.

Figure 6 VARIATION OF TRIP COST/SEAT WITH TRIP DISTANCE



8.0 Fares, Yields, and Net Yields

We shall now turn our attention to the variation of airline trip income per passenger with trip distance.

8.1 Domestic Airline Fare Structure, F

Unlike other forms of common carrier passenger transportation (except perhaps taxis) the domestic airline fare structure has a zero distance charge as airlines have attempted to recover the cost of these ground operations. Over the past twenty years, thus zero distance intercept has grown from zero to 9 dollars with a recent CAB examiner's recommendation that it be raised still further to 12 dollars.

In 1967, a CAB regression of coach fares versus trip distance found an extremely good fit for the following formula:

Coach Fares, $F_c = 6.40 + .057d$ dollars

In 1969, at the insistence of the CAB on basing fares on airport to airport distances, the following formula was adopted for coach fares as part of a general industry fare increase:

$$\begin{aligned} F_p = 9.00 &+ .060\ d_1 \\ &+ .056\ d_2 \\ &+ .052\ d_3 \\ &+ .050\ d_4 \\ &+ .048\ d_5 \end{aligned}$$

where $0 \leq d_1 \leqslant 500$ s.miles

$501 \leqslant d_1 + d_2 \leqslant 1000$

$1001 \leqslant d_1 + d_2 + d_3 \leqslant 1500$

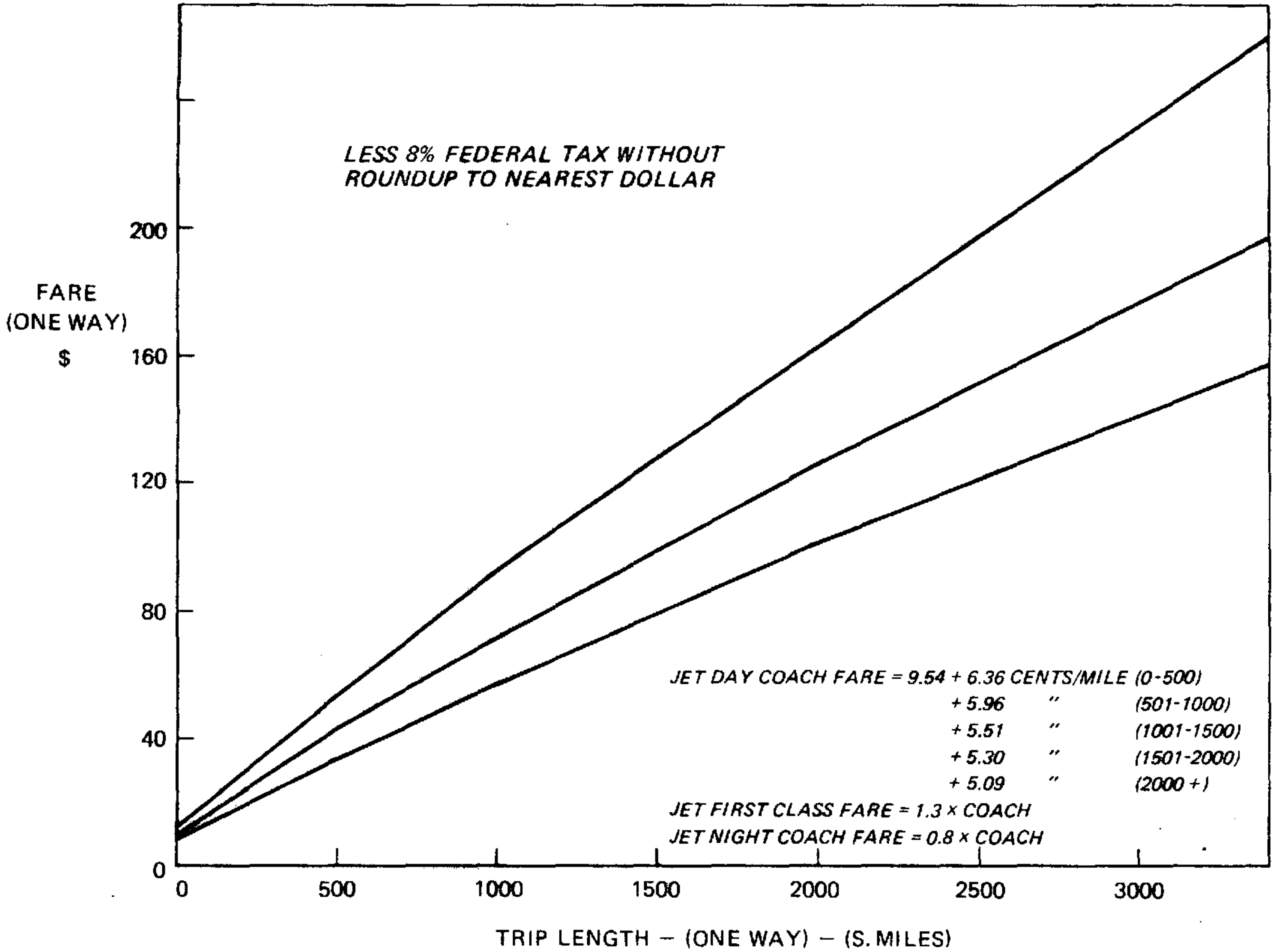
$1501 \leqslant d_1 + d_2 + d_3 + d_4 \leqslant 2000$

$2001 \leqslant d_1 + d_2 + d_3 + d_4 + d_5$

As part of this decision, first class fares, F_f were to be 1.25 times the coach fares. There was an 8% government tax applied, and then fares were rounded up to the nearest dollar.

In 1971, a further general increase of 6% in coach fares was allowed, with first class being set at 1.3 times coach fare, and night coach

Figure 7 CURRENT FARE FORMULAE, US DOMESTIC FARES, 1971-72



LESS 8% FEDERAL TAX WITHOUT ROUNDUP TO NEAREST DOLLAR

JET DAY COACH FARE = 9.54 + 6.36 CENTS/MILE (0-500)
+ 5.96 " (501-1000)
+ 5.51 " (1001-1500)
+ 5.30 " (1501-2000)
+ 5.09 " (2000 +)
JET FIRST CLASS FARE = 1.3 × COACH
JET NIGHT COACH FARE = 0.8 × COACH

fares at 0.8 times coach fare. The round up rule was retained. Figure 7 shows the current fare formulae versus distance for the basic fares before the 8% tax and rounding up to the nearest dollar. The domestic fare investigation has ended and a further change is expected before the end of 1972.

8.2 Yield per Passenger, Y_p

While the fare structure seems to determine airline revenues very explicitly, the actual airline revenue for a given city pair is the result of the traffic which moves at a mix of regular fares (coach, first class, night coach), and a variety of discount fares (½ fare student, military standby, Family Plan, excursion fares, etc). A value for yield on a route is obtained by the airline by dividing the actual revenues from the route by the number of tickets sold, i.e. yield is the average ticket price (exclusive of tax).

Thus, the yield values need not fit an explicit distance formula like the fares, and indeed may vary over month of the year for a given route. However, there is generally a good linear variation with trip distance. We shall represent this by a yield formula,

$$Y_p = Y_1 + Y_2 \cdot d$$

The value of Y_p generally has been below the level for standard coach fares in recent years, where a great number of travellers have begun to use the discount fares. It may be as much as 15% below coach in tourist markets.

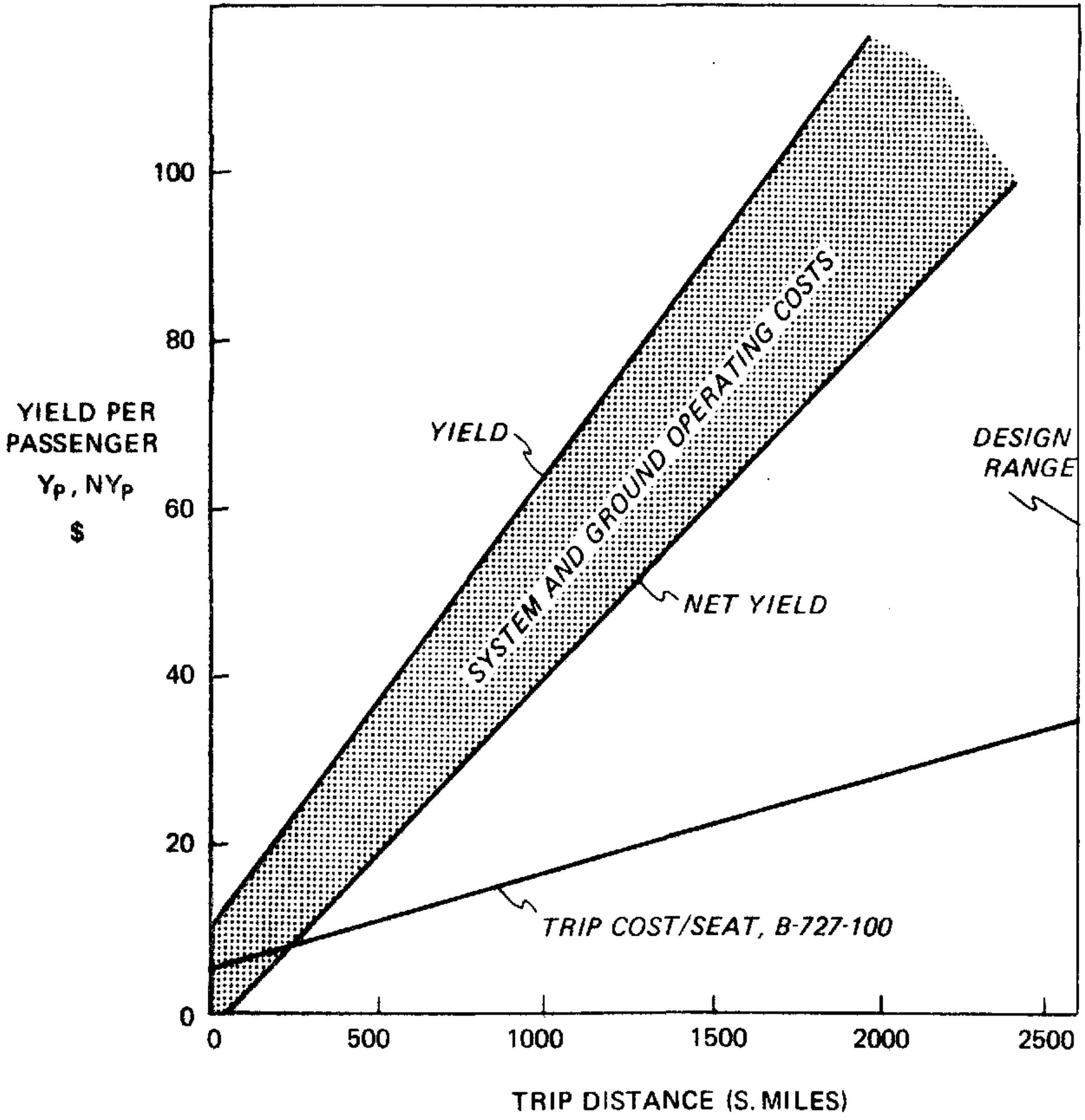
Thus, as well as forecasting the number of travellers in a given market, an estimate must be made of the breakdown of traffic moving at different fares to forecast the yield, and the future expected airline revenue.

8.3 Net Yield, NY_p

We shall define net yield here by combining the yield with the ground operating costs per passenger and the system operating costs per dollar of revenue:

$$NY_p = (1 - SC) \cdot Y_p - GC_p$$

Figure 8 YIELDS AND COSTS VERSUS TRIP DISTANCE



Since the system costs, SC, have been treated as an overhead cost, they further decrease the yield values before we subtract off the cost per passenger for reservations and sales, and traffic servicing. The value of net yield then represents a net income per passenger to be compared with the trip cost per seat from the flight and ground operations of the aircraft.

For example, if we assume a yield formula for 1970,

$Y_p = 9.00 + .055\ d$

with $SC = 0.23$

and $GC_p = 9.76$ \$/passenger.

Then, net yield per passenger becomes

$NY_p = -2.63 + .0423\ D$ dollars/passenger

Notice the negative value of net yield per passenger for distances less than 60 miles! Ground operating costs are higher than the zero distance intercept of the assumed yield formula (or the coach fare formula)

The relationship of yield,and net yield per passenger to trip cost per seat is shown against trip distance in figure 8. Notice that net yield per passenger and trip cost per seat cross around 250 miles, and that there is a large excess of net yield over trip costs as trip distance approaches full design range.

///

9.0 Trip Income and Breakeven Load Factor

We are now in a position to compare the net yield per passenger and trip cost per seat to determine income per aircraft trip, income per seat trip, and the breakeven load or load factor for an aircraft trip.

9.1 Income per Aircraft Trip

If the number of passengers on a given aircraft trip is denoted by P_{AT}, then the income per aircraft trip, I_{AT} is given by;

$$I_{AT} = NY_p \cdot P_{AT} - TC_{AT}$$

If the number of passengers required to breakeven is denoted by P_{ATB}, then when $I_{AT} = 0$,

$$P_{ATB} = \frac{TC_{AT}}{NY_p}$$

9.2 Breakeven Load Factor

If we denote the load factor, LF, as the ratio of passenger load to S, seats available at less than design range.

$$LF = \frac{P_{AT}}{S}$$

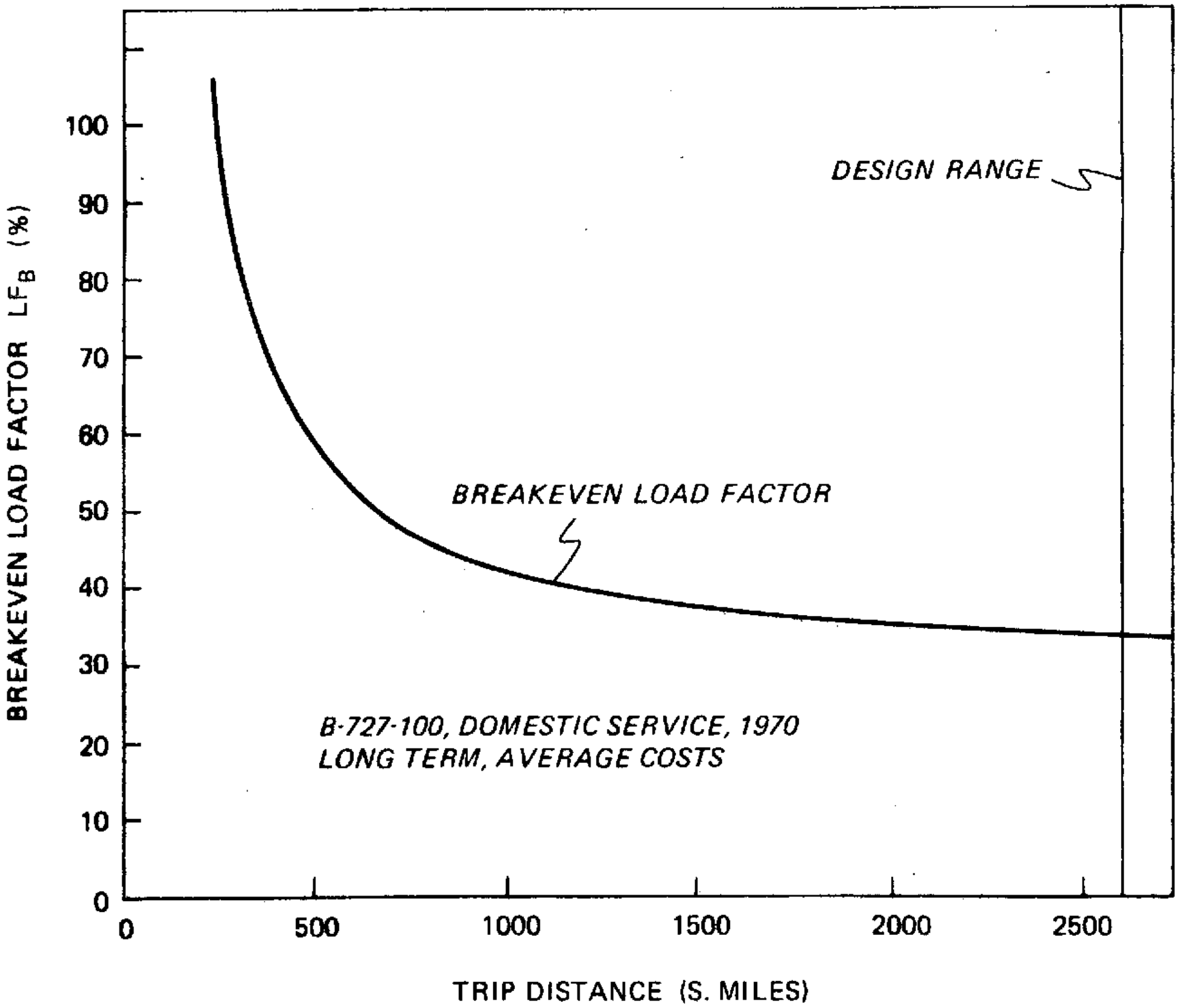
Then the breakeven load factor, LF_B

$$LF_B = \frac{P_{ATB}}{S} = \frac{TC_{ST}}{NY_p}$$

i.e. the breakeven load factor equals the ratio of trip cost per seat to net yield per passenger.

A plot of breakeven load factors for the B-727-100 in domestic service in 1970 is shown in figure 9. Because of the crossover of net yield per passenger and trip cost per seat, there usually is a large variation in LF_B with trip distance. It is over 100% at distances less than 250 miles, and reduces to 35% or less at long ranges. Notice that since we have defined load factor based on total seats, it does not break upwards after design range.

Figure 9 VARIATION OF BREAKEVEN LOAD FACTOR WITH TRIP DISTANCE



Because the variation of net yield and trip cost are linear with distance, the average breakeven load factor for a set of trips is the breakeven load factor at the average trip distance. Thus, for the B-727-100 in domestic service in 1970, the average stage distance was 500 miles where the breakeven load factor was 58%.

9.3 Income Per Seat Trip

We can also define the income per seat trip, I_{ST} as a very simple function of the actual load factor and breakeven load factor;

$$
\begin{aligned}
I_{ST} = \frac{I_{AT}}{S} &= \frac{1}{S}\left(NY_p \cdot P_{AT} - TC_{AT}\right) \\
&= NY_p \cdot \frac{P_{AT}}{S} - TC_{ST} \\
&= NY_p \cdot LF - NY_p \cdot LF_B \\
&= NY_p (LF - LF_B)
\end{aligned}
$$

Therefore, the income per seat trip is some fraction of the net yield per passenger, where the fraction is the difference between actual and breakeven load factor. This fraction shows the leverage of every point in achieved average load factor in increasing the airline trip income.

References

1. A Structure for Airline Operating Costs, FTL Technical Memo 71-9, Y.P. Chan, R.W. Simpson.
2. Aircraft Operating Costs and Performance Report, Bureau of Accounts and Statistics, CAB, Washington, D.C.
3. Standard Method of Estimating Comparative Direct Operating Costs for Turbine Powered Transport Airplanes - ATA, December 1967.
4. Uniform System of Accounts and Reports for Certified Air Carriers, US Civil Aeronautics Board
5. Domestic Jet Trends, First Edition, CAB, April 1972.
6. Direct Exhibits of Bureau of Economics, Phase 9, Fare Structure, Domestic Passenger Fare Investigation, November 1970, CAB.

The ATA-67 Formula for Direct Operating Cost

H.B. Faulkner

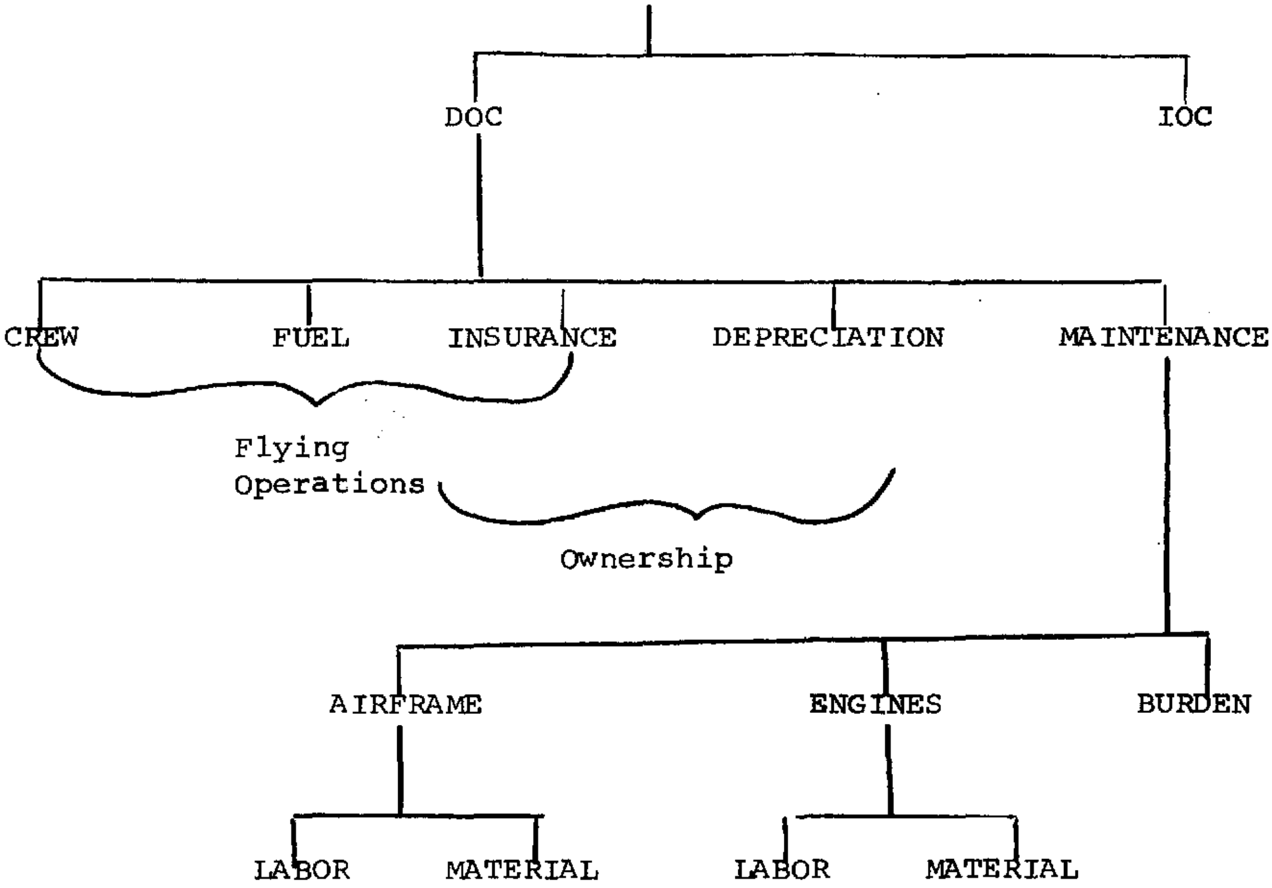
INTRODUCTION

The ATA formulas for direct operating cost were developed for the purpose of comparing different aircraft, existing or not, on the same route or the same aircraft on different routes. Such characteristics of the airline as crew pay, amintenance procedures, and depreciation schedules are kept constant. The formulas should be used for comparison only; they cannot reliably predict the actual operating cost of an airplane in service with a specific airline.

The 1967 ATA Formula is designed for turbine powered transport aircraft only. It covers only direct operating costs, which do not include such items as stewardesses and interest on investment. The formula is based on the characteristics of U.S. international and domestic airlines, and therefore it should not be applied to foreign or third level carriers. In particular, third level carriers would be likely to have smaller, unpressurized aircraft, shorter routes, and different labor rates.

In air transportation systems analysis the 1967 ATA Formula is usually used with appropriate exceptions or modifications, such as: different maintenance labor rate, total maintenance multiplied by a factor, maintenance burden deleted, different depreciation schedule, or different spares percentages. For situations outside the scope of the ATA Formula, other formulas are used, such as the Lockheed/New York Airways Formula (Reference 1) for VTOL or an updated version of the 1960 ATA formula for reciprocating power.

OUTLINE OF OPERATING COSTS



EFFECT OF MODIFICATIONS FOR NOISE ABATEMENT

The principal direct effect would be on depreciation. The cost of the modification would be spread over the remainder of the useful life of the aircraft or the depreciation period.

Other effects could occur through lower cruise speed, higher fuel consumption, or increased maintenance.

CONVERSIONS

The formula gives results in \$/aircraft mile. Knowing block speed, stage length, and the number of passenger seats, any of the following conversions can be made.

$$\$/\text{hour} = \$/\text{aircraft mile} \times \text{block speed}$$

$$\$/\text{seat mile} = \$/\text{aircraft mile} \times \frac{100}{\text{number of seats}}$$

$$\$/\text{seat trip} = \$/\text{aircraft mile} \times \frac{\text{stage length}}{\text{number of seats}}$$

$$\$/\text{seat hour} = \$/\text{aircraft mile} \times \frac{\text{block speed}}{\text{number of seats}}$$

$$\$/\text{trip} = \$/\text{aircraft mile} \times \text{stage length}$$

The following data are needed to exercise the ATA Formula. The Formula itself is provided in the appendix.

INPUTS

S = number of seats

D = stage length, statute miles

T_{cl} = time to climb, hr.

T_d = time to descend, hr. V_b = block speed, mph.

D_c = distance to climb, mi. or t_b = block time, hr.

D_d = distance to descend, mi. t_f = flight time,hr.

V_{cr} = cruise speed, mph

F_{gm} = ground maneuver fuel, lbs.

F_{cl} = climb fuel, lbs or F_b = block fuel, lbs

F_{cr} = cruise fuel, lbs

F_{am} = air maneuver fuel, lbs.

F_d = descent fuel, lbs.

$TOGW_{max}$ = maximum takeoff gross weight, lbs.

N_e = number of engines

U = utilization, hours per year

C_t = total purchase cost of aircraft without spares, $

W_a = weight of airframe, lbs.

C_a = purchase cost of airframe, $

T = takeoff thrust of one engine, lbs.

C_e = purchase cost of one engine,$

EXAMPLE

We now proceed through an example, the Boeing 737-200 as it was used on the average in 1970 (Reference 2). The following table gives the inputs to the formula. Notice that the state length is short, the block speed is low, and the utilization is low. The formula shows how to calculate block speed if that is unknown. Here we assume the full payload can be carried so we do not need to calculate reserve fuel as shown in the formula. We will show calculations for all quantities although some of them can be read from charts included with the formula.

Input

S = number of seats = 93

D = stage length = 262 statute miles

V_b = block speed = 289 mph

F_b = block fuel = 5440 lbs.

$TOGW_{max}$ = maximum takeoff gross weight = 114,500 lbs

N_e = number of engines = 2

U = utilization = 1865 hr/yr

C_t = total aircraft cost = 5.20×10^6 \$

W_a = airframe weight = 53,217 lbs

C_a = airframe cost = 4.68×10^6 \$

T = total takeoff thrust of one engine = 14,500 lbs.

C_e = cost of one engine = 261,000 \$

Flight Crew

Two Man Crew:

$$C_{am} = .05\left(\frac{TOGW}{1000}\right) + 100.0 \quad \frac{1}{V_b}$$

$$= .05\left(\frac{114,500}{1000} + 100.0 \quad \frac{1}{289}\right.$$

$$= 5.72 + 100.0 \quad \frac{1}{289}$$

$$= 0.366 \text{ \$/mi}$$

The cost components of the formula naturally are incurred as cost per hour, cost per trip, or cost per year, which are then converted to cost per mile. The cost of flight crew is incurred as cost per hour and is converted by dividing by block speed. Note that the cost depends on gross weight and number of crew.

Fuel and Oil

$$C_{am} = 1.02 \quad \frac{(F_b x \; C_{ft}) + N_e x \; .135 \; x \; C_{ot} x \; t_b}{D}$$

$$= 1.02 \quad \frac{(5440 \; x \; .0149) + (2 \; X \; .135 \; x \; .926 \; x \; .906)}{262}$$

$$= 1.02 \quad \frac{81.2 + .27}{262}$$

$$= 0.317 \quad \text{\$/mi}$$

The cost of fuel and oil is incurred as cost per trip and converted to cost per mile by dividing by stage length. Note that the cost of oil is insignificant.

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We now proceed through an example, the Boeing 737-200 as it was used on the average in 1970 (Reference 2). The following table gives the inputs to the formula. Notice that the state length is short, the block speed is low, and the utilization is low. The formula shows how to calculate block speed if that is unknown. Here we assume the full payload can be carried so we do not need to calculate reserve fuel as shown in the formula. We will show calculations for all quantities although some of them can be read from charts included with the formula.

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$$= 5.72 + 100.0 \quad \frac{1}{289}$$

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$$= 1.02 \quad \frac{(5440 \ x \ .0149) + (2 \ X \ .135 \ x \ .926 \ x \ .906)}{262}$$

$$= 1.02 \quad \frac{81.2 + .27}{262}$$

$$= 0.317 \quad \$/mi$$

The cost of fuel and oil is incurred as cost per trip and converted to cost per mile by dividing by stage length. Note that the cost of oil is insignificant.

Hull Insurance

$$C_{am} = \frac{.02 \times C_t}{U \times V_b}$$

$$= \frac{.02 \times 5.2 \times 10^6}{1865 \times 289}$$

$$= 0.193 \ \$/mi$$

Insurance is an annual expense and is converted to cost per mile by dividing by utilization and block speed.

Maintenance

Airframe Labor

$$K_{FC_a} = .05 \ (\frac{W_a}{1000} + 6 - \frac{630}{\frac{53,217}{1000} + 120}$$

$$= 2.66 + 6 - 3.63$$

$$= 6.97 \text{ hr/cycle}$$

$$K_{FH_a} = 0.59 \ K_{FC_a} = 0.59 \times 6.97 = 4.11 \text{ hr/flight hr.}$$

$$C_{am} = \frac{(K_{FH_a} \ t_f + K_{FC_a}}{V_b \ t_b} \ (4.00) \ (1)$$

$$= \frac{4.11 \times .722 + 6.97}{289 \times .906} \ (4.00)$$

$$= 0.152 \ \$/mi.$$

All maintenance expense is incurred as a cost per trip and is converted to cost per mile by dividing by stage length (block speed times block time). Maintenace labor costs are based on the labor man hours per flight hour and the labor man hours per flight cycle. Airframe labor is non-linear function of airframe weight.

Maintenance

Airframe Material:

$$C_{FH_a} = \frac{3.08\ C_a}{10^6} = \frac{3.08 \times 4.68 \times 10^6}{10^6} = 14.4$$

$$C_{FC_a} = \frac{6.24\ C_a}{10^6} = \frac{6.24 \times 4.68 \times 10^6}{10^6} = 29.2$$

$$C_{am} = \frac{C_{FH_a}\ T_f + C_{FC_a}}{V_b\ t_b}$$

$$= \frac{14.4 \times .722 + 29.2}{289 \times .906}$$

$$= 0.151\ \$/\text{mi.}$$

Maintenace material cost is based on material cost per flight hour and material cost per flight cycle. These costs are proportional to airframe cost.

Maintenance

Engine Labor:

$$K_{FH_e} = \left[0.6 + \frac{.027T}{10^3}\right] N_e$$

$$= \left[0.6 + \frac{.027 \times 14,500}{10^3}\right] 2$$

$$= (0.6 + 0.392)\ 2$$

$$= 1.98$$

$$K_{FC_e} = \left[0.3 + \frac{.03T}{10^3}\right] N_e$$

$$= \left[0.3 + \frac{.03 \times 14,500}{10^3}\right] 2$$

$$= (0.3 + 0.435)\ 2$$

$$= 1.47$$

$$C_{am} = \frac{K_{FH_e} t_f + K_{FC_e}}{V_b t_b} \qquad (4.00)$$

$$= \frac{1.98 \times .722 + 1.47}{289 \times .906}$$

$$= 0.111\ \$/\text{mi.}$$

Note that increasing the number of engines without changing the thrust increases the engine labor cost. However this can be partially offset by reducing the thrust requirement from the engine out case.

Maintenance

Engine Material:

$$C_{FH_e} = 2.5\ N_e \left[\left(\frac{C_e}{10^5}\right)\right]$$

$$= 2.5 \times 2 \times \left[\left(\frac{261{,}000}{10^5}\right)\right]$$

$$= 13.1$$

$$C_{FC_e} = 2.0\ N_e \left[\left(\frac{C_e}{10^5}\right)\right]$$

$$= 2.0 \times 2 \times \left[\left(\frac{261{,}000}{10^5}\right)\right]$$

$$= 10.4$$

$$C_{am} = \frac{C_{FH_e}\ t_f + C_{FC_e}}{V_b\ t_b}$$

$$= \frac{13.1 \times .722 + 10.4}{289 \times .906}$$

$$= 0.076\ \$/\text{mi}$$

Engine material cost is proportional to the total cost of the engines.

Maintenance

Burden:

$$C_{am} = 1.8\ (\text{Airframe Labor} + \text{Engine Labor})$$

$$= 1.8\ (0.152 + 0.111)$$

$$= 0.474\ \$/\text{mi}$$

Maintenance burden is the cost of owning and maintaining the ground facilities for aircraft maintenace. It is proportional to the sum of airframe and engine labor costs.

Depreciation

$C_t = 5.20 \times 10^6$ = total aircraft cost without spares

$.10(C_t - N_e C_e) = .10C = .10 \times 4.68 \times 10^6 = .468 \times 10^6$

= 10% airframe spares cost

$.40\ N_e\ C_e = .40 \times 2 \times 261{,}000 = .209 \times 10^6$

= 40% engine spares cost

$$C_{am} = \frac{1}{V_b}\left[\frac{C_t + .10\ (C_t - N_e C_e) + .40\ N_e\ C_e}{D_a \times U}\right]$$

$$= \frac{1}{289}\left[\frac{5.20 \times 10^6 + .468 \times 10^6 + .209 \times 10^6}{12 \times 1865}\right]$$

$$= \frac{1}{289}\left[\frac{5.88 \times 10^6}{12 \times 1865}\right]$$

=0.910 \$/mi

Depreciation is an annual expense which is converted to cost per mile by dividing by utilization and block speed.

Summary 737-200

	$/mi.	$/hr.	$/s.mi.	%
Crew	.366	106	.394	13.3
Fuel and Oil	.317	92	.341	11.5
Hull Insurance	.193	56	.208	7.0
Total Flying Operations	.876	254	.943	31.8
Airframe Labor	.152	44	.164	5.5
Airframe Material	.151	44	.163	5.5
Engine Labor	.111	32	.119	4.0
Engine Material	.076	22	.082	2.8
Total Direct Maintenance	.490	142	.528	17.8
Maintenance Burden	.474	137	.510	17.2
Total Maintenance	.964	279	1.038	35.0
Depreciation	.910	263	.980	33.2
Total	2.750	796	2.961	100.0

Notice that total flying operations, total maintenance, and depreciation are each about a third of the cost. Maintenance burden,rather than flight crew or fuel, is the largest single item.

Comparison with the Real World

737-200 $/hr.

Actual Figures are for the year 1970. (Reference 2)

	1967 ATA	United	Western	Frontier	Piedmont
Crew	106	183	119	112	107
Fuel and Oil	92	101	113	101	104
Insurance	56	12	4	24	18
Flying Operations	254	296	236	237	229
Airframe	88	51	47	62	46
Engine	54	25	45	37	36
Burden	137	70	37	38	43
Total Maintenance	279	146	129	137	125
Depreciation	263	99	104	129	89
Total	796	541	470	503	443

The formula predicts flying operations expense fairly well except insurance is high. Also United Airlines has a three man crew on the 737-200, whereas we assumed two men for the formula.

The formula is very high on maintenance. This seems to be because the formula is based on long haul aircraft, which may have high cycle costs. The example is a short haul aircraft, which has been designed to have low cycle costs. The maintenance burden is correspondingly high.

Depreciation is also high because more recent (1971-82) purchase costs were used as input to the formula and because the airlines are using different depreciation schedules from the one assumed by the formula.

The total figures show that the direct operating cost does vary significantly from airline to airline. The total cost from the formula is high and indicates the danger of using the formula to predict the absolute true cost in airline service.

REFERENCES

1. Stoessel, R.F. and Gallagher, J.E., A Standard Method for Estimating VTOL Operating Expense, Lockheed-California Co., CA/TSA/013, October 1967.

2. CAB, Aircraft Operating Cost and Performance Report, Volume V August 1971

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Technology for Design of Transport Aircraft

Lecture Notes for MIT Courses

Sem. 1.61 Freshman Seminar in Air Transportation

and

Graduate Course 1.201, Transportation Systems Analysis

Robert W. Simpson

Flight Transportation Laboratory, MIT

Revised for NASA/MIT Summer Workshop on Air Transportation

Waterville Valley, New Hampshire

July 1972

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Technology for the Design of Transport Aircraft

A) Measures of Performance

The common measures of performance for a transport aircraft are listed below:

1. Cruise Performance - Payload (passengers) versus Range (s. miles)
2. Cost Performance - ($/block hour, $/available seat mile)
3. Runway Performance - takeoff and landing distances (feet)
4. Speed Performance - max. cruise speed (mph)
5. Noise Performance - noise footprint size, or peak noise (PNdb)

For a long range transport aircraft, the designer maximizes cruise and cost performance subject to constraints specified for takeoff and landing, speed, and noise performance. If the designer optimizes takeoff and landing performance as for STOL or VTOL transport aircraft, then cruise performance will be less than optimal, and these aircraft will only perform well over short cruise ranges. Introduction of noise constraints into the design of transport aircraft requires good knowledge of the noise generation characteristics of engines and other propulsive devices as a function of size and technology, and like all constraints will cause less than optimal cruise and takeoff and landing performance.

The designer's problem is to create an aircraft design which is matched to some design mission stated in terms of desired or required levels of these measures of performance.

Here we shall discuss the design parameters which determine cruise performance for a conventional subsonic jet transport, and fix other design considerations. We shall assume the aircraft burns climb fuel to reach cruising altitude, and ask ourselves how far the aircraft can carry a given payload at cruising altitude. This simple analysis brings out the major factors in establishing the cruise performance. We shall see how the current state of aeronautical technology determines the current size of transport aircraft, (and therefore its operating cost) and how different sizes of transport are needed to provide the cost optimal vehicle for different

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given payload-range objectives.

B) Technology

We have three areas of aeronautical technology, aerodynamics, structures, and propulsion, which keep improving, and which cause newer aircraft to be superior as time goes on. In discussing cruise performance, we will use a single measure for the level of technology in each area.

Areas of Technology	Measure of Technology Level
1. Aerodynamics	V(L/D) = speed x(lift/drag ratio in cruise)
2. Structures	W_E/W_G = empty weight fraction = (operating empty weight/gross weight)
3. Propulsion	SFC = Cruise specific fuel consumption (lbs. of fuel per hour/lbs. of thrust)

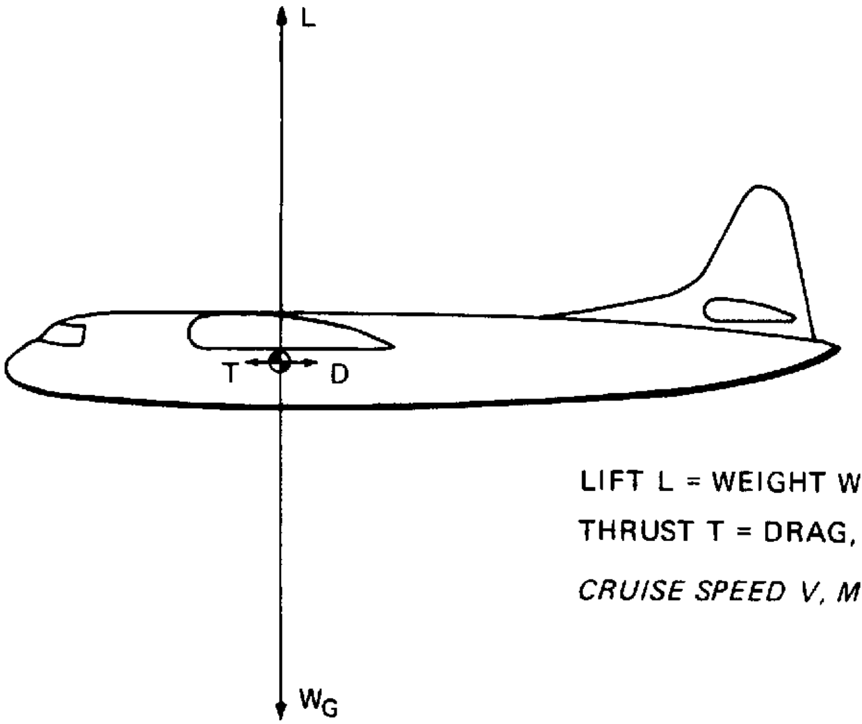
B.1 Aerodynamics Technology

The lift/drag ratio, L/D, in cruise for present subsonic aircraft is a number like 16-17, i.e. for every 16 lbs of weight, there is a requirement for 1 lb. of thrust. The steady state forces on the aircraft are shown in Figure 1. The aircraft weight W_G equals the lift L. Dividing the lift by the L/D ratio gives the drag D, which requires an equal thrust, T.

While L/D ratios of up to 40 can be obtained for sailplanes at low speeds by using large span, high aspect ratio wings and good airfoil sections, the objective for transport aircraft turns out to be the maximization of the product of speed and L/D, i.e. to achieve good L/D values at higher speeds. This objective must be compromised by aerodynamic requirements for takeoff and landing performance which demand a larger wing area than otherwise would be used for cruise.

A plot of values of V(L/D) is given by Figure 2 which shows the

Figure 1 STEADY STATE FORCES IN CRUISE

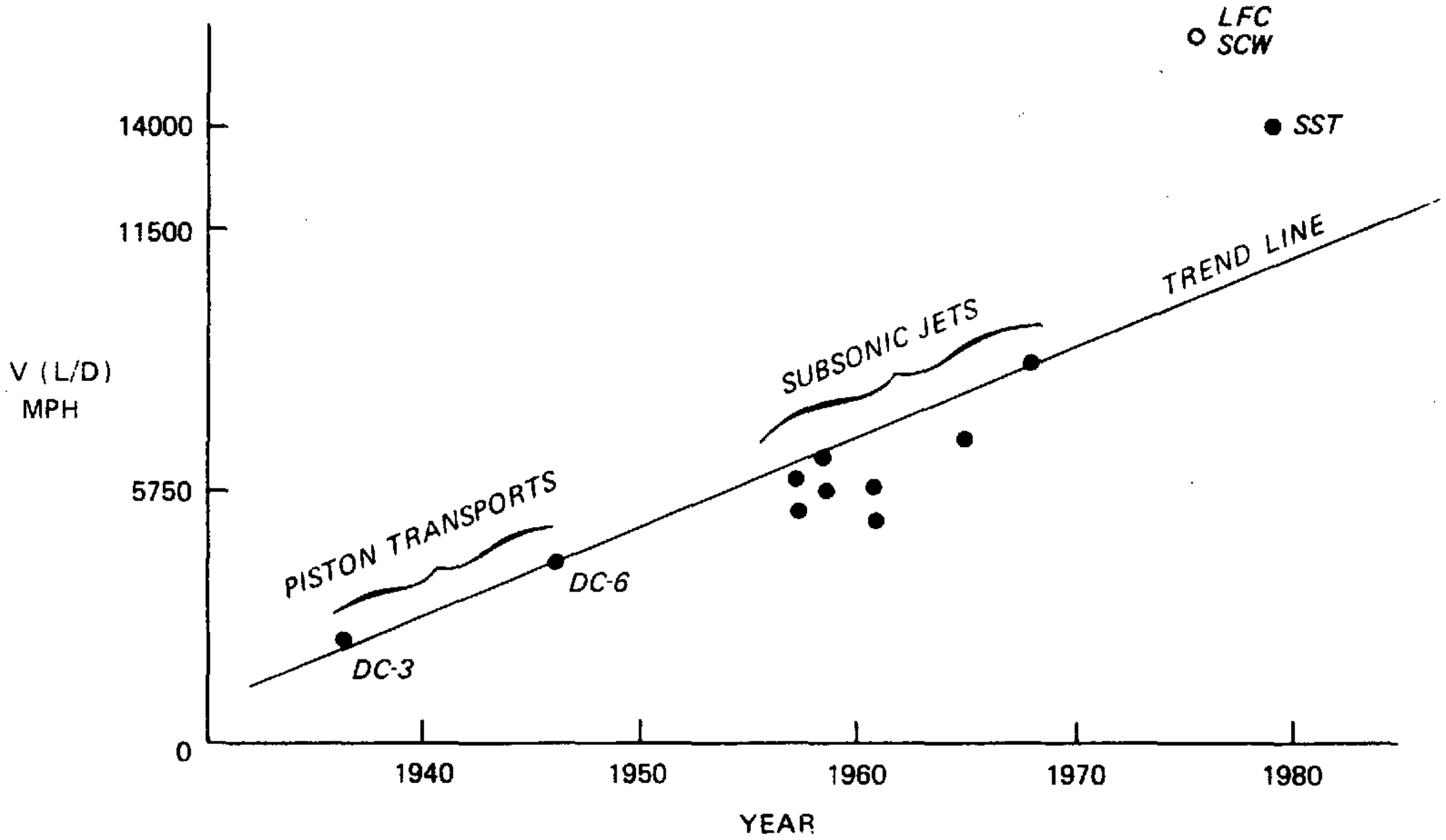


LIFT L = WEIGHT W_G

THRUST T = DRAG, D

CRUISE SPEED V, MPH

Figure 2 TREND OF V(L/D) FOR TRANSPORT AIRCRAFT



steady improvement for transport aircraft over the past 35 years. These improvements have been developments like laminar flow airfoils, thinner wings, swept wings, higher wing loadings in cruise because of better high lift devices, etc. The supercritical wing section (SCW) and perhaps laminar flow control (LFC) wing are developments which have promise of continuing improvement.

Notice that although the SST has L/D values of only 8, its speed on the order of 1800 mph gives very high values for V(L/D).

B.2 Structures Technology

Here we use the "empty weight fraction" as a measure of structures technology although it contains other than the weight of the aircraft structure.

We shall use the following, non-standard breakdown of the weight of a transport aircraft:

We define W_G = takeoff gross weight

W_{Gi} = initial cruise weight

W_{Gf} = final cruise weight

The total fuel load is divided into:

W_F = total fuel weight

W_{FC} = fuel burn in climb

W_{FB} = fuel burn in cruise

W_{FR} = weight of fuel reserve

Then $W_{Gi} = W_G - W_{FC}$

$$W_{Gf} = W_G = W_{FC} - W_{FB} = W_{Gi} - W_{FB}$$

For simplicity, we shall ignore fuel burn in descent, and range during climb, and shall be computing only range in cruise. We shall assume that $W_{FC} = W_{FR} = 5\%$ of W_G.

We define the operating weight empty, W_E, as made up of:

$$W_E = W_S + W_{FE} + W_{PP} + (W_{FR})$$

where W_S = weight of aircraft structure

W_{FE} = weight of furnishings and equipment (pilots, seats, galley, toilets, radios, etc.)

W_{PP} = weight of power plant

W_{FR} = weight of reserve fuel.

Notice that for convenience, we include the reserve fuel in the "operating weight empty" although that is not standard practice.

We define the useful load, W_U, as the difference between the initial cruise weight, W_{Gi} and W_E

$$W_U = W_{Gi} - W_E = W_G - W_{FC} - W_E$$

The useful load will consist of some combination of payload, W_P and fuel burn in cruise W_{FB}. We are going to examine the effects of range requirements on the payload fraction, W_P/W_G, which can be achieved. As range is increased, more of the useful load must be devoted to fuel, thereby decreasing the payload fraction.

Typical values of the "empty weight fraction" (without reserve fuel) for current aircraft are given by Table 1. Notice that the empty weight fraction is roughly 50%, and that lower values are obtained for long haul, large size aircraft, where emphasis is placed upon achieving a low value, and where some economy of scale

TABLE 1. Typical Values of Basic Empty Weight/Max Gross Weight

Passenger Aircraft	Empty Weight Fraction	Max. Gross Weight	Range
747	.491	710.	5,790
DC-10-30	.474	555.	5,400
L-1011	.550	426.	2,878
DC-8-63	.437	350.	4,500
707-320B	.423	327.	6,160
727-200D	.552	175.	1,543
Trident-3B	.554	150.	2,430
Mercure	.557	114.6	1,100
DC-9-40	.488	114.0	1,192
737-200B	.538	109.0	2,135
BAC-111-475	.532	97.5	1,682
F-28-2000	.557	65.0	1,301
VFW 614	.656	41.0	1,553
VAK-40	.570	36.4	807
Falcon 20T	.607	29.1	641
DHC-6	.560	12.5	745
Concorde SST	.44	385.	4,020
S-61 helicopter	.62	19.00	275
Freighters			
747F	.428	775.0	2,880
CSA	.425	764.5	3,500
707-320C	.402	332.0	3,925
L100-30(C130)	.468	155.0	2,800 -
		x 10^3 lbs.	St Miles

(Source: Jane's 1971-72)

may occur for fixed equipment like radios, galley, etc.

The major portion of the empty weight fraction is the structures weight, W_S, which is usually 30% of the gross weight. A diagram of the value of the "structures weight fraction" is shown by Figure 3. Since the construction of the DC-3 there has been very few basic changes in structural technology. However, there is considerable promise currently of new developments which use composite materials, and different construction techniques to provide extremely light weight and rigid structures. These are expensive now, but future development work may reduce their costs.

B.3 Propulsion

The specific fuel consumption is given in terms of rate of fuel burned per lb. of thrust for the engine. Here we want the cruise SFC values at cruise altitude and speed. For the early jets, SFC had a value of roughly 1.0 in cruise, which meant that a 10,000 lb. thrust engine would consume 10,000 lbs. of fuel in one hour. For present fan engines, SFC is roughly 0.6, so that only 6,000 lbs of fuel per hour would be consumed by current engines.

Another common measure of propulsion technology is the thrust to weight ratio of the engines, but here we have made it a part of the operating weight fraction as a measure for structures technology.

The most remarkable improvement over the last decade has been the improvement in cruise SFC for the engines used by subsonic transport aircraft. This is illustrated in Table 2 and Figure 4 which show the almost 50% reduction in fuel consumption by current

Table 2. Specific Fuel Consumption for Current Transport Engines

		Takeoff Conditions Static		Cruise Conditions		
Engine	Bypass Ratio	Thrust (lbs)	SFC	Mach	Altitude	SFC[9]
JT3-C	0	13,500	0.77	.69	35000	0.92
CONWAY	0.6	20,400	0.62	.83	36000	0.84
SPEY	1.0	9,850	0.54	.78	32000	0.76
JT8-D	1.03	14,000	0.57	.80	35000	0.83
JT3-D	1.4	18,000	0.52	.90	35000	0.835
TFE-731	2.55	3,500	0.49	.80	40000	0.82
M-45	2.8	7,760	0.45	.65	20000	0.72
CF-6-6	6.25	40,000	0.34	.85	35000	0.63
ASTAFAN	6,5	1,5622	0.38	.53	20000	0.63

Figure 3 TREND FOR STRUCTURES WEIGHT FRACTION FOR TRANSPORT AIRCRAFT

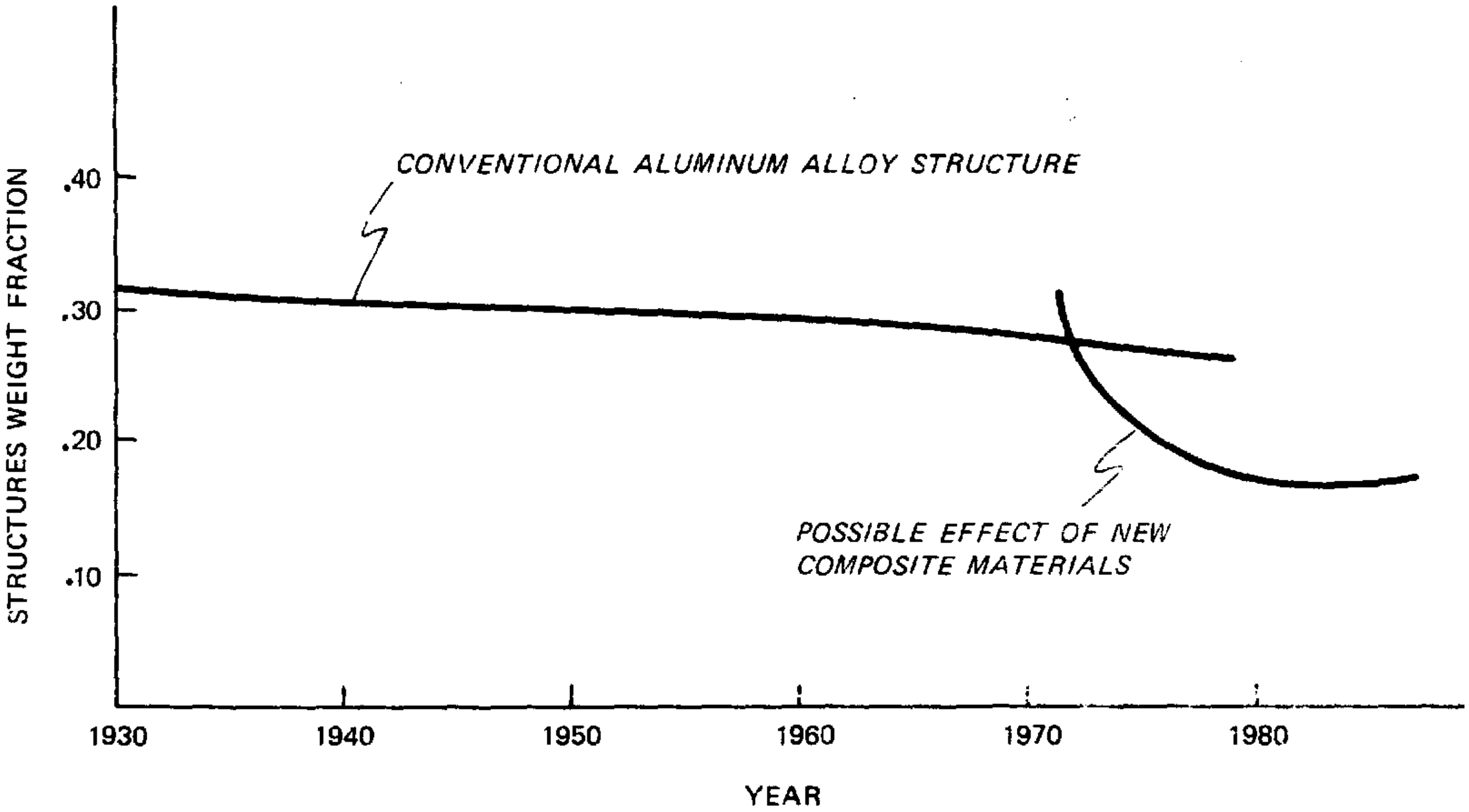
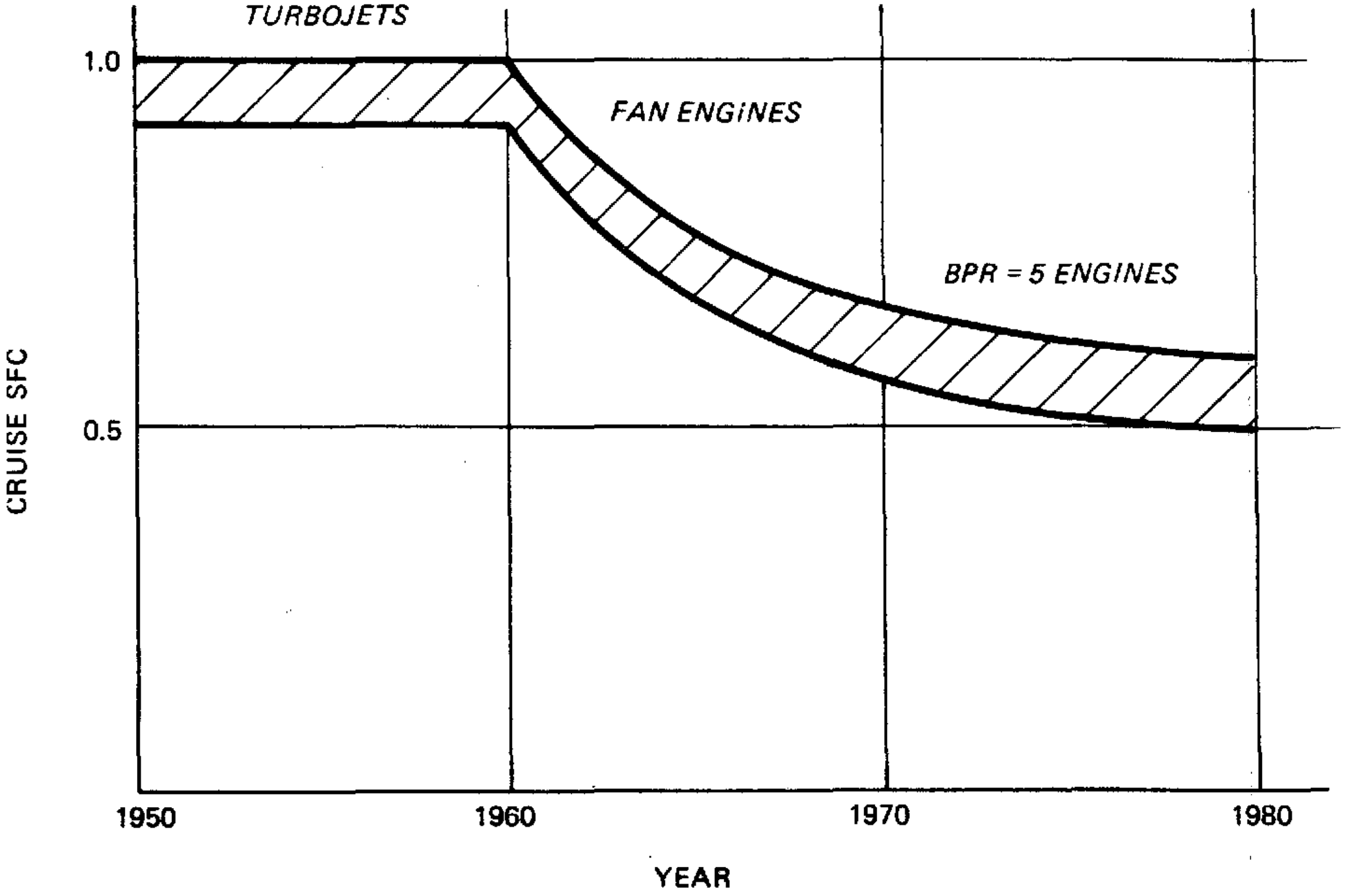


Figure 4 TRENDS IN PROPULSION — SFC



high bypass ratio fan engines over the initial pure jet engines. This improvement is due to better propulsive efficiencies from the fan, improved component efficiencies for engine components like compressors, turbines, combustors, etc., and higher cycle temperatures due to improved materials and technology in the design and construction of the turbine blades.

C) Determination of Range-Payload Performance

C.1 Short Range Aircraft

Where the fuel burn, W_{FB} is a small fraction of W_G, we can assume that W_G remains constant during cruise, or $W_{Gi} \approx W_{Gf} \approx W_G$.

If we define R = cruising range (s. miles)

m = mileage factor, (s. miles per lb. of fuel)

Then $R = m \cdot W_{FB}$ (1)

We can express m in terms of V, T, and SFC

$$m = \frac{V}{T(SFC)} = \frac{\text{s.miles/hr}}{\text{lbs of fuel/hr}} = \frac{\text{s. miles}}{\text{lb. fuel}}$$

But from Figure 1, $\frac{T}{W_G} = \frac{D}{L}$, or $T = \frac{W_G}{(L/D)}$

$$\therefore \quad m = \frac{V}{SFC} \cdot \frac{(L/D)}{W_G}$$

Substituting m in (1)

$$R = \frac{V(L/D)}{SFC} \cdot \left[\frac{W_{FB}}{W_G}\right] = r \cdot \left[\frac{W_{FB}}{W_G}\right]$$

where r is called "specific range" (s. miles)

and $\frac{W_{FB}}{W_G}$ is called "fuel burn fraction"

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Note: r has the dimensions of s. miles

e.g. if L/D = 16, SFC = 0.6 lbs. of fuel/hr. per lb. of thrust

$V = 550$ mph

$$\text{Then } r = \frac{550 \times 16}{0.6} = 14{,}700 \text{ s. miles}$$

We shall use these assumed values in later examples.

a) <u>If no payload is carried</u>, then $W_P = 0$, $W_U = W_{FB} = W_{Gi} - W_E$,

then the maximum cruise range, R_{max}

$$R_{max} = r\left[\frac{W_{FB}}{W_G}\right] = r \cdot \left[\frac{W_U}{W_G}\right] = r \cdot \left[\frac{W_{Gi} - W_E}{W_{Gi}}\right] \tag{3}$$

$$= r.(1 - \frac{W_E}{W_{G_i}})$$

So, our structures technology parameter is a strong determinant of the maximum range for a fuelled aircraft. If the "empty weight fraction" can be reduced, it increases the "fuel fraction", or "useful load fraction", and thereby the maximum range

b) If payload is carried, then $W_{FB} = W_{Gi} - W_E - W_P \quad W_G - W_E - W_P$

and for any given payload

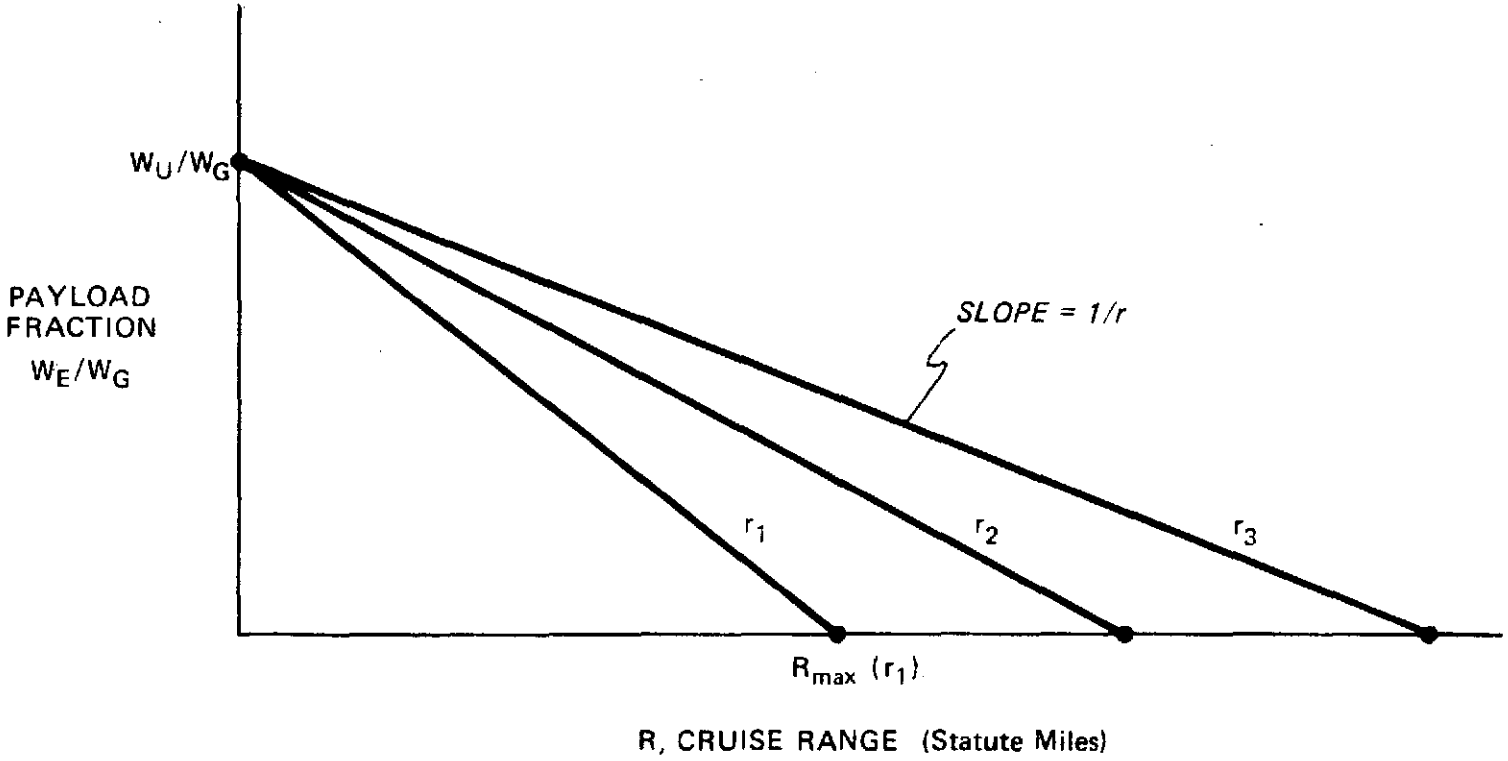
$$R = r\left[\frac{W_{FB}}{W_G}\right] \approx r\left[\frac{(W_G - W_E - W_P)}{W_G}\right]$$

$$= R_{max} - r \cdot \left[\frac{W_P}{W_G}\right] \qquad \text{from (3)}$$

where $\frac{W_P}{W_G}$ is called the "payload fraction".

We can plot the payload fraction against R in Figure 5

Figure 5 PAYLOAD FRACTION versus RANGE



where $\frac{W_P}{W_G} = \frac{1}{r} \cdot (R_{max} - R)$ (5)

At $R = 0$, $\frac{W_P}{W_G} = \frac{R_{max}}{r} = \frac{W_U}{W_G}$ from equation (3)

For this short range case the variation of payload fraction is linear in R, decreasing to zero at R_{max}. As r is improved, the payload fraction at any range improves, and R_{max} increases. As $\frac{W_E}{W_G}$ is decreased, $\frac{W_U}{W_G}$ is increased which gives higher payload fractions for all ranges.

This simple analysis has been for the short range case where W_G may be considered as remaining constant over the cruise, or the fuel burn fraction is small for the short range mission.

C.2 Long Range Aircraft

For a long range aircraft, the change in W_g during the flight cannot be ignored (W_g = instantaneous gross weight)

e.g. a B-707-300 on a NY to Paris trip

W_{G_i} out of NY ≈ 315000 lbs

W_{G_f} at Paris ≈ 230000 lbs

so final weight is 2/3 of initial weight.

Equation 2 still applies over a small increment of cruise so we resort to the calculus which produces a different, more precise formula called the "Breguet Range Equation". Equation (2) becomes

$$dR = \frac{r}{W_g} \cdot d\,W_{FB}$$

where dR = increment of range

$d\ W_{FB} = -d\ W_g$ = increment of fuel burn

= decrease in W_g

$$\therefore \quad dR = r \cdot \left[\frac{-dW_g}{W_g}\right]$$

If the value of W_g at start of cruise is W_{gi}, at end of cruise is W_{gf}, then we have to integrate from W_{gi} to W_{gf} to get the exact formula for R

$$R = r \cdot \int_{W_{Gi}}^{W_{Gf}} \frac{-dW_g}{W_g} = r \int_{W_{G_f}}^{W_{Gi}} \frac{dW_g}{W_g} = r.\ln\left[\frac{W_{G_i}}{W_{G_f}}\right] \qquad (2a)$$

If we compare to Equation (2) we see that the specific range is now modified by a logarithmic expression involving the initial and final cruise gross weights;

i.e. $\frac{W_{FB}}{W_G} \approx \frac{W_{FB}}{W_{Gf}}$ is now replaced by $\ln\left[\frac{W_{Gf} + W_{FB}}{W_{Gf}}\right] = \ln\left[1 + \frac{W_{FB}}{W_{Gf}}\right]$

a) <u>If no payload is carried</u>, then $W_P = 0$, $W_U = W_{FB} = W_{Gi} - W_E$ then the maximum range becomes,

$$R_{max} = r.\ln\left[\frac{W_{Gi}}{W_{Gf}}\right] = r\ \ln\left[\frac{W_{Gi}}{W_E}\right] = r\ \ln\left[\frac{1}{W_E/W_{Gi}}\right] \qquad (3a)$$

As before, if W_E/W_{Gi} is reduced, R_{max} will be increased. However since W_g now decreases as fuel is burned, R_{max} is greater in (3a) than from the simple case (3).

For example, if r = 14,700 as before, and $\frac{W_{FC}}{W_G} = .05$, and we assume $\frac{W_E}{W_G} = 0.60, \quad \frac{W_E}{W_{Gi}} = \frac{0.60}{0.95} = 0.632$

or $\frac{W_{FB}}{W_G} = 0.35, \quad \frac{W_{FB}}{W_{Gi}} = \frac{0.35}{0.45} = 0.370$

From (3), $R_{max} = 14,700 \times (0.37) = 5450$ s. miles in cruise

From (3a), $R_{max} = 14,700 \ln \frac{1}{0.632} = 14,700 \ln (1.58) = 6770$ s. miles

The correct formula makes a 1320 s. mile difference in R_{max}!

b) <u>If payload is carried</u>, then $W_{FB} = W_{Gi} - W_E - W_P$, and the payload becomes

$$R = r.\ln\left[\frac{W_{Gi}}{W_{Gf}}\right] = r.\ \ln\left[\frac{W_{Gi}}{W_E + W_P}\right] = r.\ln\left[\frac{1}{W_E/W_{Gi} + W_P/W_{Gi}}\right]$$

If we unlog this expression

$$\frac{W_E}{W_{Gi}} + \frac{W_P}{W_{Gi}} = e^{-R/r}$$

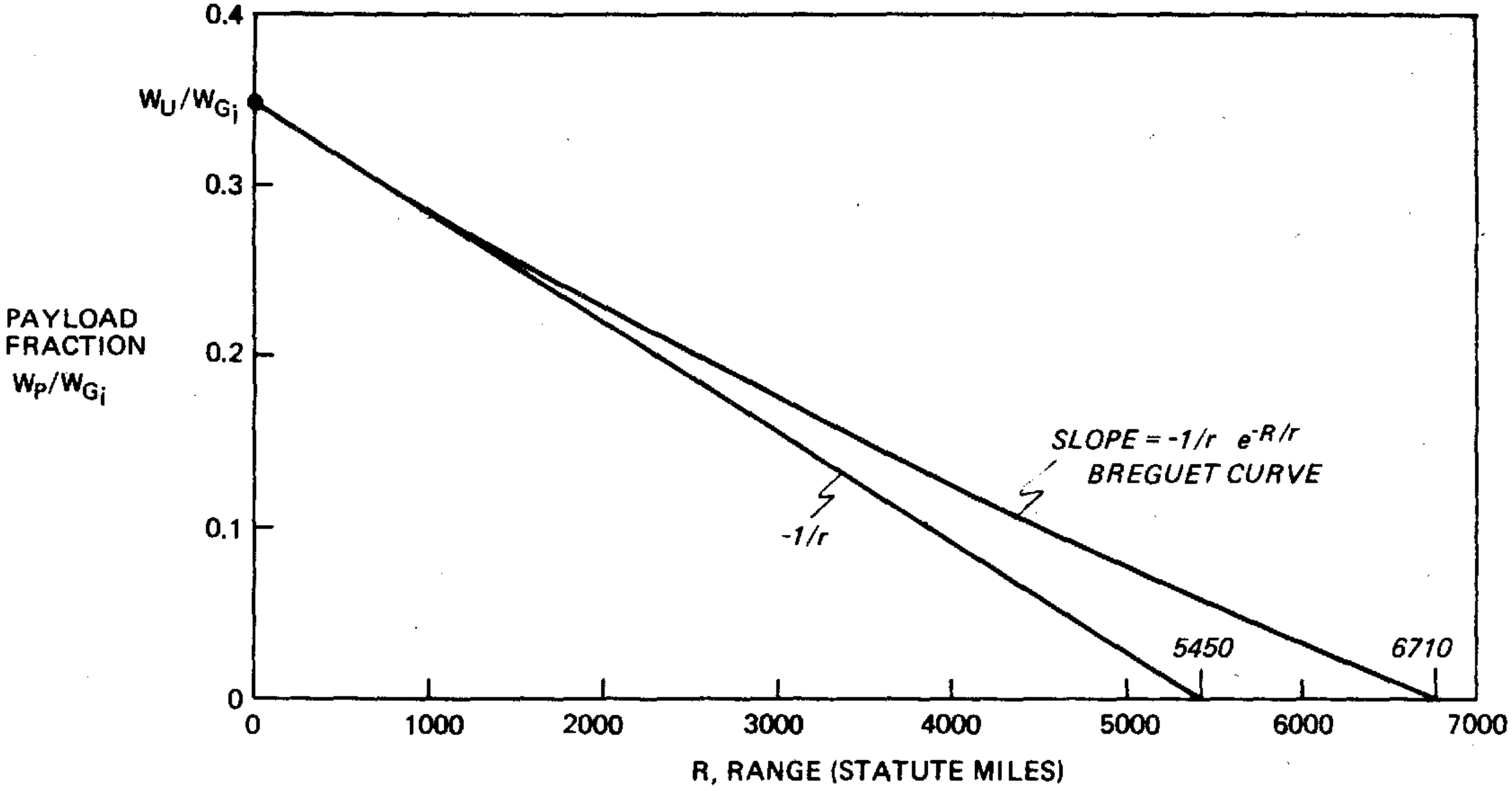
or payload fraction, $\frac{W_P}{W_{Gi}} = e^{-R/r} - \frac{W_E}{W_{Gi}}$ 4(a)

At $R = 0$, $\frac{W_P}{W_{Gi}} = 1 - \frac{W_E}{W_{Gi}} = \frac{W_U}{W_{Gi}}$ as before for short range case

At $R = R_{max}$, $\frac{W_P}{W_{Gi}} = 0$

As shown in Figure 6, the payload fraction curve is now a shallow exponential. Near maximum range, the payload fraction becomes very small, and very sensitive to errors in estimating technology measures.

Figure 6 PAYLOAD FRACTION versus RANGE



D. Weight-Range Diagram

We can now show the weight breakdown versus design range for a conventional subsonic jet at a given level of aircraft technology. From Figure 7, we see that the payload fraction is strongly dependent on design range.

For a long range aircraft, the payload fraction will be very small, and aircraft payload-range performance will be very sensitive to the values of r and W_E/W_G which can be achieved. For example, if W_P/W_G is 10% for some design range, then every lb. saved in empty weight converts directly to payload, and saves 10 lbs. in design gross weight.

However, for a short range aircraft where W_P/W_G may be 33%, then every lb. saved in empty weight still converts directly to payload, but saves only 3 lbs. in design gross weight.

Therefore, a critical decision in the design of any transport aircraft is the choice of the full payload-design range point. Once this is selected, we have a good idea of the required aircraft gross weight for a given level of aircraft technology, and consequently, as we shall see, its probable purchase cost and operating cost.

For our example technology, we can compute payload fractions at design ranges from 6000 to 500 s. miles. Table 3 gives the result of applying equation (3a), and quotes typical gross weights for a 50,000 lb. and 100,000 lb. payload, or roughly a 250 and 500 passenger vehicle.

Figure 7 WEIGHT BREAKDOWN versus RANGE

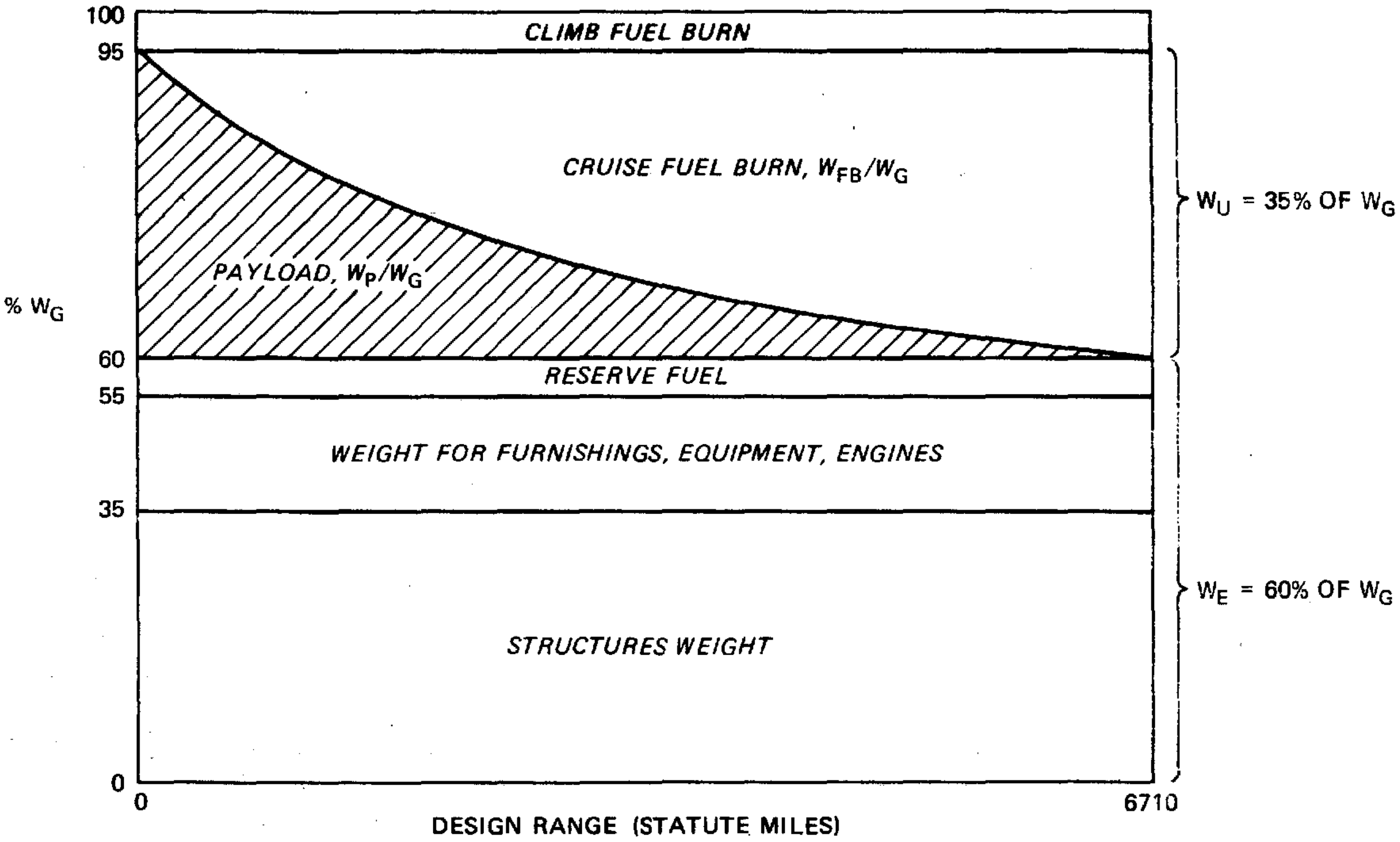


TABLE 3. SIZING TRANSPORT AIRCRAFT

Cruise Design Range (s. miles)	Payload Fraction (W_P/W_G)	W_G/W_P (lbs. per payload)	Gross Weight	
			250 pax or 50,000 lbs.	500 pax or 100,000 lb
6000	.04	25	1.25×10^6	2.5×10^6
5000	.075	13.3	666,000	1.33×10^6
4000	.122	8.20	410,000	820,000
3000	.177	5.65	282,000	565,000
2000	.230	4.35	217,500	435,000
1000	.284	3.52	176,000	352,000
500	.317	3.15	158,000	315,000

E) Payload-Range Diagrams

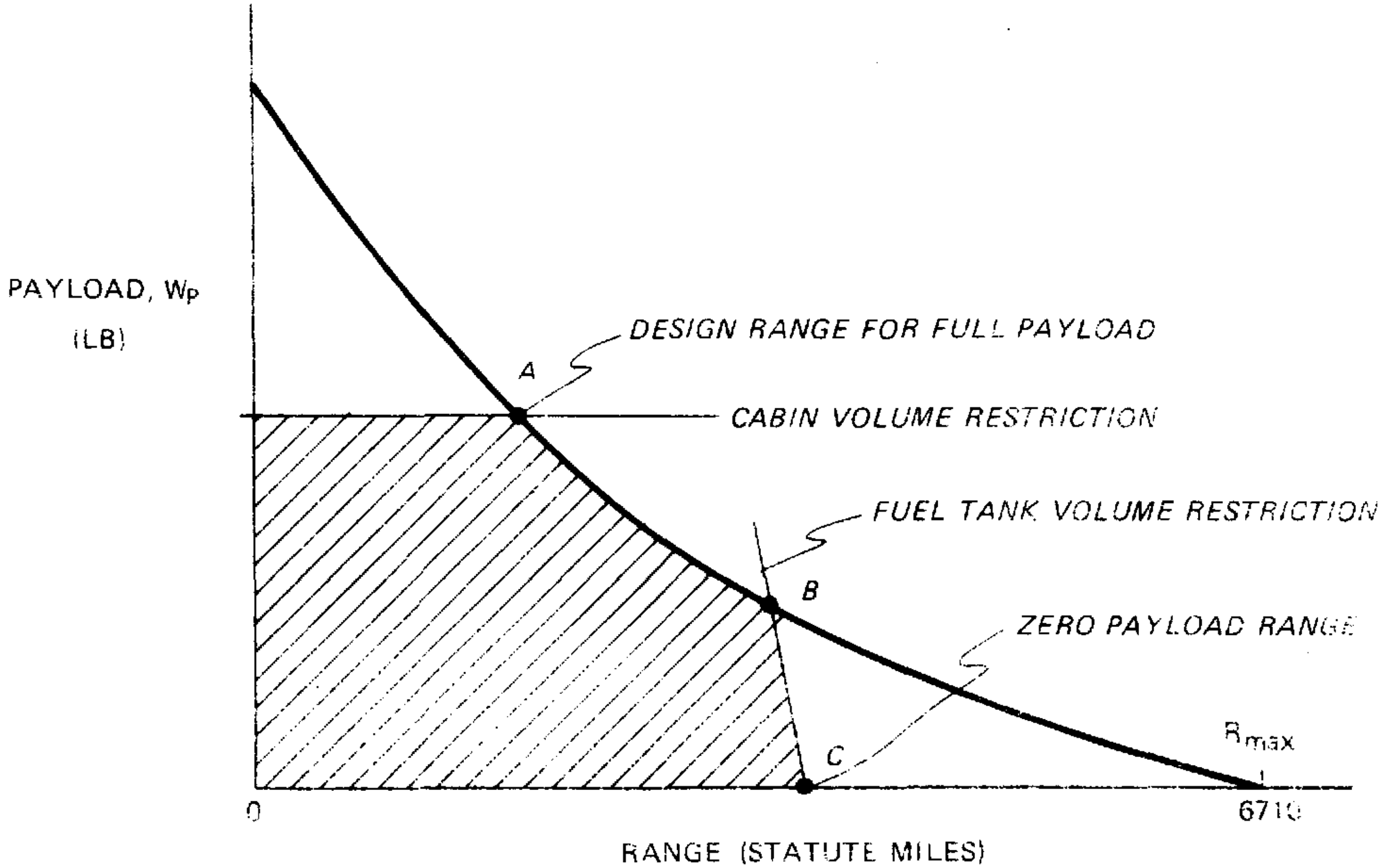
Having chosen the design range point for a given payload weight, there are two volume decisions which subsequently must be made. First, a fuselage volume must be selected to comfortably house a number of passengers corresponding to the payload, or a cargo load of a given density, or container configuration. Secondly, a fuel tank volume must be selected.

The fuselage volume restriction prevents the addition of passengers or cargo on trips of shorter than design range where the fuel load can be reduced. The fuel volume restriction prevents extending the ranges on trips where less than full payload is being carried. These volume restrictions are shown in Figure 8.

Point A is the design range for full payload. Point B is a point where the fuel tanks are completely filled and a reduced payload is carried. Along the lone AB the aircraft operates at full gross weight, and trades off payload and fuel load. Point C is the zero payload range, and the aircraft takeoff weight is reduced from the maximum gross weight as we move along the line BC. Any payload-range point inside the shaded area can be handled by the aircraft by operating at reduced gross weights.

By choosing different volumes, the designer establishes points A and B, and can provide quite different range-payload performance for transport aircraft of constant gross weight as exemplified by the exponential curve which is now dimensional on Y-axis.

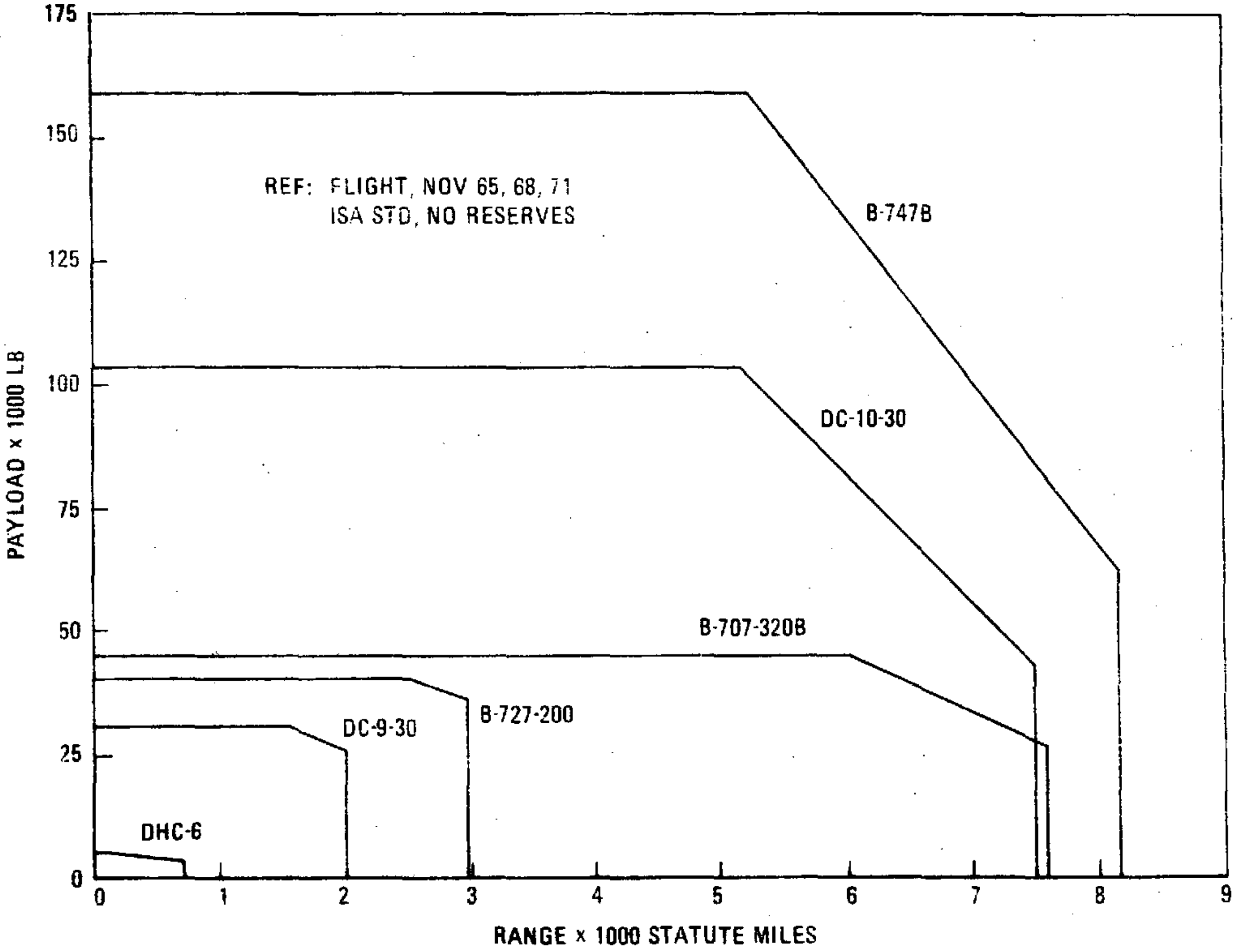
Figure 8 VOLUME RESTRICTIONS ON RANGE-PAYLOAD PERFORMANCE



We now have derived one of the two basic diagrams describing transport aircraft performance. It is called the "payload-range" diagram. Payload-range diagrams for various current jet transports are shown in Figure 9. Since smaller aircraft are cheaper to own and operate, airlines buy several kinds of aircraft even at a given level of technology to match their fleet capabilities to their traffic loads on routes of varying distances. Traffic load points should be kept near the outer boundaries of the range-payload diagrams for profitability. This will be shown later using the second basic diagram, the direct operating cost-range curve.

As technology improves, a smaller gross weight airplane can be constructed to provide the same payload-range capability at lower costs. For long range aircraft, these technology improvements can provide spectacular changes in gross weight. For example, if the present cruise engines of SFC = 0.60 did not exist, a transport aircraft of the general size of the B-747 (i.e. the second aircraft in Table 3, Range = 4000 miles, Payload = 100,000 lbs) would increase in gross weight from 820,000 lbs to 1.67 million lbs. if the cruise SFC were only 0.8. One can safely say that the C-5A, B-747, DC-10, L-1011, etc. would not have been built if it were not for the development of this better engine technology. The construction of new engines of smaller thrust will similarly cause new smaller transports to be built in future years to replace the present DC-9 and B-727.

Figure 9 PAYLOAD-RANGE DIAGRAMS FOR CURRENT TRANSPORT AIRCRAFT



F) Direct Operating Cost

F.1 Effects of Size and Range on Operating Cost

We shall now discuss the second basic diagram describing transport aircraft performance, the direct operating cost curve, or DOC curve. The direct operating costs are made up of crew, fuel, maintenance, and depreciation costs directly associated with operating the aircraft. A fuller discussion of total airline costs is the subject of a separate lecture. In this section we shall make some observations on the effects of aircraft size and range (as determined by technology) on these operating costs.

We shall use a single cost measure, FC_{HR}, the flight operating costs per block hour to show the effects of size as measured by the gross weight, W_G, and range as measured by the full payload-design range. Figure 10 shows a typical result of FTL computer design studies for CTOL jet transports. For a level of technology described as 1970 technology, it shows a linear variation of hourly costs with gross weight (or payload size) for a given design range. However, there is also a variation with design range, so that a set of linear rays far out from a zero weight point of 100 \$/block hour. The hourly costs for current transport aircraft are shown in Figure 10. The rays correspond to a level of technology used in the DC-10 and B-747 aircraft, and good agreement is shown for those aircraft.

The positive intercept at zero gross weight causes an economy of scale as aircraft size is increased for a given design range. We will show this by introducing another basic cost measure, FC_{SHR}, the flight operating cost per seat hour. The variation of FC_{SHR} as payload is increased (shown for a design range of 1000 s. miles) is given by Figure 11(a). Obviously, there is a significant economy of scale as payload increases from 50 passengers (5.40 \$/seat hour) to 200 passengers (3.64 \$/seat hour). Note that the gains are not significant after that size, but there clearly are benefits from introducing

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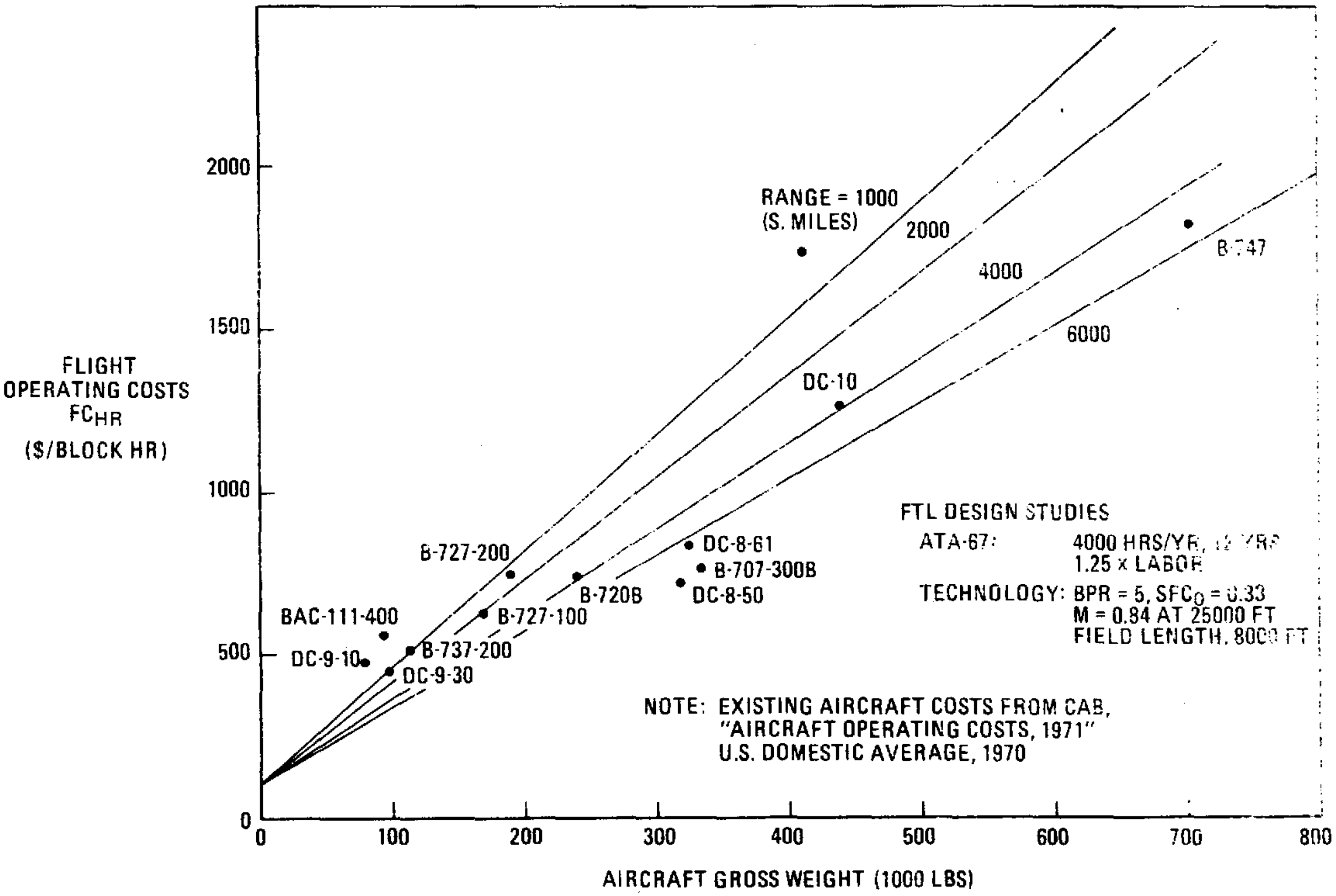
Figure 10 OPERATING COSTS PER BLOCK HOUR versus GROSS WEIGHT AND RANGE



NOTE: EXISTING AIRCRAFT COSTS FROM CAB,
"AIRCRAFT OPERATING COSTS, 1971"
U.S. DOMESTIC AVERAGE, 1970

Figure 11 EFFECT OF PAYLOAD SIZE ON FLIGHT COSTS PER SEAT HOUR

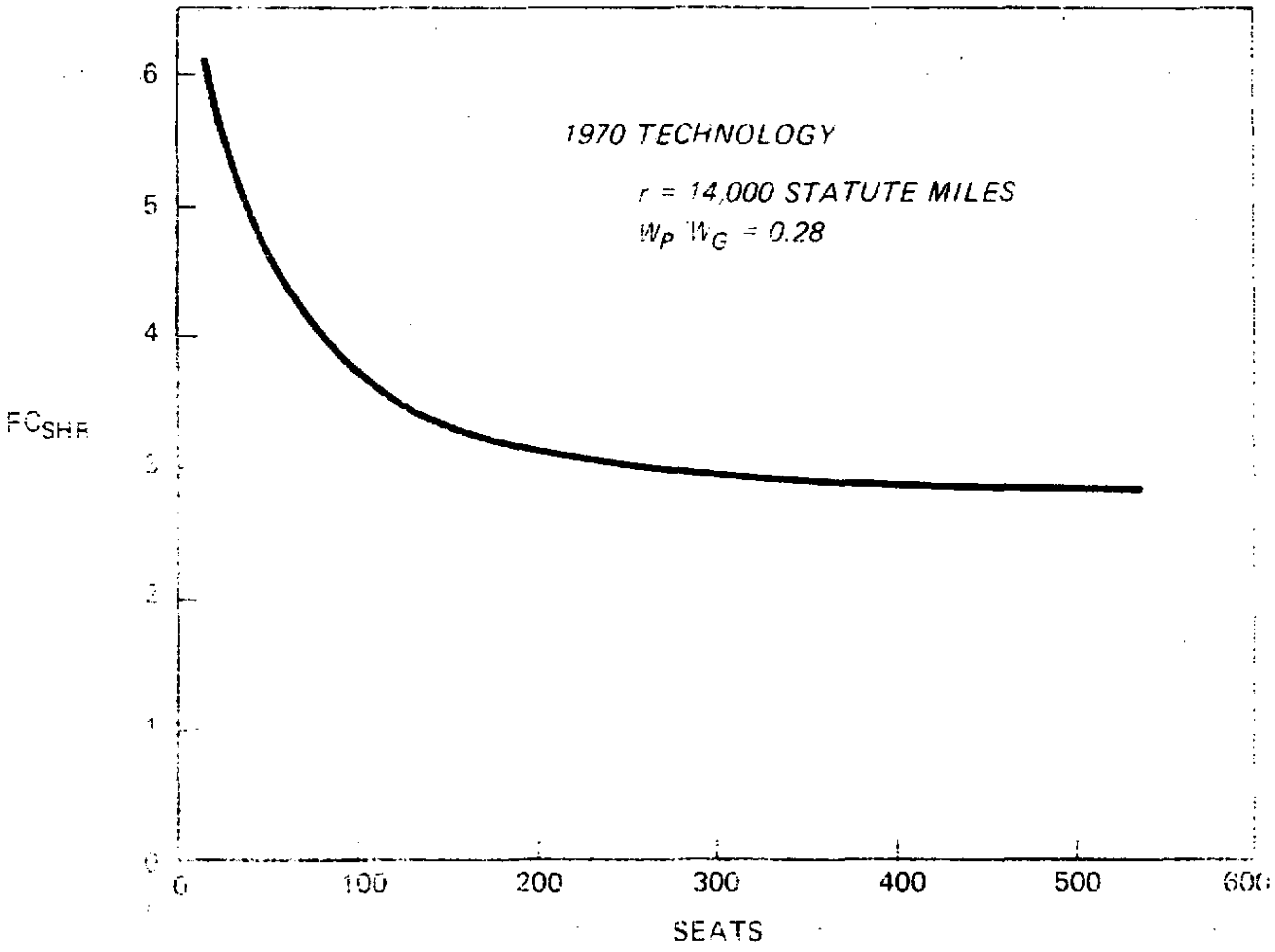


Figure 11a EFFECT OF PAYLOAD SIZE ON FLIGHT COSTS PER SEAT HOUR

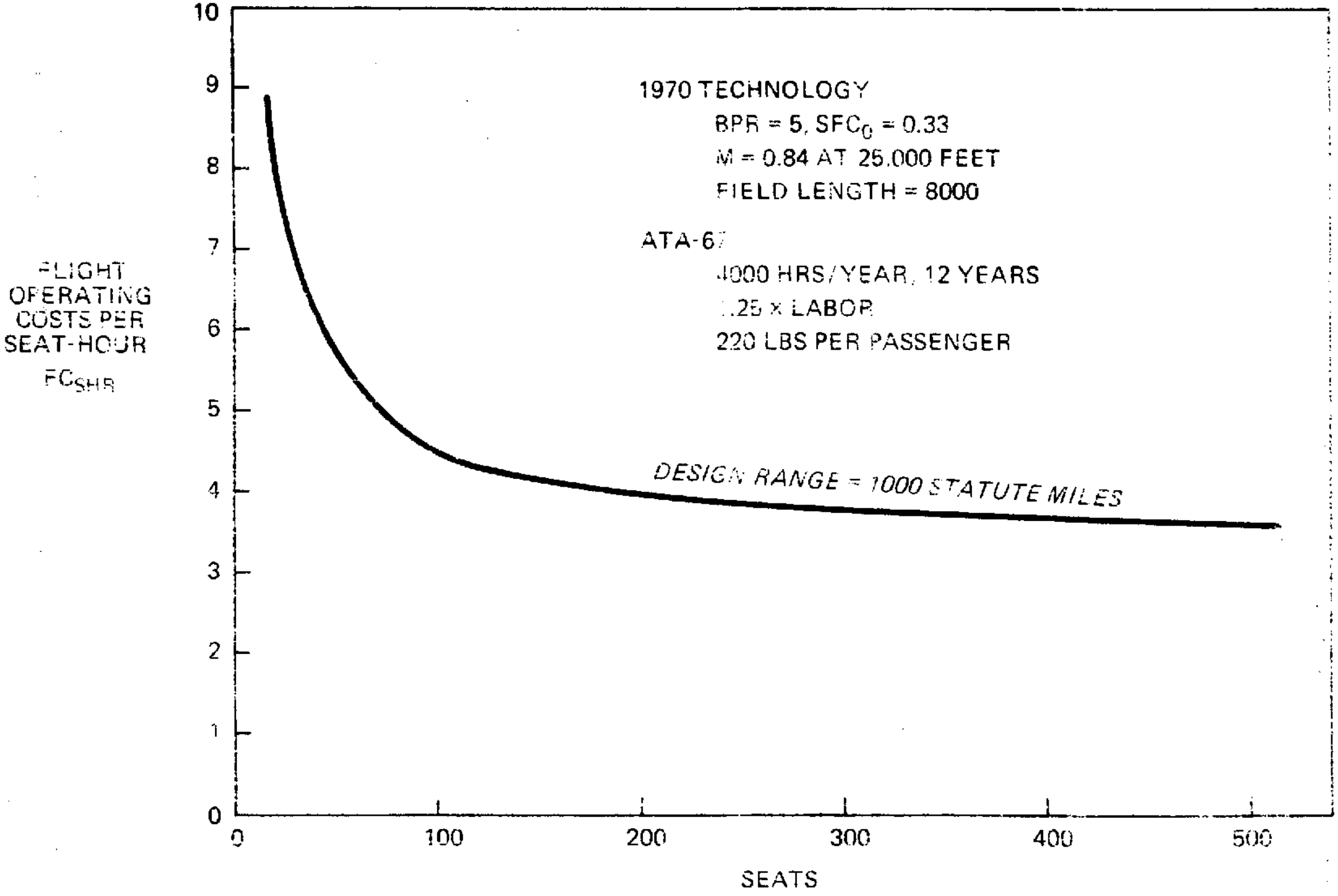
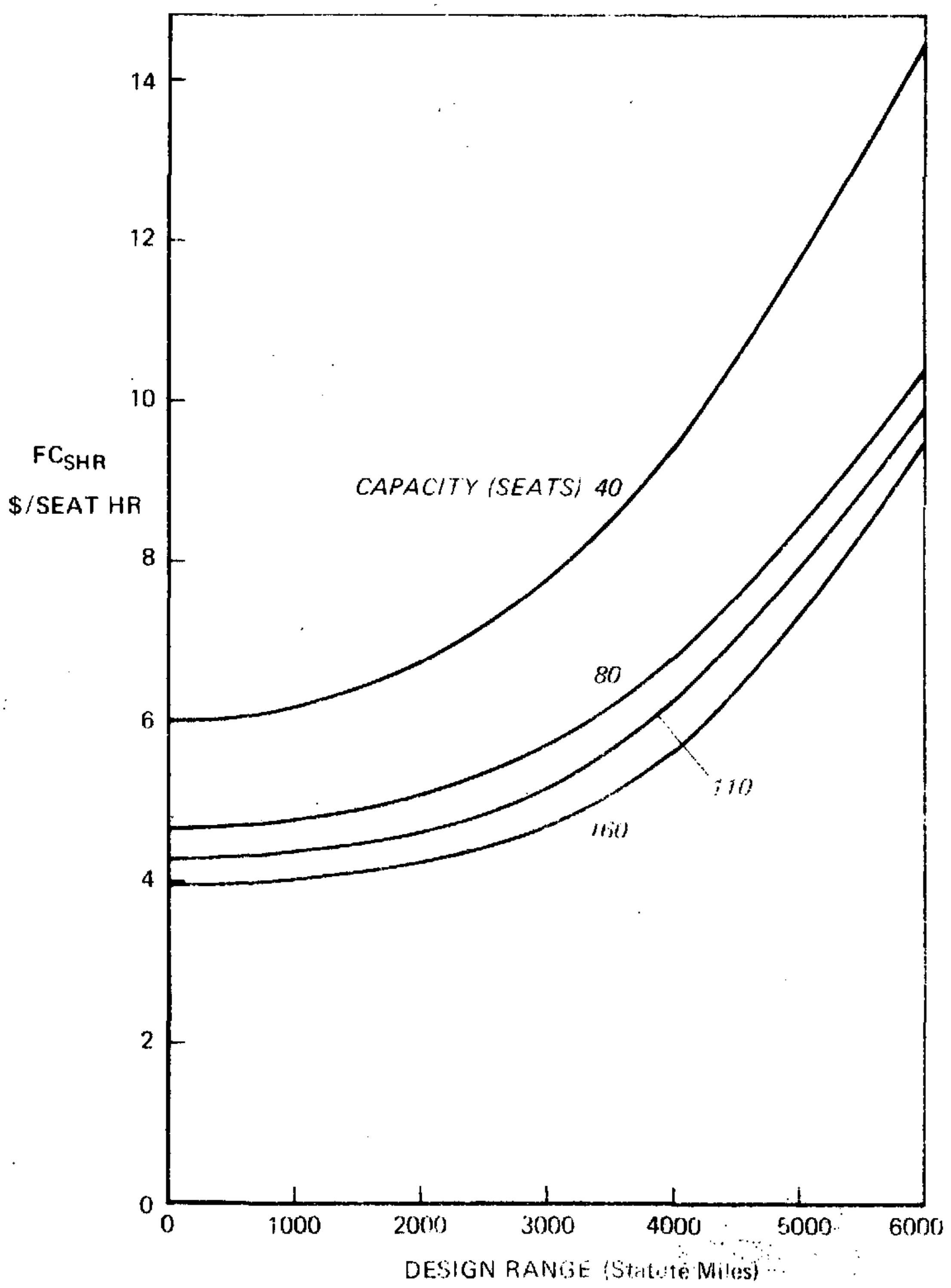


Figure 11b EFFECT OF DESIGN RANGE ON FLIGHT COSTS PER SEAT HOUR



larger size aircraft whenever traffic loads warrant their usage.

The variation of FC_{SHR} with design range at constant payload is shown by Figure 11(b). Here as range is increased, there is an exponential growth in FC_{SHR}, so that for a given payload size, there are benefits from using the shortest design range vehicle which will perform the task. Figure 11(b) shows the effect of size and range simultaneously, (a crossplot of the 1000 mile design range points actually produce Figure 11(a).) Notice that a smaller, but lesser design range vehicle can be cheaper than a larger, but longer design range vehicle. The cheapest vehicle is the one designed for exactly the payload and range of the transportation task to be performed. Using a larger vehicle is cheaper per seat, but not cheaper per passenger.

F.2 Derivation of DOC Direct Operating Costs ($/available seat mile)

For a given aircraft, we can compute the operating cost per hour, FC_{HR}. From this basic cost measure, we can derive the DOC curve in terms of cents per available seat mile versus range. We shall now show this derivation.

First, we must know the variation of block time with range. This is shown in Figure 12 as a linear form, where the slope of the curve is inversely proportional to cruise speed, V_{CR} and the zero distance intercept accounts for taxi time, takeoff and landing times, circling the airport for landing and takeoff, and any delays due to ATC congestion. This curve can be obtained by plotting scheduled times versus trip distance, and Figure 12 shows a typical result.

Figure 12 BLOCK TIMES FOR DOMESTIC SERVICE

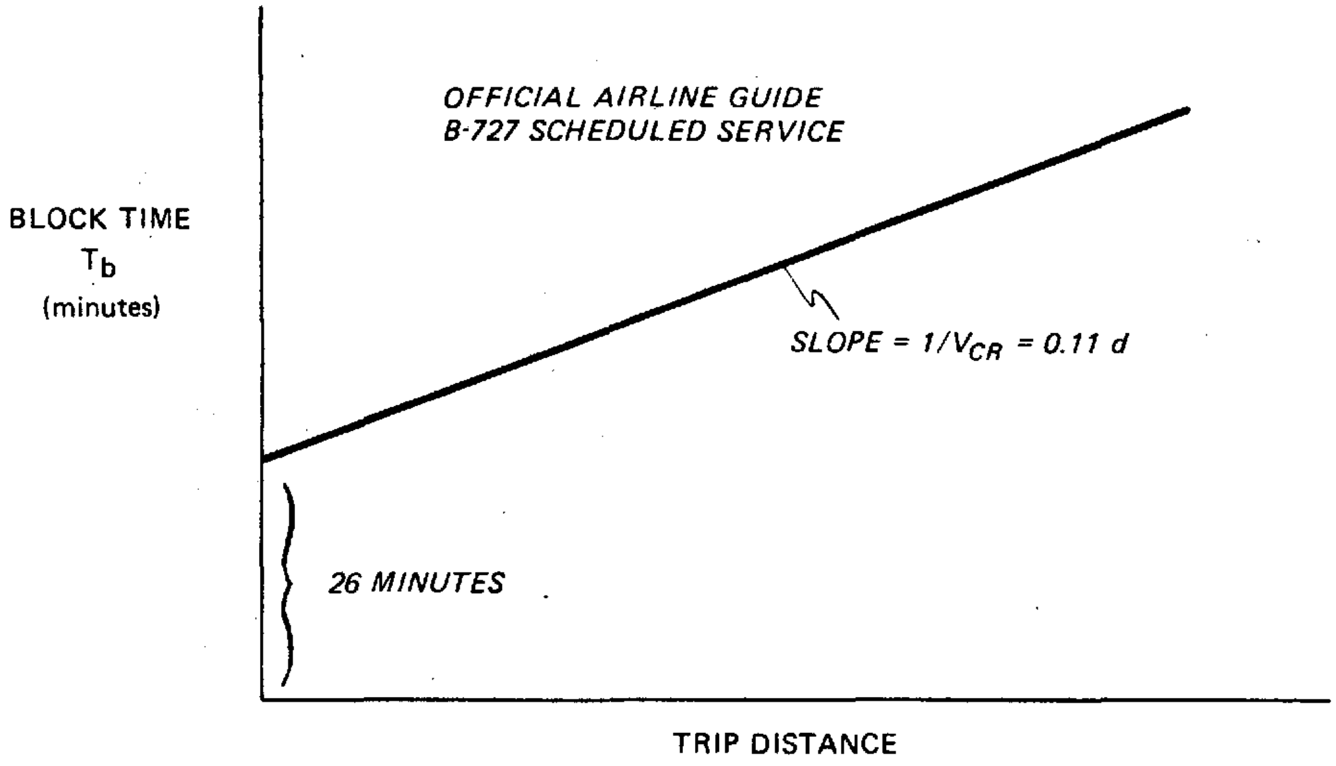


Figure 13 BLOCK SPEED VARIATION WITH TRIP DISTANCE

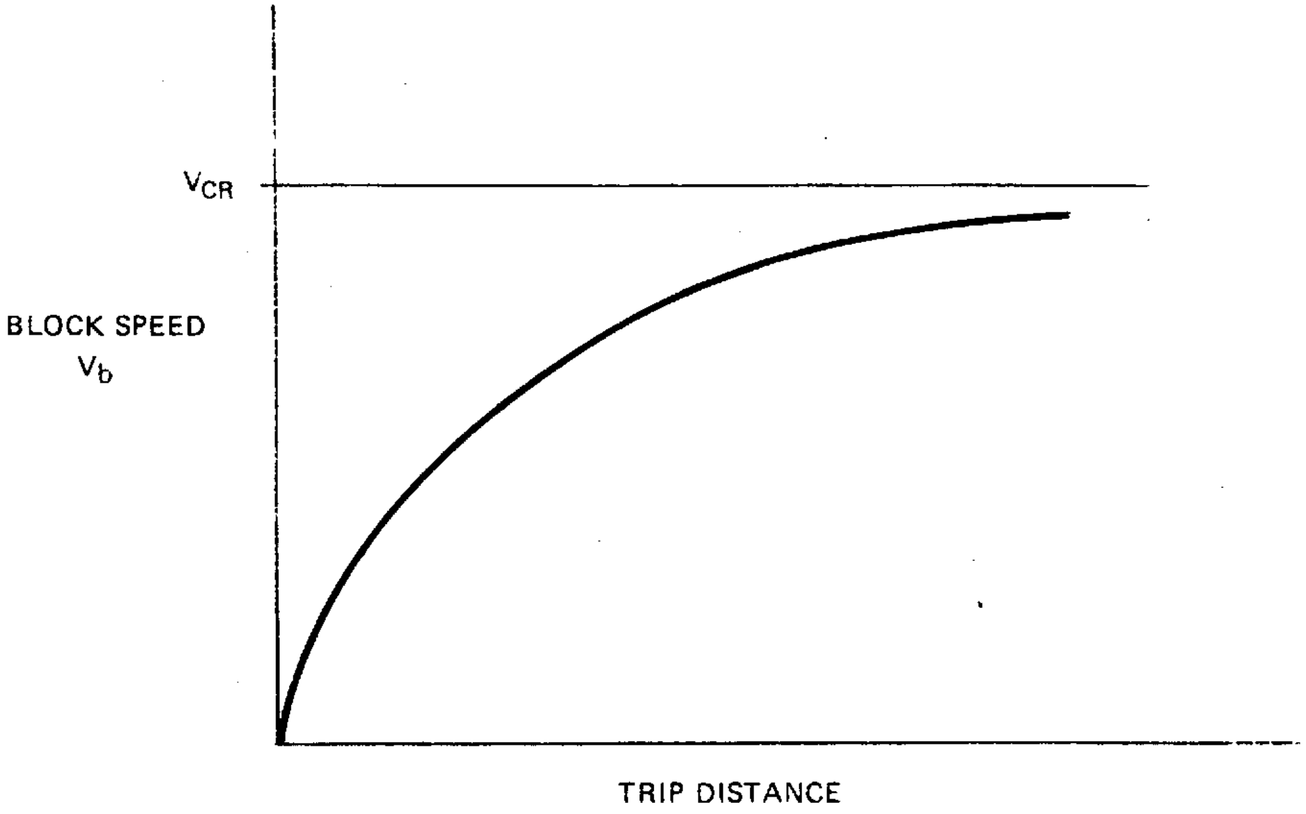
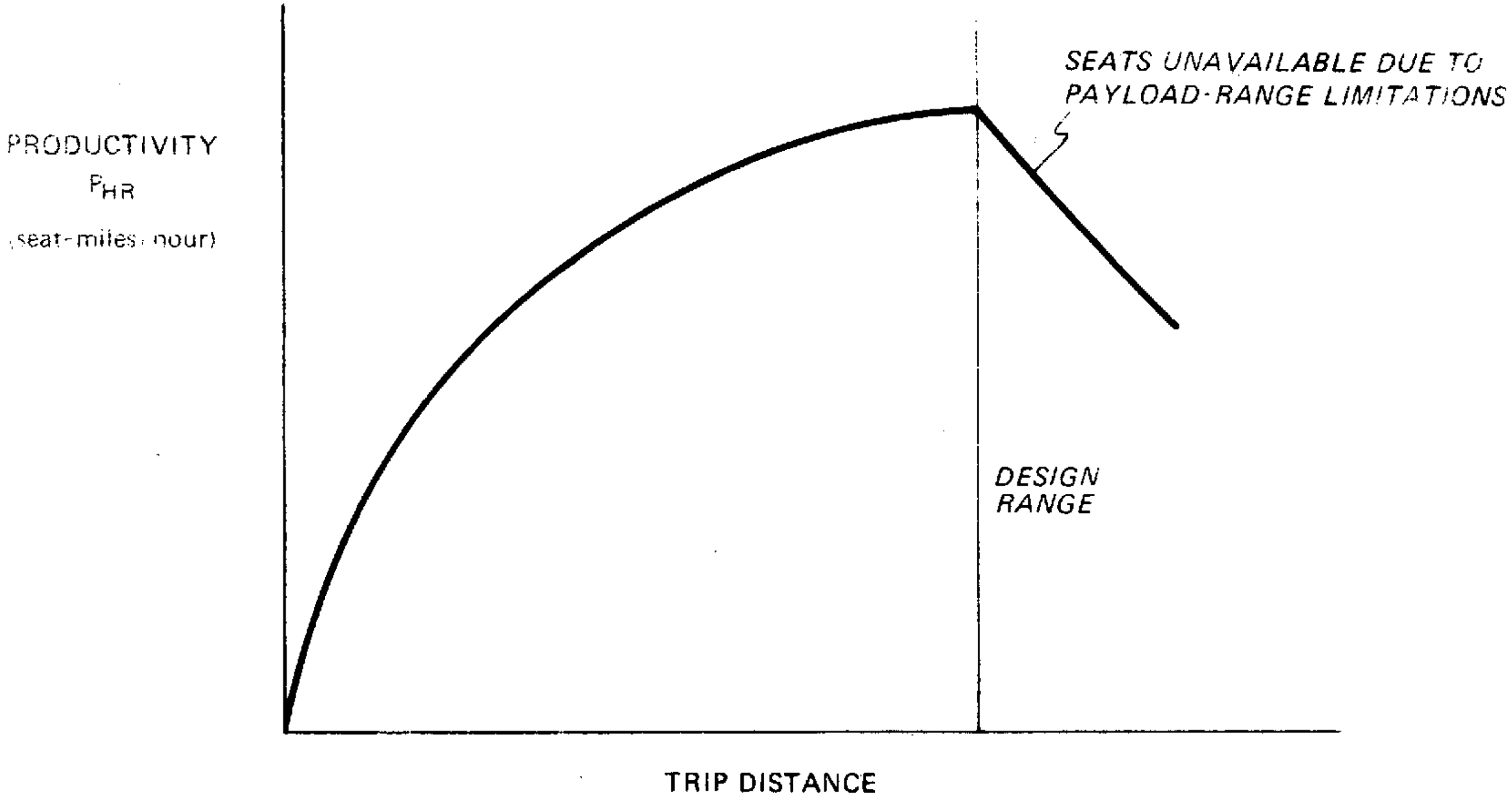


Figure 14 VARIATION OF PRODUCTIVITY WITH TRIP DISTANCE



If we compute block speed, V_b, as trip distance divided by block time, we get the asymptotic curve shown in Figure 13 where at longer ranges, the blockspeed begins to approach the cruise speed.

If we define P_{HR} = productivity per hour in terms of seat-miles per hour where S_a = available seats for a given trip, then a curve shown in Figure 14 is obtained. It is proportional to the V_b curve up to the full payload design range point where the number of available seats begins to be reduced causing the aircraft productivity to decrease after that point.

Now if we divide the hourly cost by the hourly productivity, we obtain the second basic diagram for transport aircraft, the DOC curve (Direct Operating Cost).

$$DOC = \frac{FC_{HR}}{P_{HR}} = \frac{\$ \text{ /hour}}{\text{seat miles/hour}} = \$\text{/available seat mile}$$

Since FC_{HR} is a constant, this curve is the inverse of the P_{HR} curve and produces the form shown in Figure 15, where DOC is high for short trips, decreases towards the design range point, and increases thereafter.

If we consider different payloads and ranges for the DOC curve, we see that a 50 seat vehicle is more expensive than a 100 seat vehicle, and a vehicle designed for 1000 miles will be cheaper than one designed for 2000 miles as stated previously.

Figure 15 VARIATION OF DOC WITH TRIP DISTANCE

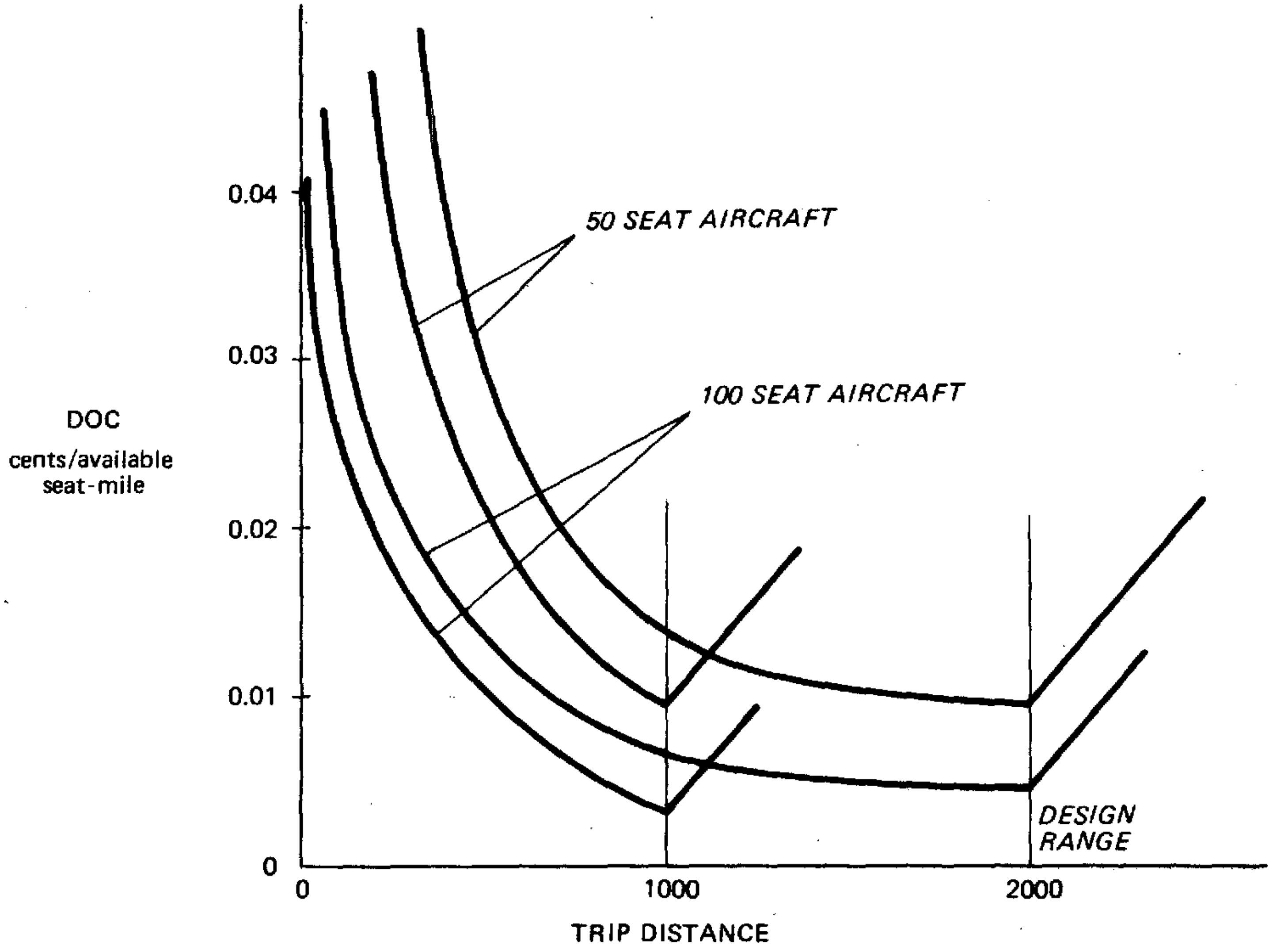


Figure 16   VARIATION OF FLIGHT TRIP COST WITH TRIP DISTANCE

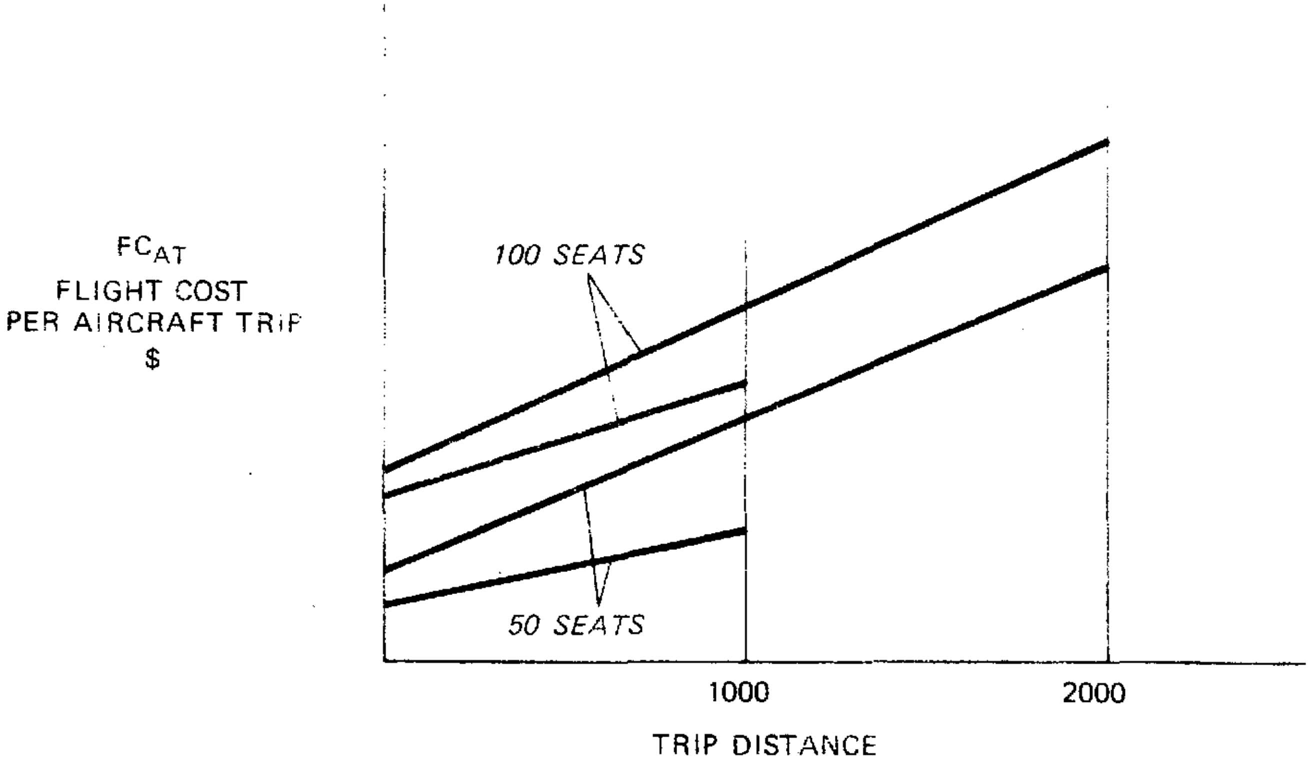
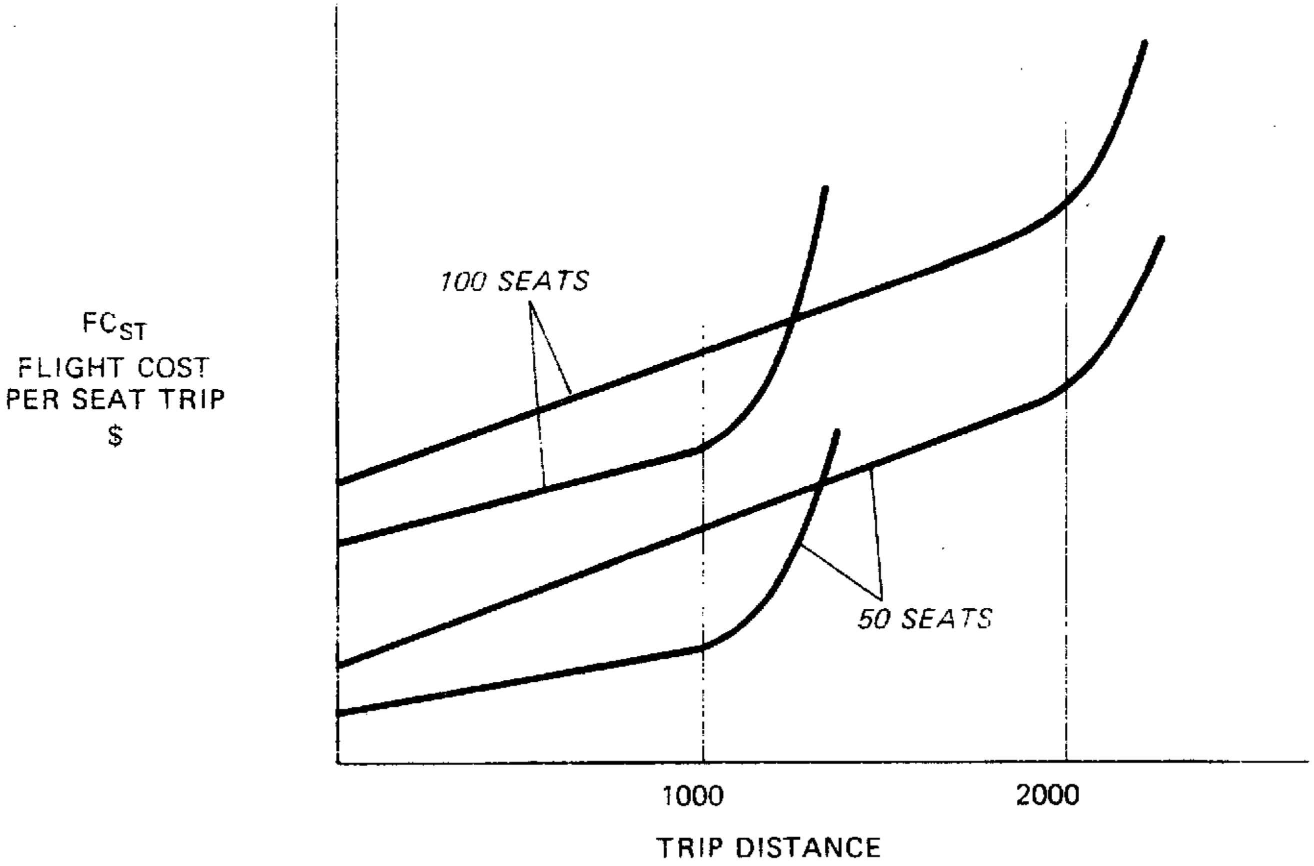


Figure 17 VARIATION OF FLIGHT TRIP COST/SEAT WITH TRIP DISTANCE



These curves may cross so that a smaller, shorter range vehicle is cheaper at certain ranges than a larger, longer range vehicle.

Because of this hyperbolic shape, it is easier to work with trip cost measures which have a linear form with distance since they are proportional to block time. We define two trip cost measures here:

FC_{AT} = flight cost per airplane trip = $c_1 + c_2 d \approx FC_{HR} \cdot T_b$

where c_1 and c_2 are know cost coefficients

FC_{ST} = flight cost per seat trip = $\frac{FC_{AT}}{S_a}$

where S_a = available seats

The form of EC_{AT} and FC_{ST} with distance is shown in Figures 16 and 17. After design range, where S_a is decreasing FC_{ST} becomes non-linear.

Generally, these trip cost measures are easier to understand and more useful than the DOC curve with its hyperbolic shape. One needs only to compute c_1 and c_2 for a given airplane and cruise schedule, and know the variation of available seats with trip distances

It must be emphasized that because of the strong variation in DOC with trip distance, any value quoted for DOC is meaningless unless accompanied by a value for trip distance. This point is often forgotten by economists, laymen, and inexperienced systems analysts.

G) Profitable Load Diagrams

The two basic diagrams, range-payload and DOC, may be combined to form a "profitable load" diagram of certain major assumptions are made:

1) It is necessary to assume a variation of revenue yield with distance. While a fare formula may be known, yield for a given route is an average net contribution in terms of dollars per passenger computed by taking into account the mix of standard and discount fares, sales commissions, taxes, and perhaps short term, variable indirect operating costs per passenger arising from ticketing, reservations, passenger handling, etc. Here we assume Y is linear with trip distance.

2) It is necessary to assume a variation of total costs, TC with distance, or to ignore allocation of overhead costs and produce a short term profit (or contribution to overhead) diagram. Here we shall assume that short term total operating seats per seat trip, TC_{ST} have the same linear form as the flight costs, FC_{ST}.

The usual relationship of Y and TC_{ST} is shown on Figure 18 where the linear forms cross at some short range. The result is a hyperbolic form for breakeven load decreasing to very low values at design range as shown in Figure 10. As with DOC, any value quoted for breakeven load factor must be accompanied

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Figure 18 VARIATION OF TOTAL COSTS AND YIELD WITH TRIP DISTANCE

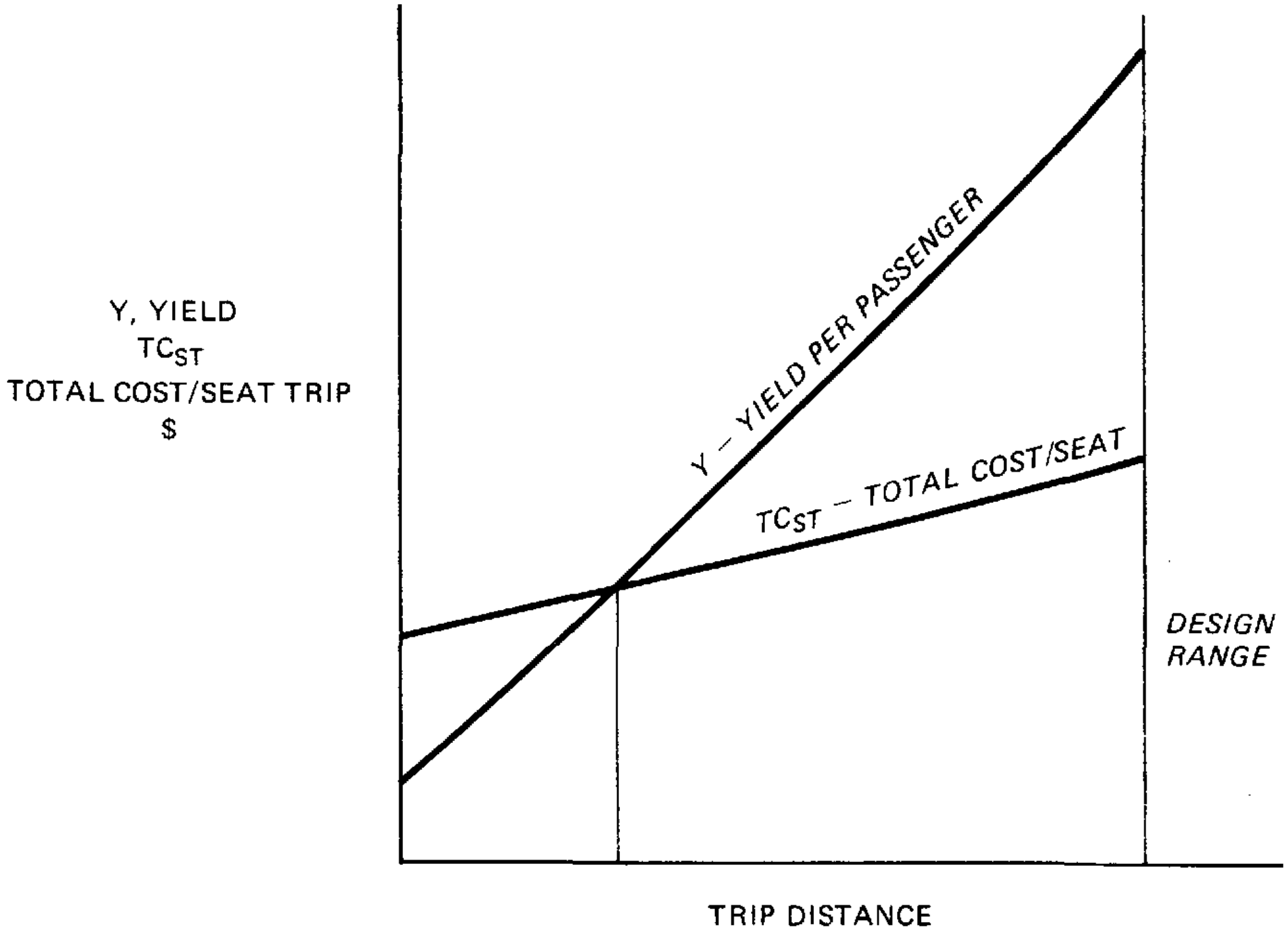
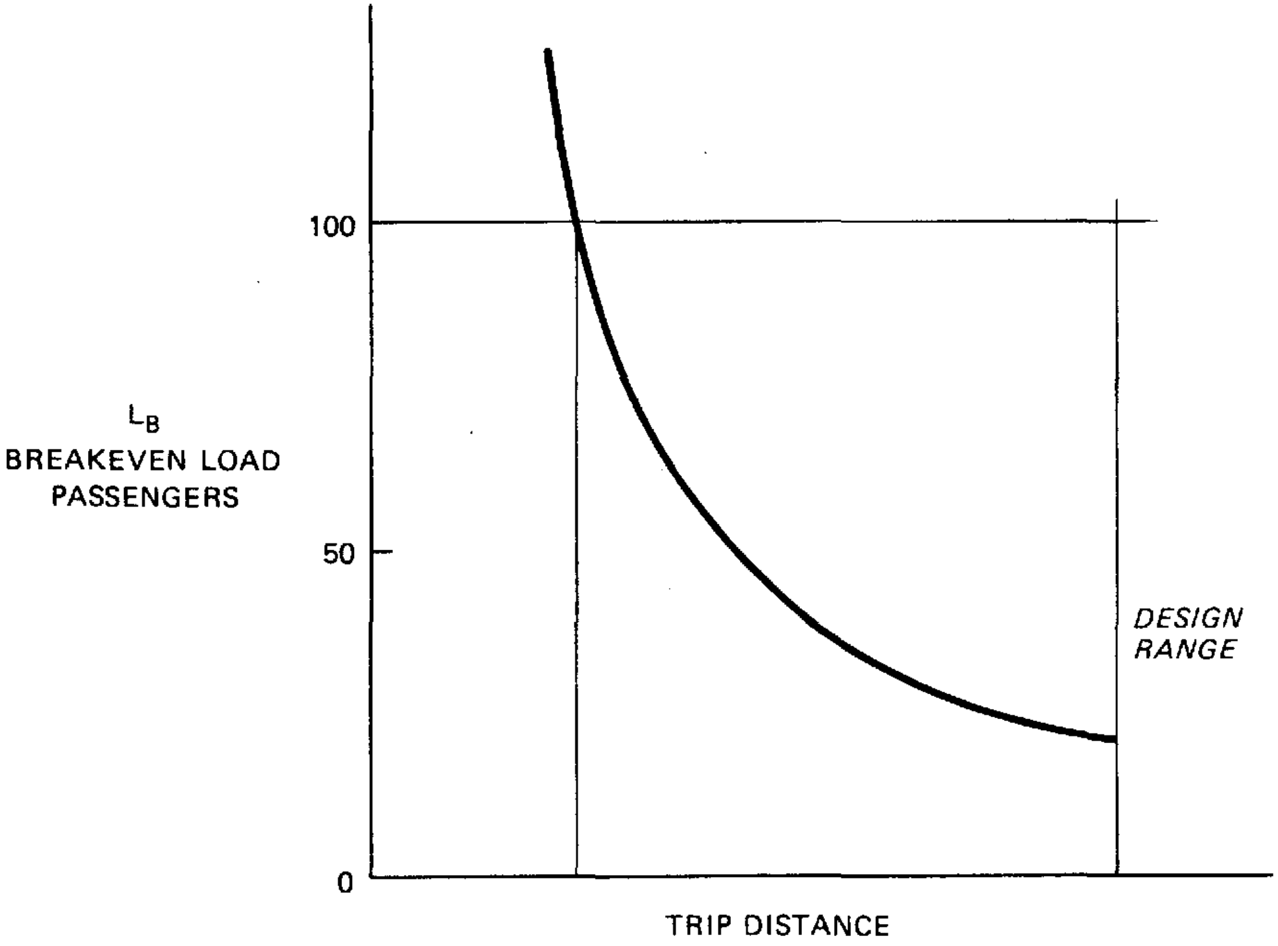


Figure 19 TYPICAL VARIATION OF BREAKEVEN LOAD WITH DISTANCE



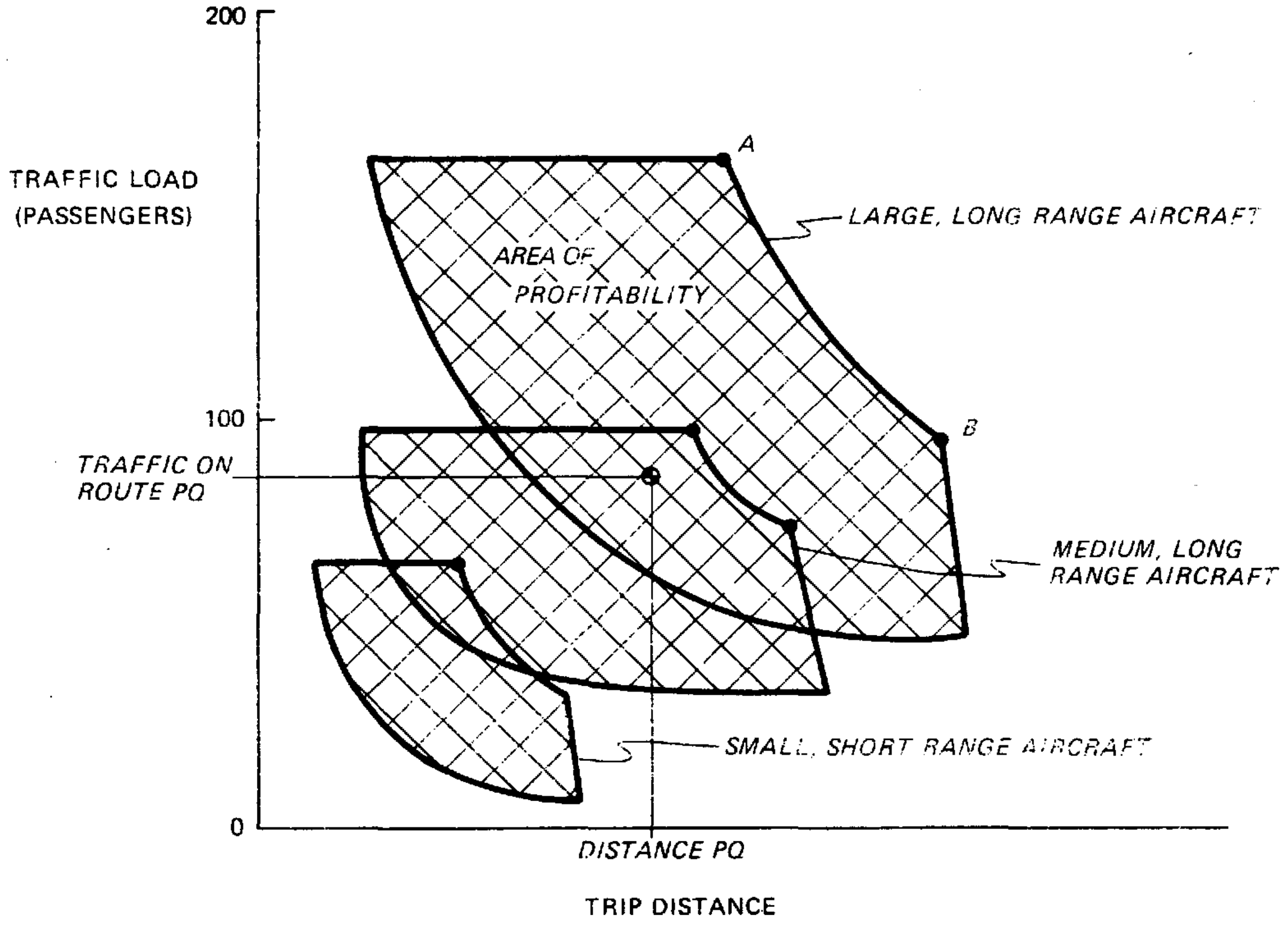
by a quoted value for trip distance.

The payload-range and breakeven load curves can now be combined to form a "profitable" load diagram as shown in Figure 20. The shaded areas represent points where a "profit" can be made using the aircraft to carry a given load over this trip distance. If the areas overlap, it is preferable to choose an aircraft where the point lies close to the upper boundary of payload-range limits since it is more profitable. E.g., choose the medium range aircraft for point PQ in Figure 20.

Notice that the profitable load diagram cannot be uniquely associated with a particular aircraft because of its assumptions. It must be associated with an airline and a set of routes since the indirect costs are specific to the airline, and the yield values are specific to a set of routes or city pairs. Thus when profitable load diagrams are shown, these additional data should be quoted.

Notice also that the hyperbolic form of the breakeven load curve is due to the differing slopes of the yield and total cost curves with trip distance. If yields, or fares were proportional to cost over distance, then the breakeven load would be constant with trip distance. Recent fare changes have moved fares much into line with costs by raising the zero distance intercept for coach fares

Figure 20 PROFITABLE LOAD DIAGRAMS



from \$6.00 to \$12.00. This provides much lower breakeven loads for shorter distance trips.

H) The Price of Transport Aircraft

As mentioned earlier, the purchase price and therefore depreciation costs are proportional to aircraft size. To demonstrate this Figure 21 shows a plot of current prices against aircraft operating empty weight. A good fit is given by the curve,

$$P_a = 1.9 \times 10^6 + 66.W_E \qquad \$$$

where P_a = fully equipped market price

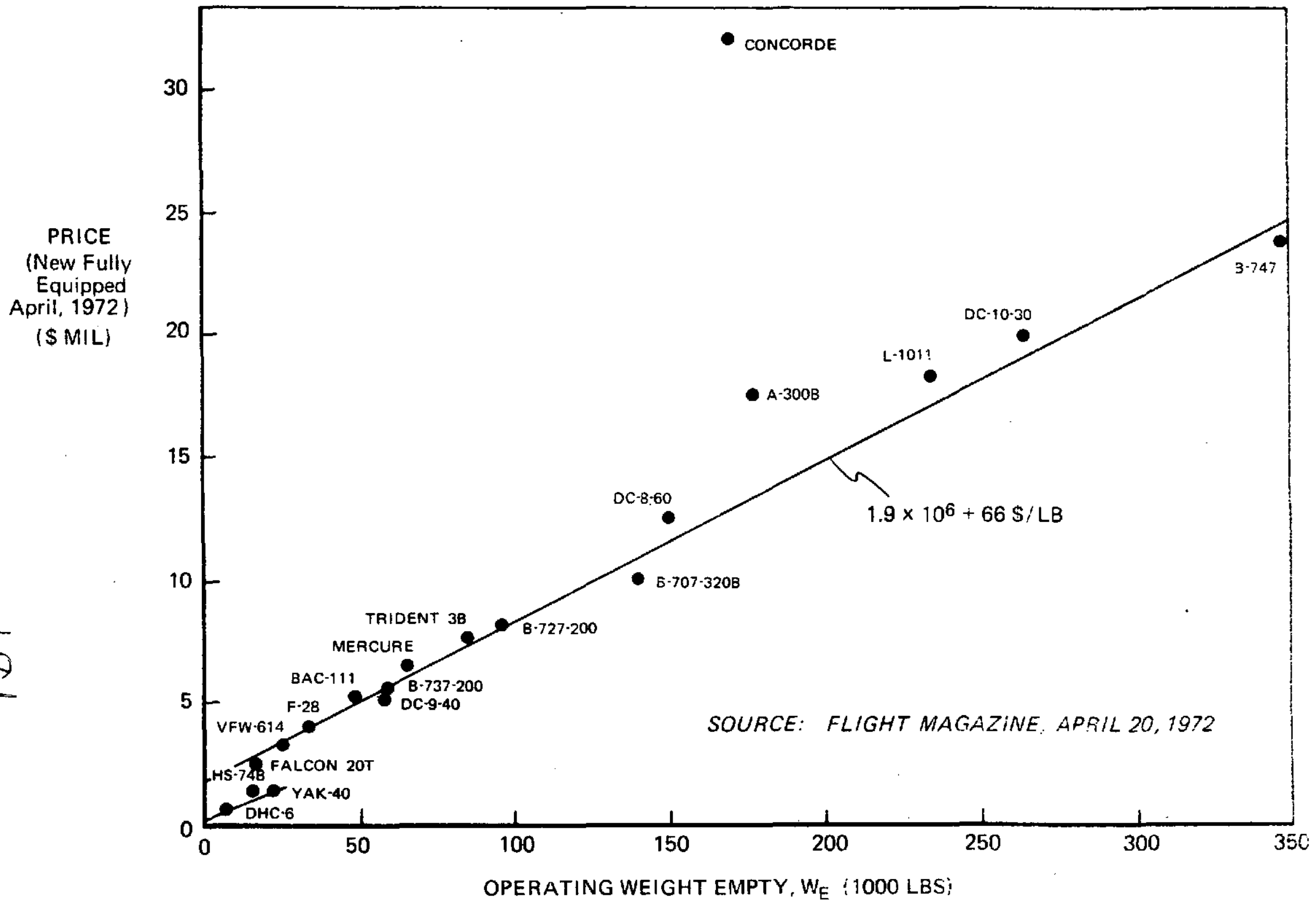
W_E = basic operating weight empty

This correlation does not mean that W_E is the causative factor in determining the price which a manufacturer will decide to establish for his new product. Competition from existing aircraft, the expected size of the production run, etc. are factors which he considers closely. It is merely interesting to note the correlation with empty weight.

Notice also, that the DHC-6, a simple STOL transport from Canada, and the YAK-40, a new entry in world markets from Russia, are well below the minimum price for conventional transport aircraft from the Western world.

A set of data on prices for current new and used jet transports taken from the weekly editions of Esso's "Aviation News Digest" is given by Table 4. There is considerable variation in unit prices which may be due to various amounts of aircraft spares included with the purchase.

Figure 21 THE PRICE OF CURRENT TRANSPORT AIRCRAFT



SOURCE: FLIGHT MAGAZINE, APRIL 20, 1972

Table 4. ACQUISITION PRICES FOR NEW LONG-RANGE TRANSPORT AIRCRAFT

SERIES	Month of Purchase	Airline Purchaser	Aircraft	Number Purchased	Total Price Millions of $)	Price/Aircraft (Millions of $)
B-747	April 1972	World Airways	B-747C	3	100.00	33.33
	November 1971	Japan Airlines Ltd.	B-747	7	209.80	29.97
	October 1971	Delta Airlines	B-747	1	25.40	25.40
	August 1971	Alitalia	B-747	1	26.00	26.00
	July 1971	Qantas Airways	B-747	1	28.30	28.30
	May 1971	South African Airways	B-747B	2	48.00	24.00
	February 1971	British Overseas Airways Corp.	B-747	4	108.00	27.00
DC-10	May 1972	Continental Airlines	DC-10	4	83.00	20.72
	April 1972	Iberia	DC-10	3	72.80	24.27
	March 1972	Martinair	DC-10F	1	23.00	23.00
	March 1972	Laker Airways	DC-10	2	47.30	23.65
	January 1972	Trans-International Airlines	DC-10 (cargo)	3	57.00	19.00
	December 1971	Scandinavian Airlines System	DC-10-30	2	58.00	29.00
	October 1971	Western Airlines	DC-10-10	4	85.00	21.25
	August 1971	Alitalia	DC-10	4	97.00	24.25
	April 1971	World Airways	DC-10	3	72.00	24.00
	February 1971	National Airlines	DC-10	2	35.00	17.50
	February 1971	Finnair	DC-10-30	2	48.00	24.00
L-1011	November 1971	Court Line Aviation	L-1011	2	48.00	24.00
	January 1971	Pacific Southwest Airlines	L-1011	2	30.00	15.00
A300B	November 1971	Air France	A300B-2	6	75.00	12.50
B707	May 1971	Cathay Pacific Airways	B707-320B	1	8.60	8.60
DC-8	July 1971	Air Congo	DC-8-63	1	14.50	14.50
	June 1971	Scandinavian Airlines System	DC-8-63	1	11.46	11.46
	March 1971	World Airways	DC-8 Super 63	3	40.00	13.33

Source: Weekly editions of Esso's "Aviation News Digest", January 1, 1971 through May 1, 1972.

Table 4 (cont.) ACQUISITION PRICES FOR NEW MEDIUM AND SHORT-RANGE TRANSPORT AIRCRAFT

SERIES	Month of Purchase	Airline Purchaser	Aircraft	Number Purchased	Total Price (Millions of $)	Price/Aircraft (Millions of $)
B-727	May 1972	Continental Airlines	B-727-200	15	119.00	7.93
	April 1972	Ansett Transport of Australia	B-727-200	4	38.80	9.58
	April 1972	Trans Australia Airlines	B-727-200	4	40.15	10.04
	April 1972	Iberia	B-727-200	16	140.30	8.77
	April 1972	Condor Flugdienst	B-727-200	3	30.00	10.00
	April 1972	Delta Airlines	B-727-200	14	100.00	7.14
	March 1972	Western Airlines	B-727-200	2	15.00	7.50
	February 1972	Eastern Airlines	B-727-200	15	115.00	7.67
	October 1971	Western Airlines	B-727-200	3	22.50	7.50
	May 1971	Tunis Air	B-727-200	1	9.70	9.70
	April 1971	Ansett Transport of Australia	B-727-200	6	69.75	11.63
DC-9	April 1972	United States Navy	DC-9	5	25.30	5.06
	April 1972	Yugoslovenski Aero Transport	DC-9-30	6	30.00	5.00
	October 1971	Iberia	DC-9	11	67.50	6.14
	August 1971	Alitalia	DC-9	1	5.50	5.50
	June 1971	Austrian Airlines	DC-9	8	38.00	4.75
	February 1971	Scandinavian Airlines System	DC-9	5	27.30	5.46
BAC-111	January 1971	Fiji Airways	BAC-111-475	1	3.60	3.60
B-737	April 1972	Pacific Western Airlines	B-737-200	2	10.90	5.45
	April 1972	Malaysian Airlines System	B-737-200	18	112.00	6.24
	November 1971	Pacific Western Airlines	B-737	1	5.00	5.00
	October 1971	Saudi Arabian Airlines	B-737	5	37.30	7.46
	October 1971	Malaysian Airlines	B-737	6	41.50	6.92
	August 1971	Air Algerie	B-737-200	1	7.00	7.00
	August 1971	Braathens SAFE	B-737	1	4.30	4.30
	August 1971	Southwest Airlines	B-737	1	5.00	5.00
	April 1971	National Airways Corp	B-737-200	1	4.50	4.50
	March 1971	Pacific Southwest Airlines	B-737-200	1	4.70	4.70
Mercure	February 1972	Air Inter	Mercure	10	80.00	8.00

Source: Weekly editions of Esso's "Aviation News Digest", January 1, 1971 through May 1, 1972

Table 4 (cont.) ACQUISITION PRICES FOR USED TRANSPORT AIRCRAFT

SERIES	Month of Purchase	Airline Purchaser	Aircraft Seller	Aircraft	Number Purchased	Total Price (Millions of $)	Price/Aircraft (Millions of $)
B-707	April 1972	China Airlines	Continental Airlines	B-707-324C	1	6.20	6.20
	Decem 1971	Transavia Holland	American Airlines	B-707-123B	1	3.60	3.60
	Novem 1971	Trans American Airways	Braniff International	B-707-320C	1	4.85	4.85
	Oct 1971	Cathay Pacific Airways	Northwest Airlines	B-707-320B	2	10.00	5.00
	August 1971	Varig Airlines	American Airlines	B-707-320C	1	2.40	2.40
	July 1971	BEA Airtours	Britist Overseas Airways Cor.	B-707-436	7	10.30	1.47
DC-8	April 1972	Japan Airlines Ltd.	Eastern Airlines	DC-8-61	3	20.40	6.80
	Novem 1971	Intersuede Aviation AB	Eastern Airlines	DC-8-51	2	6.00	3.00
	Oct 1971	Air Jamaica	McDonnell Douglas Corp	DC-8-51	1	2.90	2.90
	Oct 1971	Icelandic	Seaboard Airlines	DC-8-63F	1	10.80	10.80
	July 1971	Air New Zealand	United Airlines	DC-8-52	2	3.70	1.85
B-727	Decem 1971	Braniff International	Boeing Allegheny Frontier Grant Aviation	B-727	13	87.30	6.71
	Sept 1971	Aerovias Nacionales(Colombia)	Boeing Corp	B-727-24C	3	9.18	3.08
DC-9	April 1972	Air Canada	Continental Airlines	DC-9	3	6.00	2.00
	Jan 1971	Finnair	McDonnell Douglas Corp	DC-9	8	22.30	2.79
BAC-111	March 1972	Allegheny Airlines	Braniff International	BAC-111	11	14.50	1.32
B-737	May 1971	National Airways Corp	Aloha Airlines	B-737	1	3.80	3.80
Caravelle	Decem 1971	Sterling Airways	United Airlines	Aerospatiale Caravelles	13	6.80	0.52

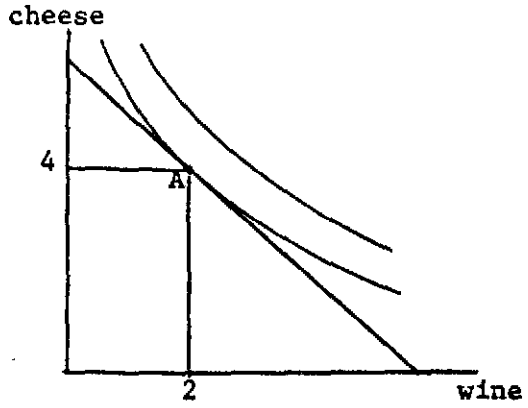
Source: Weekly editions of Esso's "Aviation News Digest", January 1, 1971 through May 1, 1972

Basic Economic Principles

T. Nicolaus Tideman

Economics shares with engineering a concern with solving problems: problems like how to produce shoes efficiently or how to control pollution--or how to design an efficient transportation system. However, the economic approach to solving problems differs from the engineering approach in one crucial way: In an economic context every problem has a solution. Economists achieve this miracle by defining their goals in such a way that doing without something is the correct "solution" if it is too expensive or impossible to obtain it. Thus if pollution can be eliminated only at a prohibitive cost, economists will seek the optimal amount of pollution. If Lockheed loses money no matter what it does, the economic solution is for Lockheed to go out of business.

Formally, the economic approach involves maximizing an objective function that reflects both goals and costs. This idea is sometimes stated incorrectly as, for example, "getting the most pollution control for the least amount of money." A correct statement in words is somewhat cumbersome: The goal is to control pollution at whatever level in a cost-minimizing manner, and to choose the level of pollution control that is most worthwhile considering its minimum cost. Similarly, economists look at the behavior of a consumer as solving a problem in the allocation of time and money. The goal for a consumer is to spend whatever money is earned in the manner that maximizes his satisfaction, or "utility," and to earn that amount of money that is most satisfying considering the disagreeableness of working harder and the satisfaction to be obtained from what the earnings from extra work will buy. Considering for the moment a



choice between just two goods, say wine and cheese, we can associate any pair of quantities of the two goods with a point in the first quadrant of a graph with Cartesian co-ordinates. Thus point A may represent 2 glasses of wine and 4 ounces of cheese. The other combinations of wine and cheese that would be equally satisfying to a consumer will, under reasonable assumptions, be on a curve through A that is convex to the origin. Economists call such a curve an "indifference curve." Combinations that are preferred over A lie on indifference curves farther from the origin. If the prices of wine and cheese are given, the other combinations that can be bought for the same amount of money as A will be on a straight line through A (the budget line), the slope of which is determined by the relative prices of wine and cheese. If A is preferred to all other combinations that can be bought with the same amount of money, then the indifference curve through A must be tangent to the budget line at A. Thus a graphical depiction of a process of consumer maximization involves finding where the boundary of attainable points is tangent to an indifference curve. In a more formal formulation a continuous variable called "utility" is assumed to depend on the quantities of wine and cheese in such a way that each indifference curve corresponds to a different level of utility, with higher levels of utility associated with indifference curves further from the origin. The consumer's problem is then one of maximizing

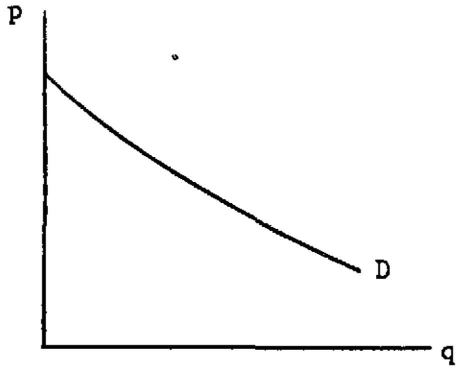
$$U = f(q_w, q_c) \tag{1}$$

subject to the constraint that

$$I = p_w q_w + p_c q_c \ , \qquad (2)$$

i.e., that expenditure be equal to income. To solve this kind of problem economists use Lagrangian constrained maximization techniques. Generalization to more than two commodities is straightforward.

A demand curve can than be derived by finding the quantities of a good that solve the maximization problem as one varies the price of that commodity, holding income and the prices of all other goods constant. Or, more directly, one can say that a demand curve expresses the quantity of a good that a utility-maximizing person will want to buy as a function of the price, assuming that income and all other prices are fixed at given levels, and assuming that the person has no way of affecting the price he pays. For reasons of consistency with historical diagrams, economists always put quantity on the horizontal axes of their graphs and price on the vertical axes, even though they usually think of quantity as the dependent variable. Market demand at any price is obtained by summing the quantities demanded by all persons in the market at that price. Economists are often concerned with the "elasticity of demand," by which they mean



$\frac{dq}{dp} \cdot \frac{p}{q}$, the limit of the ratio of percentage changes in quantity to percentage changes in price along the demand curve.

A supply curve is derived by applying the idea of profit maximization of firms. Technology determines a relationship between inputs and output.

Economists call that relationship a "production function," but we won't delve into it. Suffice it to say that the production function and the prices of inputs determine a "total cost function," C(q) which gives the minimum cost at which any quantity of output can be produced. The profit, π, that a firm makes can be considered the difference between revenues and costs, each of which depend on the quantity of output:

$$\pi = R(q) - C(q) \tag{3}$$

If a firm cannot affect the price at which it sells its output (as in the economists' model of perfect competition), then revenue is simply the product of quantity and that inflexible price:

$$\pi = p \cdot q - C(q) \tag{4}$$

The condition for profit maximization can be obtained by differentiating with respect to q and setting that derivative equal to 0:

$$\frac{d\pi}{dq} = p - \frac{dC}{dq} = 0. \tag{5}$$

Thus

$$\frac{dC}{dq} = p. \tag{6}$$

Economists refer to the derivative of total cost with respect to quantity as "marginal cost," that is, the cost of producing one addition unit. Similarly, the derivative of revenue with respect to quantity is called marginal revenue. Profit maximization involves equating marginal revenue and marginal cost, which, in the cost of a competitive firm means choosing that output where marginal cost is equal to the price received. This is efficient because it means that the prices by which consumers choose how much to buy correspond to the costs of producing what they buy.

There is a second-order condition of profit maximization: Marginal cost must be rising. And one further condition: revenue must be greater than "variable costs," that is the costs that could be avoided by not producing. This condition may also be stated as the condition that price be greater than average variable cost. All three conditions are summarized in the statement that a competitive firm's supply curve is that part of its marginal cost curve that is greater than average variable cost and rising.

A market supply curve is obtained by summing the quantities that all firms would supply at each price. If all firms have the same cost functions, then in the long run, when all costs are variable, a competitive market will supply unlimited quantities at a price that just covers costs. Profit, exclusive of an ordinary return to capital and entrepreneurial effort, is exactly zero.

The competitive result may be contrasted with the profit maximizing outcome when a firm can affect the price of its output by varying the quantity it produces. Then (2) may be written as

$$\pi = p(q) \cdot q - C(q). \tag{7}$$

Differentiating and setting the result to zero,

$$\frac{d\pi}{dq} = \frac{dp}{dq} \cdot q + p - \frac{dC}{dq} = 0. \tag{8}$$

Rearranging,

$$\frac{dC}{dq} = p + \frac{dp}{dq} \cdot q, \tag{9}$$

or

$$\frac{dC}{dq} = p\left(1 + \frac{1}{\frac{dq}{dp} \cdot \frac{p}{q}}\right) \tag{10}$$

In words, a profit-maximizing producer who can affect the price of his product will choose a level of output where marginal cost is equal to price multiplied by one plus the reciprocal of the elasticity of demand. Since the elasticity of demand is negative, this means that marginal cost will be less than price, so that consumers will be economizing on this output inefficiently, treating it as if it were more valuable than it is in terms of resources used in production.

A regulated firm might have no control over the price of its product, but it could affect both revenues and costs through such variables as advertising and frequency of service. An economic analysis would predict that regulated firms would maximize with respect to the variables they did control, setting them at levels where their marginal contributions to revenues equaled their marginal contributions to costs, with appropriate second-order conditions.

For further reading

R. G. Lipsey and P. O. Steiner, *Economics* (Harper & Row).

P. A. Samuelson, *Economics* (McGraw-Hill)

Kelvin Lancaster, *Introduction to Modern Microeconomics* (Rand McNally)--
a more theoretical treatment.

J. M. Henderson and R. E. Quandt, *Microeconomic Theory* (McGraw-Hill)--
a mathematical treatment.

3-22

BASIC TRANSPORTATION ECONOMICS

Monday, July 10, 1972

James T. Kneafsey
Massachusetts Institute of Technology

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Introduction

Under the terms of this workshop, the lectures are to be published basically in the original form which you heard in the class. In the matter of revision, I have made only small adjustments in order to preserve the flavor of the original lecture. I mention this partly because lectures, like sermons, do not make books. No matter how resonant and uplifting they sound, at least to the lecturer during presentation, they remain unimpressive in print. With this caveat in mind, the reader is introduced to the session titled "Basic Transportation Economics."

The Scope of Transportation

Transportation economics is the application of economic principles to the examination of issues in various modes of transportation. It is usually not treated as a separate discipline but rather as a mix of general transportation and applied microeconomic theory.

The occasion of this lecture seems an appropriate moment to evaluate the general state of transportation as a profession, science, art, or however one may view it. In making this evaluation, it would be helpful to observe the significant areas of transportation and to indicate to you where economics fits in. As a starting point, one might classify transportation into five general areas: (1) transportation engineering, (2) transportation planning, (3) transportation policy, (4) transportation regulation and law, and (5) transportation economics.

The first of these areas is transportation engineering, in which there are the two sub-areas: "hardware" and "software." Hardware pertains to analysis in the actual production of transportation equipment and invokes the use of traditional engineering principles. The software area, which involves the application of analytic tools and techniques to transportation problems, would include systems analysis, demand modelling, and computer programming applications.

The second area of transportation is transportation planning, which develops a decision-making apparatus to handle the social, political, and environmental aspects of a multitude of current and future problems at urban, regional, and national levels. The third area refers to transportation policy, the "piece de sustenance" of all transportation analysts. Issues of transportation policy can range widely from the question of labor featherbedding to SST investment to subsidy for mass transit systems. To this area I have added logistics and physical distribution management, that is, the management of the movement of physical goods from points of origin to points of destination.

The fourth area of transportation regulation and law will comprise a substantial portion of this seminar and its activities concerning the air sector will be explained accordingly. This brings us to the fifth area of transportation economics, the use of economic analysis in transportation.

Transportation Economics

Economics evolved in the eighteenth and nineteenth centuries as an attempt to explain and to justify a market system. The coordinating and controlling mechanisms in those centuries were the competitive markets and the systems of prices that emerged from the bargains between freely contracting buyers and sellers. The rationalization of the competitive market is still in large measure relevant to most advanced economies today. For all the great modifications to which market economies have been subjected in practice during the twentieth century and for all the qualifications that must be attached the case for such an economy, the competitive market model is still an important measure (in some ways--essential) descriptive both of reality and of the aggregate conception of what an ideal economic system should be.

Yet there are at least two large sectors of the U.S. economy that the competitive market model cannot even purport to describe. These are the huge and growing public sector,where the allocation of resources is determined mainly by political decisions, and the regulated sector in which the organization and management are mostly private but the central economic decisions are subject to direct governmental regulation. In general, industries which fall under the aegis of the various independent regulatory commissions may be classified into communications, banking and finance, energy, public utilities, and transportation. In these instances the primary guarantor of acceptable activity is conceived to be not competition or self-restraint but direct governmental prescription of major aspects of their structure and economic performance. Transportation industries are distinguished from other sectors of the economy by four principal components of this regulation: control of entry, fare and rate fixing, the prescription of quality and conditions of service, and the imposition of an obligation to serve all users under reasonable conditions. Transportation economics then is an analysis of the economics of that regulation--its characteristics and consequences, the principles that govern it, and the principles by which it ought to be governed.

If you read today the classic treatise of two centuries ago by Adam Smith on the Wealth of Nations[1], you would note that he submitted three general propositions which have provided the basis of economic analysis over the decades. These three propositions in paraphrase form are the following:

> First, that the wealth of a nation is the product of its labor;
> Second, that the greatest improvements in the product of labor result from the division of labor; and
> Third, that the division of labor is limited by the extent of market.

Now to these three propositions I would add a fourth which many economists, especially regional economists, have argued: the extent of the market is controlled by the cost of transportation. If you interpret these four propositions in a syllogistic fashion, you could argue the linkage between transportation cost and the wealth of a nation. If the nation's wealth can be measured by the national income accounts, GNP statistics reflect quite clearly the importance of the transportation sector.

In terms of economic analysis one must distinguish between the different modes of transportation because the institutional arrangement,

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[1] Adam Smith, <u>An Inquiry Into the Nature and Causes of the Wealth of Nations</u>, Edwin Cannan edition, London: Methuen and Co., Ltd., 1925.

managerial practices, and market structure are very different in the air, rail, water, motor and pipeline industries. The analysis must indicate the distinctions between passenger and freight traffic, between intercity and urban movements, and between domestic and international transportation. Even in the case of a single mode, the analyst must define the scope of his study very carefully. As an example, the analysis for evaluating TACV would be very different from examining AMTRAK or previous intercity rail passenger service with conventional technology because neither the immediate nor long-run effects of TACV are known.

Especially since each economic analysis requires stringent assumptions about the constancy of all variables except the ones under focus, it is essential for the analyst to specify <u>each time</u> the location, environment, and time period to which his analysis is applicable. In technical terms, this feature is referred to as "ceteris paribus"--everything else being equal--and the analysis is known as one of partial equilibrium.

In terms of the above scope of an analysis of transportation economics, one also must keep in mind that there are several components to the total transportation picture involving the actual users of transportation, the firms (carriers) which are providing the services, the extent of government agency participation, and the impacts on nonusers (or what is often referred to as the public interest elements). An economic analysis conducted solely at the user level in urban transportation might suggest different policy implications than an analysis at the firm or agency level since firms and users often have different interests and are striving for different objectives. Many riders in the Boston corridor may be interested in free transit but the MBTA cannot offer commuter services at zero fares unless large subsidies were involved. The cross-effects on nonusers as a result of the income transfers necessary to pay for these subsidies and the increasing role of governmental involvement would complicate the analysis.

Market Structure, Conduct, and Performance

How are these components best treated simultaneously? In terms of most effectively solving the total picture by using the airline industry as an example[2]: first, we look at how the firms or agencies are structured in offering the air transportation service to the public, namely, how are they organized, how large are they, how do they compete? Why do we have trunk line carriers? Why are there supplementals? Why do we have local air carriers? Why cargo carriers? In terms of an economic analysis of the air transport industry, market structure refers to the degree of competition, the size distribution of firms, absolute size, types of competition, and barriers to entry. In general, market structure pertains to the ways in which airline firms are organized and the resulting structure of firms from such organizations. Just as the credibility of a demand or cost analysis depends on the specification of a location and time period, so does the merit of a market structure analysis require the specification of relevant markets (routes) and types of service.

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[2] The total picture of transportation can be portrayed in Figure 1.

<u>INGREDIENTS AND SCOPE OF TRANSPORTATION ECONOMICS</u>

<u>Passengers</u>:
- International
- Domestic
    - Intercity
    - Urban

<u>Commodities</u> (Freight):
- International
- Domestic

<u>ANALYSIS BY MODE</u>

(1) Air
(2) Rail
(3) Motor
  (a) Auto
  (b) Bus
  (c) Truck
(4) Water
  (a) Inland
  (b) Ocean
(5) Pipeline
(6) New Technology

Figure 1

The Total Picture of Transportation Economics

Along the line of the structural elements, a second feature to examine relates to what is called in legal terms market conduct or simply conduct. Market conduct pertains to the ways in which firms or agencies in air transportation behave in relation to the statutory or other legal requirements within the context of their market structure. Issues of certification, route structure, and fares fall into this category.

Related specifically to the conduct area are the ways in which firms and agencies behave with respect to economic yardsticks. This third area refers to what is called economic or market performance. Measures of economic performance would include rates of return on investment, profit rates, number of innovations, returns on research and development, and rates of return on stockholder equity.

From all of this emerges a really basic question: What is the relationship between market structure and market performance? The degree of such a relationship has been an often debated and well documented topic, with proponents ranging from one extreme to the other. Suffice it to say that, if the testimony of many participants in airline merger cases is an indicator, it appears that at least in the airline industry changes in market structure induce changes in market performance. If the C.A.B. in the future regards its adjudicating role in merger cases seriously, then substantial research must be undertaken linking the forecasts of expected changes in economic performance to changes in market structure resulting from merger activities.

Production Functions, Costs, and Demand

How does one go about measuring these variables? Say we want to examine profit to the firm as a measure of performance. From an empirical point of view, we need to have estimates of revenues and costs. In order to forecast revenues, we must estimate a demand function; and to estimate costs, we need some estimate of the underlying production function.

What then is a production function? A production function is merely a behavioral relationship between the inputs required to provide transportation services and the output which is derived (see Figure 2). A very difficult question in terms of transportation, particularly airline transportation, is what is output? This is especially difficult when you encounter the empirical problems of trying to measure output (whether it be seat-miles, departing seats, revenue-seat-miles, number of movements, etc.). For purposes of illustration, let us assume that the input side can be classified by three items: capital, labor, and fuel. The production function then associates this combination of inputs with producing a certain level of output. Again both the location and time period must be carefully specified.

There are numerous types of production functions that can be tested empirically but the most frequently applied type is the multiplicative production function, which could be represented from Figure 3 in the following way: output (Z) is derived from a joint combination of capital (K), labor (L), and fuel (F). The result is a lograithmic production function. Taking natural logs on both sides of the equation yields a log linear equation where the exponents become coefficients and represent the elasticities of output with respect to each of these inputs.

PRODUCTION FUNCTIONS:

TWO VERSIONS

(1) $Z = F(X_1, X_2, \ldots X_n)$

inputs

(2) $Z = F(C, L, V, T, E, D)$

characteristics

Where Z represents output

$X_1, X_2, \ldots, X_n$ represent capital, labor, fuel, etc. and the characteristics can be depicted by cost, level of service, volume, technology, environment, etc.

Figure 2

Two Methods of Specifying Production Functions

$$Z = F(K, L, F)$$

$$Z = AK^{\alpha} L^{\beta} F^{\gamma}$$

$$\alpha + \beta + \gamma \underset{<}{\overset{>}{=}} 1$$

$$TC = rK + wL + mF + FC$$

<u>OBJECTIVE:</u>

$$\text{minimize } \phi = rK + wL + mF + FC + \Gamma(Z - AK^{\alpha}L^{\beta}F^{\gamma})$$

Figure 3

A Multiplicative Production Function
with Three Inputs

For example, in Figure 3, α represents the elasticity of output with respect to capital, β the elasticity of output with respect to labor, and γ the elasticity of output with respect to fuel. The sum of these exponents is a measure of the returns to scale. If the sum equals one, constant returns to scale result, that is, a 10% increase in capital, labor and fuel simultaneously would yield a 10% increase in output or volume (Z). If the sum exceeds one, increasing returns to scale results; if the exponents sum to less than one, then decreasing returns to scale occur (for the same 10% increase in inputs, a less than 10% increase in output would occur).

The use of production functions is becoming the most frequently used procedure for identifying the growth component attributable to progress in all industries, including air transportation. In view of the productivities of the physical inputs in some base period, we can estimate the increase in input that would have occurred since the base period if, given the level of technological knowledge of that period, the increase of output had been brought about merely by the growth of the quantity of physical inputs. The difference between the output growth actually observed and the so calculated hypothetical growth (i.e., the residual) may be regarded as an excellent measure of productivity change. Quite obviously, this measure requires estimates of both inputs and outputs and of the behavioral linkage between the two in the form of the coefficients of the production function.

There are at least three principal reasons for suggesting a production function approach to the development of improved productivity measures in air transportation. One is the general desirability for accuracy, precision, and clarity to facilitate scientific analysis. A second and related reason concerns a particular objective: if we know a priori why we want to measure performance in air transportation, we can then decide what kinds of measures of inputs and outputs are appropriate. Statistical testing then becomes the means by which this appropriateness is determined.

A third reason for being concerned with the production function approach relates to the infrastructure of general cost analysis and to the estimation of cost functions. The statistical estimate of cost functions has been in the strict sense an empirically evasive effort despite the literature being replete with different sorts of estimation attempts. The chief reason for a paucity of meaningful estimates is that rarely are the cost functions related to the behavioral properties of the production functions. In the past researchers in their haste to relate cost to output forgot that in theory and in practice one cannot say anything about the properties of cost functions unless something is known about the underlying properties of the productions from which cost functions can only be derived.

On the assumption that the prices of these inputs are known, that is, the price of capital, the price of labor, and the price of fuel (r, w, and m in Figure 3), one can specify a general cost function which can be derived from the production function. Notice that the cost function (TC) contains a term for fixed cost (FC) in addition to the variable prices above. Another way of expressing a total cost function is to relate costs directly to output (see Figure 4, Equation1). From this traditional cost function (a cubic expression) can be derived a complete set of relationships involving average and marginal costs. These relationships are useful in an airline's determination of short run cost minimization. From Figure 5, notice that the marginal cost curve intersects both the average total cost curve and the average variable cost curve at their minimum points. From the total cost curve, the average cost curve which Professor Tideman drew is total cost divided by Z and the result is a U-shaped curve. The partial derivative of total cost (TC) with respect to Z yields marginal cost. It says neither anything about demand, nor anything about revenues, which must be treated as separate behavioral analyses in order to test for profit maximization conditions.

On the demand side, single equation estimates usually specify a relationship between the quantity demanded of air service and variables such as population, income, and fares. Some analysts would prefer to combine the population and income variables into a single variable called income per capita. A shift in population will cause a direct change in the quantity demanded of air service. A change in the fares will affect the change in quantity demanded but in a negative fashion. When fares increase, by the law of demand, generally the volume will go down, assuming again ceteris paribus.

Several sessions in this workshop will be devoted to issues of demand. In these sessions we will observe a variety of techniques used for forecasting demand including trend analysis, market research approaches, and econometric methods.

The specification of demand is crucial since at any particular time, average fare multiplied by the number of passengers using the services will yield revenues. Keeping in mind that the airline company is pursuing some one or more managerial objectives, like profit maximization, an accurate assessment of revenues is required to offset cost in order to generate profits. Profits are maximized when total revenues exceed total costs by the largest amount for some Z or, as Professor Tideman has demonstrated, when marginal costs equal marginal revenues. These two conditions will occur simultaneously.

In many situations airline companies will be pursuing objectives other than profit maximization yet the foundations for any alternative hypothesis still require an accurate assessment of costs and revenues. In fact, the need for extremely accurate estimates becomes much more compelling as one considers additional alternative objectives. A separate analysis of some of these objectives is the topic of a later session in this workshop. The importance of cost and demand functions will become apparent to you in the topics of other sessions which will focus on issues of competition, regulation, fare levels, excess capacity, growth, and long run survival.

Summary

Transportation economics is an integral part of all transportation activities. We have observed the scope of transportation and the niche which transportation economics occupies in that scope. To the extent

(1) TC (total cost) $= a_0 + a_1Z - a_2Z^2 + a_3Z^3 = \text{TFC} + \text{TVC}$

(2) TFC (total fixed cost) $= a_0$

(3) TVC (total variable cost) $= a_1Z - a_2Z^2 + a_3Z^3$

(4) ATC (average total cost) $= \frac{\text{TC}}{Z} = \frac{a_z}{Z} + a_1 - a_2Z + a_3Z^2$

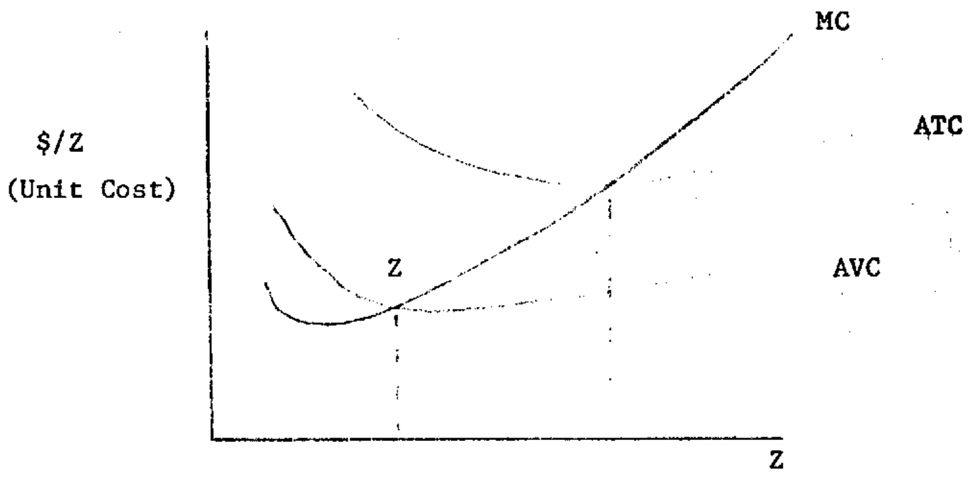
(5) AFC (average fixed cost) $= \frac{\text{TFC}}{Z}$

(6) AVC (average variable cost) $= \frac{\text{TVC}}{Z} = \text{ATC} - \text{AFC}$

(7) MC (marginal cost) $= \frac{\partial\,(\text{TC})}{\partial\, Z} = a_1 - 2\,a_2Z + 3a_3\,Z^2$

Figure 4

Cost Functions



SHORT RUN OPTIMIZATION: MC = ATC

$$MC = \frac{d(TC)}{dZ} = \frac{d(TVC)}{dZ}$$

$$\frac{d(ATC)}{dZ} = 0 \rightarrow MC = ATC$$

Figure 5

Cost Minimization

that there exists a need for more refined, detailed, and careful analyses, we have examined the contributions of the market structure--conduct-performance methodology and the specification of production, cost and demand functions.

DETERMINATION OF FARES: PRICING THEORY AND ECONOMIC EFFICIENCY*

by

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The primary purpose of this presentation is to describe the concept of economic efficiency, its application to the pricing of air transport services, and its relevance as a policy objective. The first two sections discuss economic efficiency in general terms, whereas the third applies this norm to several airline pricing problems. The final section emphasizes the importance of industry behavior as a parameter in policy analysis.

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I. The Nature and Relevance of Economic Efficiency

A market is said to be "efficient" (in economic terms) when there is no other feasible means of production, no other combinations of qualities and quantities of outputs, and no other distribution of outputs which would make actual and potential producers and consumers as a group better off. If for some reason a market is not efficient, then by definition there exists some change which could improve the economic "welfare" of the market's participants: that is, there are potential modifications in production and/or distribution which could increase the utility (or "enjoyment") of at least one consumer (and/or producer) without decreasing the utility of anyone else.

More specifically, economic efficiency in airline service means that, given production and cost relationships, the quality and quantity of service output is one which satisfies consumers (and furthermore compensates producers) as well as any other. If the airline market is not efficient, then on balance someone could gain from a change. For example, airline customers as a group might prefer less quality and a commensurate lower fare (the lower quality requiring less cost and thus profits -- or return to carrier investment -- remaining unchanged). Or, carriers might be able to improve the existing production process, thus raising profits, increasing service quality, and/or lowering fares.

Of course, economic efficiency may not be the only rational public policy objective of an industry such as the airlines. In particular, for over 30 years it has been public policy to consider other goals in commercial aviation, including: (a) "the promotion, encouragement, and development of civil aeronautics," (b) "the promotion of safety in air commerce," and (c) meeting "the present and future needs of the foreign and domestic commerce of the United States, of the Postal Service, and of the national defense."[1] While generally these and other goals mentioned in the Civil Aeronautics Board's "Declaration of Policy" are at least compatible with economic efficiency, depending on one's interpretation, in extreme form they can become overriding. For example, an efficient service is a reasonably safe one, but to " . . . assure the highest degree of safety . . . " (emphasis mine) would mean no service at all. Moreover, an efficient airline market is one which "promotes and encourages" air service to the extent consistent with optimizing resource use, but promotion beyond that means a less efficient market. Finally, to tailor air service to the special dictates of the Postal Service (PS) and/or the Department of Defense (DOD) probably would mean significant efficiency losses. However, provided PS and DOD "demands" for air service are weighed like those of other users, economic efficiency may obtain.[2]

There are many other public policy goals for the airline industry that could be mentioned. For example, the stability of rates and service. As we

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[1] Section 102 of the Federal Aviation Act of 1958.

[2] Other goals implied by Section 102 of the FA Act likewise, depending on interpretation, are at least consistent with economic efficiency. Examples include: (a) recognition and preservation of inherent advantages of air transport, (b) coordination of services, (c) competition, (d) sound economic conditions, (e) adequate, economical and efficient service, (f) reasonable charges, (g) absence of price discrimination, and (h) limitations on predatory competition.

shall see below, for the market mechanism to function properly, prices (and service) will change from one time period to the next; thus, to some extent, "stability" may conflict with economic efficiency. Another role the industry conceivably may take is furthering the economic development of sparsely populated regions of the country. While undoubtedly this was a successful role for the railroads in developing the West, there is little hard evidence that commercial air service has a significant impact on community development, and, even if it did, one could speculate that development in one area is at the sacrifice of another. It would appear therefore that an undue emphasis on an economic development role for the airlines can conflict with economic efficiency.

Finally, another, very important public policy goal is "equity." For example, the institution of charging children less than adults is so ingrained that to suggest something different ruffles most people's sensitivities. Yet, from an economic efficiency standpoint (vis-à-vis profit or revenue maximizing price discrimination) there is little or no "justification" for children's discounts except in extraordinary circumstances. Another example, which incidentally, shows changing attitudes toward equity, is airline discounts for "youth" and the elderly. Because of backlash to student agitation in the late 1960's, people generally have become less inclined toward permitting youth-fare discounts, whereas discounts for the elderly are more in favor. However, a special discount for businessmen, aged 30-40, would doubtless be strongly opposed.

In summary, achieving economic efficiency in a market would appear to be a worthwhile, if not paramount, objective. There are many other public policy goals for the airlines, and for the most part these are at least consistent with economic efficiency, depending, of course, on one's interpretation. However, in some cases economic efficiency cannot obtain if certain other goals are given too great a weight. In light of this, perhaps the most important role of an economist is to indicate something of the economic efficiency "costs" of pursuing non-economic objectives.

II. Optimal Pricing, Quantity, and Service Quality

If we can assume that other industries are characterized by economic efficiency, then we may perform a "partial analysis" on a single industry such as the airlines. If this assumption does not hold, then one may have to resort to that analytical framework called the "economics of the second best."[1] For the purposes of this presentation we shall assume that economic efficiency does obtain elsewhere and further that there are no real (as opposed to pecuniary) externalities. In such a setting the prices paid for resources attracted into the industry in question reflect the true opportunity costs of their use elsewhere. For example, the price paid by the airlines for an aircraft reflects the value of those resources used in making the aircraft (labor, working capital, metal, etc.) had they been utilized in producing something

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[1] Cf., R.G. Lipsey and Kelvin Lancaster, "The General Theory of the Second Best," Review of Economic Studies, Vol. 24, No. 1 (1956-1957).

else (e.g., automobiles). By assuming that there are no externalities, we rule out changes in air service having any positive or negative impact on the rest of the economy not transmitted through the price mechanism. For example, increased air travel may lessen auto travel and thus (for a time at least) lower the value of General Motors stock, reduce the rate of advance in United Auto Workers' incomes, and decrease the pay received by executives with special expertise in auto production and sales. This, however, is a pecuniary externality, and has no effect on optimal resource allocation. On the other hand, increased air travel may augment air pollution over auto plants and raise costs of production. This is an example of a real externality, but for the moment we presume that these are unimportant.

Technical Efficiency

One requirement for economic efficiency in any industry is "technical efficiency," and by that we mean achieving any output at lowest cost.[1] Given a production function of the form

$$X = f(a, b, c, \dots), \qquad (1)$$

there is a least-cost combination of inputs a, b, c, etc. which for any level (and quality) of output X', yields the lowest total cost to the firm. This technically efficient combination, of course, depends on the nature of the

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[1] This distinction between technical efficiency and "allocative efficiency" is somewhat arbitrary since the well-known efficiency conditions for production are closely akin to the allocative efficiency conditions in consumption. Nevertheless, it is a useful distinction and we will adopt it in this presentation.

production function and the prices paid for the inputs.[1] In a manner of speaking, then, given resource input costs and given equation (1), there is a (total) cost function which gives the lowest feasible cost for any level of output:

$$C = g(X). \qquad (2)$$

This question of technical efficiency and the lowest-cost function may be visualized by referring to Figure 1. The average cost (i.e., cost per unit) curve labelled AC* is the technically efficient one, since all others (e.g., AC' and AC") have a higher average (and total) cost for each rate of output (in this case taken to be available seat miles per year).

Of course, an airline produces many "outputs" (service between different city pairs, different "classes" of service, etc.), so really it is more accurate to speak of a production function of many outputs as well as many inputs. In implicit form this can be written as

$$h(X_1, X_2, \ldots, X_n, a, b, c, \ldots) = 0, \qquad (3)$$

where X_1, X_2, etc., are the various outputs. The technically efficient cost equation then becomes,

$$C = 1(X_1, X_2, \ldots X_n). \qquad (4)$$

This, of course, means that for any combination of outputs, X_1, X_2, etc., there is a least-cost means of production.

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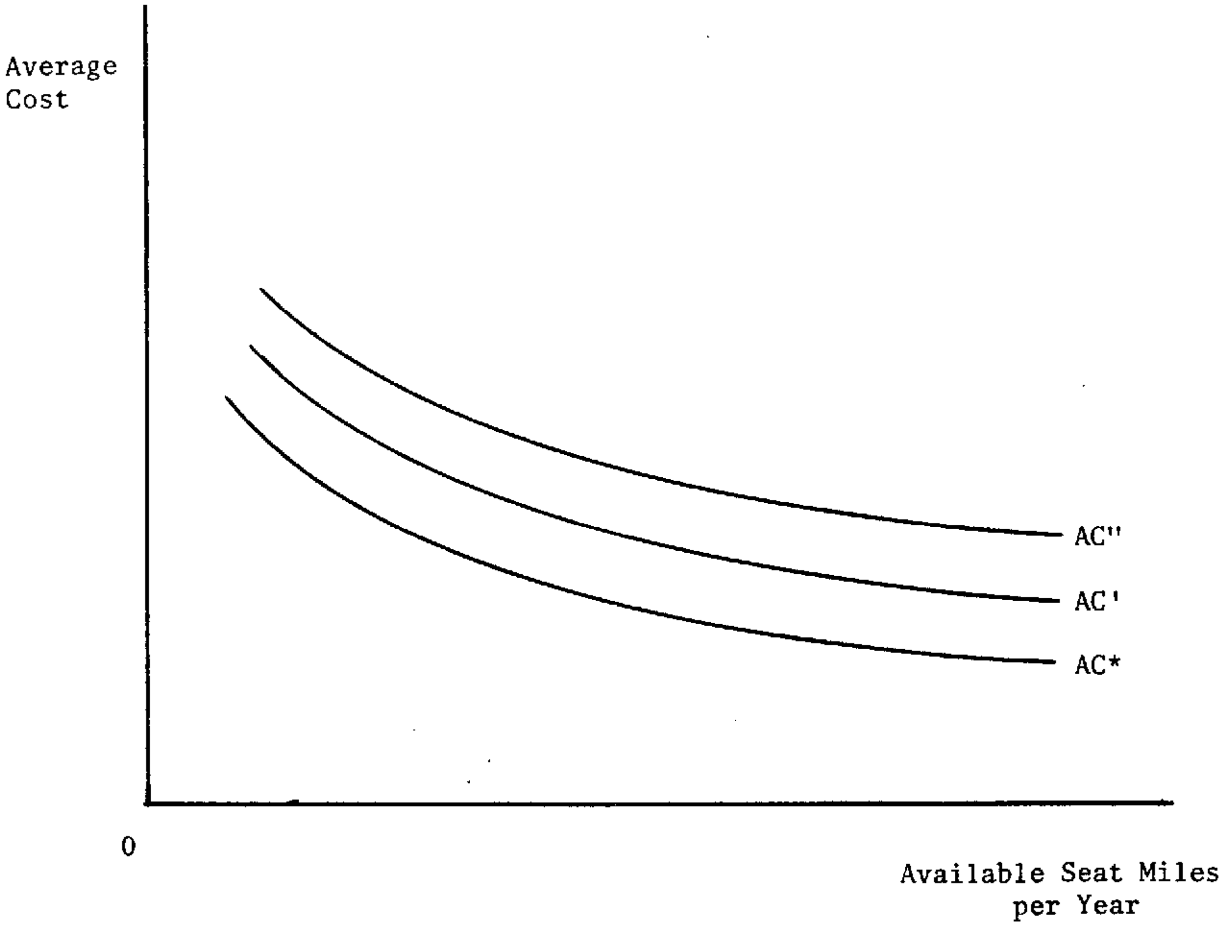
[1] The necessary condition is that the ratio of marginal productivity to input price be the same for all inputs. Cf., James M. Henderson and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach (New York: McGraw-Hill Book Company, 1958), Chapter 3.



<u>Figure 1</u>

Allocative Efficiency

So far we have talked about what may be termed the "supply side." Equally important is the "demand side." That is, presuming that all outputs will be produced at lowest total cost, what are the appropriate amounts of each output and what is their optimal distribution? This is the basic purview of what economists term "allocative efficiency."

It should be obvious that we are trying to maximize something. What we are trying to maximize is the collective "economic welfare" of producers and consumers. Producer welfare is straightforward -- profits. These are net revenues exceeding a normal return on investment. The economic welfare of consumers is a bit more difficult to define. In essence it is the excess of what they would be willing to pay for the service over what they actually do pay. Obviously consumers will increase their rate of purchase of any service as price is lowered. This is the so-called "law of demand." Stated another way, the maximum price consumers would pay for any incremental increase in total output is given by the inverse of the demand relation, or,

$$P_i = P_i(X_i), \tag{5}$$

where P_i is the demand price for output X_i. Consumers' total utility for consumption of any rate of X_i can be approximated by the area under relation (5). Subtracting total revenues paid, (net) consumer welfare is given by:

$$CW = \sum_{i=1}^{n} [\int_{o}^{X_i} P_i(X_i)dX_i - P_i(X_i)\cdot X_i]. \tag{6}$$

In analogous fashion, the welfare of producers (i.e., profit) is defined as:

$$PW = \sum_{i=1}^{n} P_i(X_i) \cdot X_i - C(X_1, X_2, \ldots, X_n). \tag{7}$$

We are now in a position to maximize total economic welfare, weighting the welfare of producers and consumers equally.[1] Adding (6) and (7) and simplifying,[2] we have:

$$TW = \sum_{i=1}^{n} \int_{o}^{X_1} P_i(X_i) dX_i - C(X_1, X_2, \ldots, X_n). \tag{8}$$

The first-order conditions for maximizing (8) are:[3]

$$P_i(X_i) - \partial C/\partial X_i = 0 \qquad i = 1, 2, \ldots, n. \tag{9}$$

This merely states that resources are allocated efficiently when the price of each output $[P_i(X_i)]$ equals the marginal cost of producing that rate of output $(\partial C/\partial X_i)$.

We may verbalize this result as follows. Marginal cost reflects the additional cost of production associated with increasing output by that unit. Demand price is a measure of the value consumers place on the marginal unit. Because demand price decreases with extra units, an output less than where price equals marginal cost means that some consumer values additional output more than the extra cost of production. From a societal point of view, output in that (sub)market is thus suboptimal. There exists a potential for a buyer to compensate a producer for the extra costs incurred and still be better off.

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[1] Other weights, of course, could be used.

[2] The total revenue term cancels out.

[3] We shall assume without further comment that second-order conditions obtain.

On the other hand, if the rate of any output exceeds that commensurate with a marginal price equal to marginal cost, then output is "superoptimal" and allocative efficiency does not obtain. In such a case, consumers value the marginal unit less than the associated increment of cost. Alternatively, a reduction in output would mean a savings in cost in excess of the lost value to consumers. Such reasoning thus leads to the conclusion that price must equal marginal cost in each market for allocative efficiency to obtain.[1]

In order to achieve allocative efficiency, it is essential that there be no arbitrary limitations on consumer "eligibility" for particular markets. That is, all consumers must have access to each type of output. Arbitrarily making one group of consumers ineligible and having to enforce such a restraint means that some consumers in the group discriminated against would willingly pay more than the marginal cost of output and thus economic efficiency does not obtain. A similar case is where different consumer groups pay different prices for the same output. To have to enforce such a partition means that some in the group discriminated against would willingly exchange money (i.e., a lower price) for the output consumed by the group most favored. If the favored group obtains output below marginal cost this still means an efficiency loss, for their consumption (at the margin) is valued less than the associated (marginal) cost of production.

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[1] We note in passing that generally the production of airline services is characterized by constant returns to scale for relevant ranges of output. [See "Testimony of James C. Miller III," CAB Docket 21866-7, DOT-T-1 (August 25, 1970) and the references cited therein.] Thus "marginal cost pricing" would mean total revenues sufficient to cover total costs.

Optimal Quality

Another allocative efficiency type question relates to the optimal quality of service. (Thus far we have assumed that quality is given.) For example, as George Douglas has shown, lower average load factors mean that flights are more frequent and that the probability of getting a seat on the desired flight is greater. But lower load factors, like other service amenities (such as speedy baggage claim, more elegant on-board accommodations, and more personal attention) can be achieved only at greater cost to the firm and thus to the consumer. From the individual consumer's viewpoint, the problem is basically one of "trading off" the (marginal) value of increased quality with the associated increase in cost. The important thing to consider is that service quality does matter.[1] If the "wrong" quality of service is provided, then allocative efficiency does not obtain any more than efficiency obtains when prices are unequal to marginal costs.

The (conceptual) determination of optimal service quality is illustrated in Figure 2. Quality is measured on the horizontal axis in units and on a scale

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[1] The relevance of service quality can be seen with the model sketched out as follows. Individual i's utility is defined by $U_i=U_i(X, Q, W,)$, where X= quantity of output, Q=quality of output, W=work expended, and where $\partial U_i/\partial X>0$, $\partial U_i/\partial Q>0$, and $\partial U_i/\partial W<0$. The perfectly competitive supply total cost of output is defined as $C=C(X, Q,)$, where $\partial C/\partial X>0$ and $\partial C/\partial Q>0$. Finally, total income (for spending on output) is the wage rate r times work expended, W. The maximization problem then resolves into Max: $Z=U_i(X, Q, W) - \lambda[C(X, Q)-rW]$. Not counting the budget constraint, the first-order conditions (second-order assumed to hold) come down to: $(\partial U_i/\partial X)/(\partial C/\partial X) = (\partial U_i/\partial Q)/(\partial C/\partial Q) = (\partial U_i/\partial W)/(-r)$, which means that the ratios of marginal utilities of output quantity, output quality, and work expended to their respective "costs" are equal.

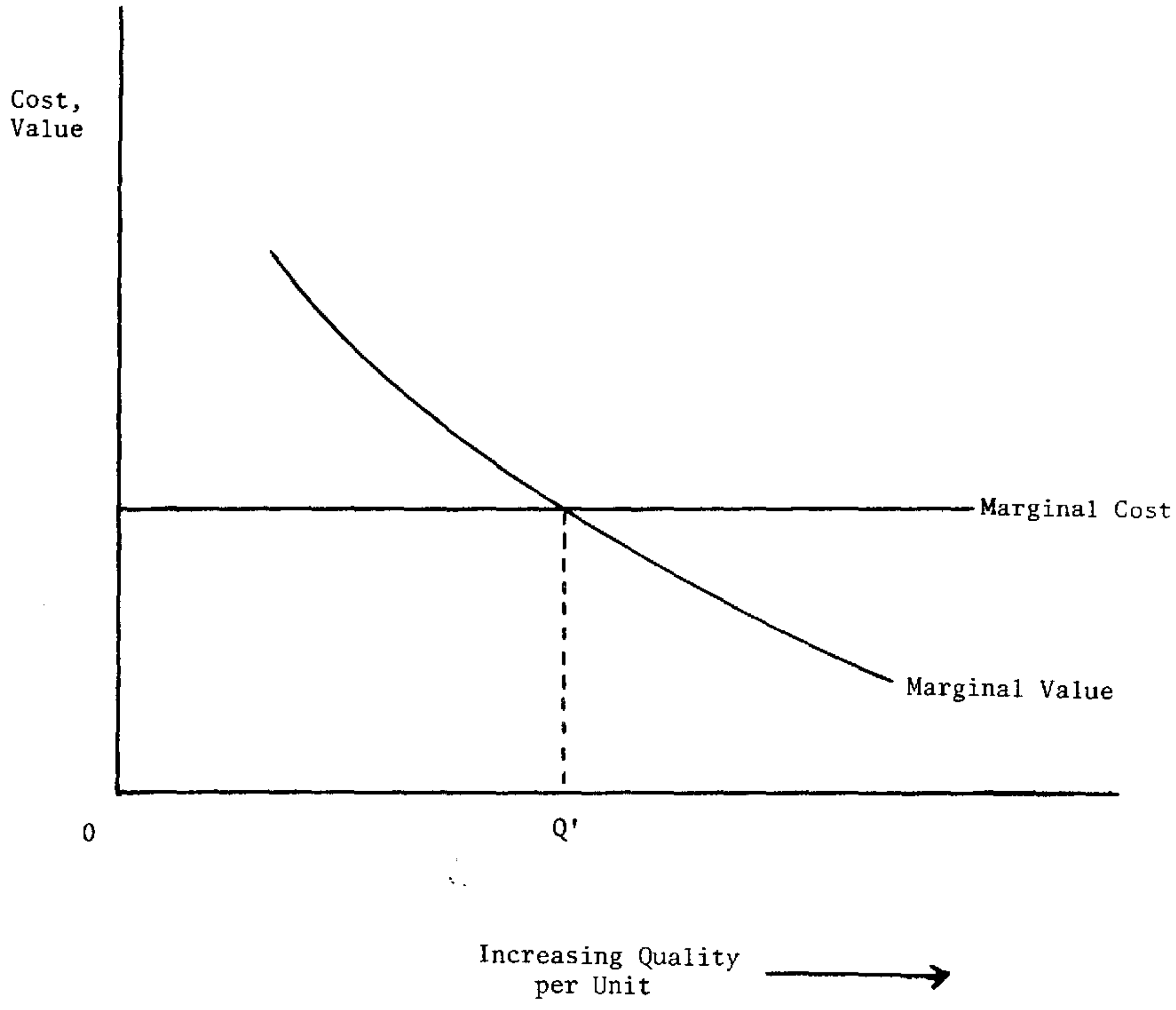
Cost,
Value
Marginal Cost
Marginal Value
0
Q'
Increasing Quality
per Unit

Figure 2

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which is commensurate with equal outlays for successive quality increases. While higher quality, of course, is desirable, one presumes that after a point the (extra) value of increased quality becomes less and less. Thus, for quality less than Q', the individual in question values increased quality more than the commensurate increase in per-unit cost. Past Q', greater quality is still desirable, but of less value than the extra cost. Thus, allocative efficiency requires that the quality of service be at Q' and in addition the price of service be equal to marginal cost.

III. Applications to Airline Pricing and Resource Allocation

Having set out these general rules for efficient resource allocation, it is important to understand that their application to transportation industries, specifically the airlines, is no easy task. The pricing of airline service is complicated by a number of very important characteristics of air transport cost and demand.

On the cost side there are indivisibilities in production. Not only do aircraft come in discrete units, but what is probably more important, their seat capacity is not subject to instantaneous change. Even if it were possible to select the "best" aircraft (in the sense of seating capacity) for a set of city-pair markets, because there are variations in density of travel among such cities and because there are economies in reducing the number of different aircraft types employed, one normally would expect that on some routes either aircraft would fly with some empty seats and/or passengers would be left at the gate unless there were sufficient pricing flexibility to ration off excess demand and/or fill empty seats. Moreover, as Douglas has described, demand is not "certain," but stochastic. Because of this characteristic there will be additional instances of excess demand for seats on the one hand, and excess capacity (i.e., aircraft not fully loaded) on the other.

Another characteristic of airline costs is that seat-mile costs for a given trip distance fall with larger aircraft size. This accounts for the propensity for users of air service to consolidate their demands. While some high-salaried executives may indeed depart via a personal turbojet aircraft when and where they desire, the strong scale economies associated with aircraft size make it desirable for most travelers to aggregate their preferred departure points (and destinations) and their preferred departure (and arrival) times to common ones.

On the demand side, users of airline services place some value on the reliability and stability of rates and service. Since information is not perfect and costs of coordination are not negligible, the convention of scheduled service at assured fares has emerged. If the information and adjustment processes were without cost, then the efficient solution would require holding up departures until a full load of passengers could be generated (at a price commensurate with 100 percent load factors). Or, as William Vickery has suggested, price could be varied instantaneously so as to fill the aircraft by the precise time of departure.[1] Actually, neither scheme is optimal simply because users of air service value certainty and wish to save on information costs.[2]

A related characteristic of demand is that because of the emerging convention of scheduled service, the presence of excess capacity is highly valued. (This was described by George Douglas in the previous presentation.) If average load factors are 50 percent rather than 75 percent, then the probability of a user's being able to secure passage on the scheduled flight of his choice is higher. Also, for given aircraft capacities, a lower average load factor means a greater frequency of service and thus a higher probability that a flight is scheduled reasonably close to the user's most desired time of departure.

As noted before, however, excess capacity has its costs, since users must pay for it if total costs are to be covered. Thus, the relevant decision is not whether to have excess capacity, but rather how much is optimal. On an aggregate level this depends on users' perception of the marginal values and marginal costs of excess capacity.

There are a number of other economic efficiency questions having to do with excess capacity, an important one being the argument for discriminatory discount fares.[3] Essentially, the proposition is as follows: given that the

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[1] William Vickery, "Responsive Pricing of Public Utility Services," The Bell Journal of Economics and Management Science (Spring 1971), pp. 341-2.

[2] Compare the advantage of having readily-available information on flight prices and departure times with a need to monitor constantly changing flight-time and price alternatives.

[3] These include youth and military discounts, discounts for children, etc.

airlines have excess capacity, why not give a price break to new, previously untapped markets; if these consumers pay anything in excess of "marginal" costs (presumed to be very low), then existing passengers too stand to benefit since this means their fare can be lowered. This argument, while intuitively appealing, fails to recognize the essential role of excess capacity in the quality of service and further ignores relevant opportunity cost concepts.

If excess capacity is one dimension of service quality, then the addition of reserved-seat discount passengers lowers service quality for "regular" passengers. In addition to the lower probability of obtaining a seat on the desired flight, there is the disadvantage of sharing flight attendants with more passengers, plus the extra crowding on-board and greater time taken in aircraft ingress and egress.

More relevant, however, is the fact that the real (i.e., opportunity) cost of adding a discount passenger is the value of the service to the (marginal) potential regular passenger who does not fly because the discount is not made available generally. And because the real cost of the extra service to the (marginal) discount passenger exceeds the fare he pays, there are allocative efficiency losses.

There are two relevant modifications to this analysis that should be mentioned, both having to do with the total volume of traffic under the two pricing schemes. If under discriminatory discount fares the total volume of traffic at any point in time is greater than with a non-discriminatory, lower price (or alternatively lowering the regular price won't "fill" existing aircraft as effectively as employing discriminatory fares), then this is simply an indication that total airline capacity is excessive. On the other hand, as George Douglas has shown, in very small markets the increase in service quality (via greater frequency, lower seat costs of larger aircraft, etc.) arising out of increased total traffic volume with discounts (as opposed to lower normal fares) provides some justification for discount fares, at least in those markets. However, the optimal fare differential under such circumstances is likely to be very small.[1]

Excess capacity is also related to seating density, another obvious quality parameter. For a given flight, the greater the seating density the greater is quality in terms of seat availability, but the less is seating comfort. Of course, passengers differ in their preferences, but it would appear likely that after some point the typical user would prefer to convert some excess capacity (in the form of extra seats) into less dense seating. Moreover, since for a given rate of travel between city pairs the cost of excess capacity is greater for long-haul flights than for short-haul, one would expect optimal load factors and seating densities to be higher for long-distance travel. Finally, since for a given length of haul the marginal value of excess capacity (in terms of reducing delay time) is greater for lower density markets, one would expect optimal load factors and seating densities to be higher the greater the total volume of traffic.[2]

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1. George W. Douglas, "Price Discrimination and Scale Economies in Scheduled Air Transportation" (Chapel Hill: processed, 1971).
2. Also, see George Douglas' presentation.

The institutions surrounding commercial aviation raise several more interesting types of efficiency problems. For example, since under current arrangements the non-fulfillment of a reservation is costless, for a typical flight more reservations are made than passengers show up. This, in turn, leads carriers to "overbook" flights, relying on "no-shows" to yield enough extra seats. Occasionally, however, the number of showing reserved-seat passengers exceeds the flight's capacity. The U.S. Civil Aeronautics Board (CAB) now fines airlines for this practice, but obviously, given the institution of free reservations, some overbooking is optimal. In fact, the optimal fine is one which causes airlines to overbook just to the point that the number of additional reserved passengers left at the gate just offsets the number of extra passengers who could have been accommodated in seats made available by no-show reservation passengers.

The subject of airline safety is much too broad to receive adequate attention here. However, it is important to note that safety has its "costs." Its benefit, of course, is a reduced probability of a serious or perhaps fatal accident. Depending on one's valuation of human life and suffering, the optimal expenditure on safety is where the expected value reduction in accident "costs" just equals the marginal cost of this (increased) safety provision.[1]

Another type of allocation problem arises in connection with the efficient pricing of different outputs on the same aircraft flight. As between first-class

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[1] For an interesting discussion see Thomas C. Shelling, "The Life You Save May Be Your Own," in Samuel B. Chase, Jr., (ed.), Problems in Public Expenditure Analysis (Washington: The Brookings Institution, 1968).

and coach service, it is important to recognize that the opportunity cost of first-class space is the eliminated coach space; and vice-versa.[1] In effect, except for the extremely short run, first-class and coach space are common costs (i.e., their proportions may be easily varied by moving the bulkhead and changing a few seats). Keeping in mind that first-class passengers receive extra service amenities in the form of more personalized stewardess services (fewer passengers per stewardess), more expensive meals, etc., that they exit the aircraft before coach class (and thus considering opportunity cost their cost is higher), that the space between rows of seats is greater than in coach class, and that load factors in first class are usually lower than in coach, a good rule of thumb is that first-class accommodations should be priced at least 50 percent higher than coach, since first class has four seats abreast whereas coach class typically has six.[2]

The optimal relationship between passenger and cargo prices is more difficult to determine. The problem is that while the ratio of passenger vs. cargo space on a "combination" aircraft is variable at the aircraft manufacturing

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[1] Aircraft are much more commonly space-constrained as opposed to weight-constrained. Thus, space is the relevant scarce resource, although obviously weight constrained cases are important.

[2] It is worth noting that in many cases what a first-class passenger buys is not so much more luxurious accommodations but simply a confirmed space. That is, since load factors average much lower in first class, peak-hour accommodations are typically rationed by the first-class fare. Also, obviously people pay extra for the ability to obtain a reservation "at the last minute." Both roles for first class could be handled more efficiently by peak-load-pricing and perhaps by reserving a block of standard seats for last-minute sales (at a higher price).

stage, once an aircraft has been produced it is most difficult to reallocate space.[1] Thus, in the long run, cargo and passenger space are common products; in the strict short run they are joint products. As a forthcoming paper by the author suggests, an appropriate pricing rule is to charge "belly freight," a price equal to the cost of carrying such freight (at comparable service quality) in all-freight aircraft.[2]

IV. The Relevance of Industry Behavior

Many pricing problems in the airlines must be considered within the context of industry behavior. By "industry behavior," we mean the response pattern that describes industry "competition." Briefly, as DeVany, Douglas, Eads, Jordan, Yance, and I have argued, the domestic airline industry can be characterized as a non-price competing cartel.[3] Prices are given, being regulated by the CAB. Carriers then "compete" (or rival) in non-price (i.e., quality) dimensions, primarily the extent of excess capacity. Our operational

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1. Almost all commonly used passenger aircraft have cargo space in excess of that required for passenger baggage.
2. See "Cargo Pricing and the Configuration of Combination Aircraft," Journal of Transport Economics and Policy (forthcoming).
3. See Arthur DeVany, "The Economics of Quality Competition: Theory and Evidence on Airline Flight Scheduling," unpublished (c. 1969); George W. Douglas, CAB Docket 21866-9, DOT-T-3 (May 17, 1971); George Eads, "Competition in the Domestic Trunk Airline Industry: Excessive or Insufficient?" (Washington: The Brookings Institution, forthcoming); William A. Jordan, Airline Regulation in America: Effects and Imperfections (Baltimore: Johns Hopkins Press, 1970); Joseph V. Yance, CAB Docket 21866-6, DOT-RT-1 (July 27, 1970); and James C. Miller III, CAB Docket 21866-6, DOT-T-1 (July 6, 1970).

hypothesis is that over time schedule frequency will adjust in individual (competitive) markets so that actual load factors approximate break-even (including a normal return on investment).[1]

To see that carriers have incentives which cause them to move in the direction of break-even load factors, consider first a situation where prevailing load factors are above break-even. In this disequilibrium situation, carriers will expand scheduling in hopes of making profits on extra flights. Load factors will fall. If on the other hand prevailing load factors are below break-even, carriers will be prompted to cut back on scheduling as a means of reducing losses. Load factors will rise.[2]

We may illustrate the importance of policy-makers' understanding industry behavior with three examples.

Cross-Subsidy by Length of Haul

For many years the CAB has fostered a policy of "cross-subsidizing" long-haul and short-haul markets. Essentially the argument is that fares

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[1] Recently the CAB has recognized the applicability of this model to airline regulation, stating,

> "It is indisputable that every fare level has a built-in load factor standard. We find, as DOT has stated, that the higher the fare level in relation to cost, the more capacity carriers will offer and the lower load factors will be; and, conversely, the lower the fare level, the less capacity carriers will operate and the higher load factors will be." (CAB Order 71-4-54, April 9, 1972, p. 23.)

[2] This argument is often missed (and perhaps purposely obfuscated) by those placing especial emphasis on market share relationships. Douglas and I deal with this in our Brookings study (*op. cit.*).

cannot be raised to the level of average cost in short-haul markets since there would be "undue diversion" to alternative, competitive modes. Fares in long-hauls, however, should exceed costs, the long-haul profits thereby used to (cross-) subsidize losing short-haul business. The basic price-cost relationship by length of haul is illustrated (conceptually) in Figure 3.

"While this may work in theory, it doesn't work in practice." What happens is that because break-even load factors are high in short-haul markets, actual load factors also tend to be high. Because break-even load factors are low in long-haul markets, actual load factors also tend to be low. This is seen in Table 1. (N. B., load factors for very short-haul markets include many local service subsidized routes where because of the subsidy, break-even load factor is lower than otherwise.) Note particularly the monotonic decline in load factors past 500 miles.

In short, cross-subsidy is largely a fiction and it will continue to be as long as carriers are free to adjust capacity in response to prices and costs.

Pricing Strategies to Control Pollution

With increasing public concern over the "environmental impact" of economic activities, commercial airports have been singled out (somewhat unfairly) as a primary source of air and noise pollution. Much is being done by way of "retrofitting" old jet engines and redesign of new ones. However, this may be viewed as a longer-range solution and even under technology likely to materialize could not be expected to eliminate aircraft pollution entirely.

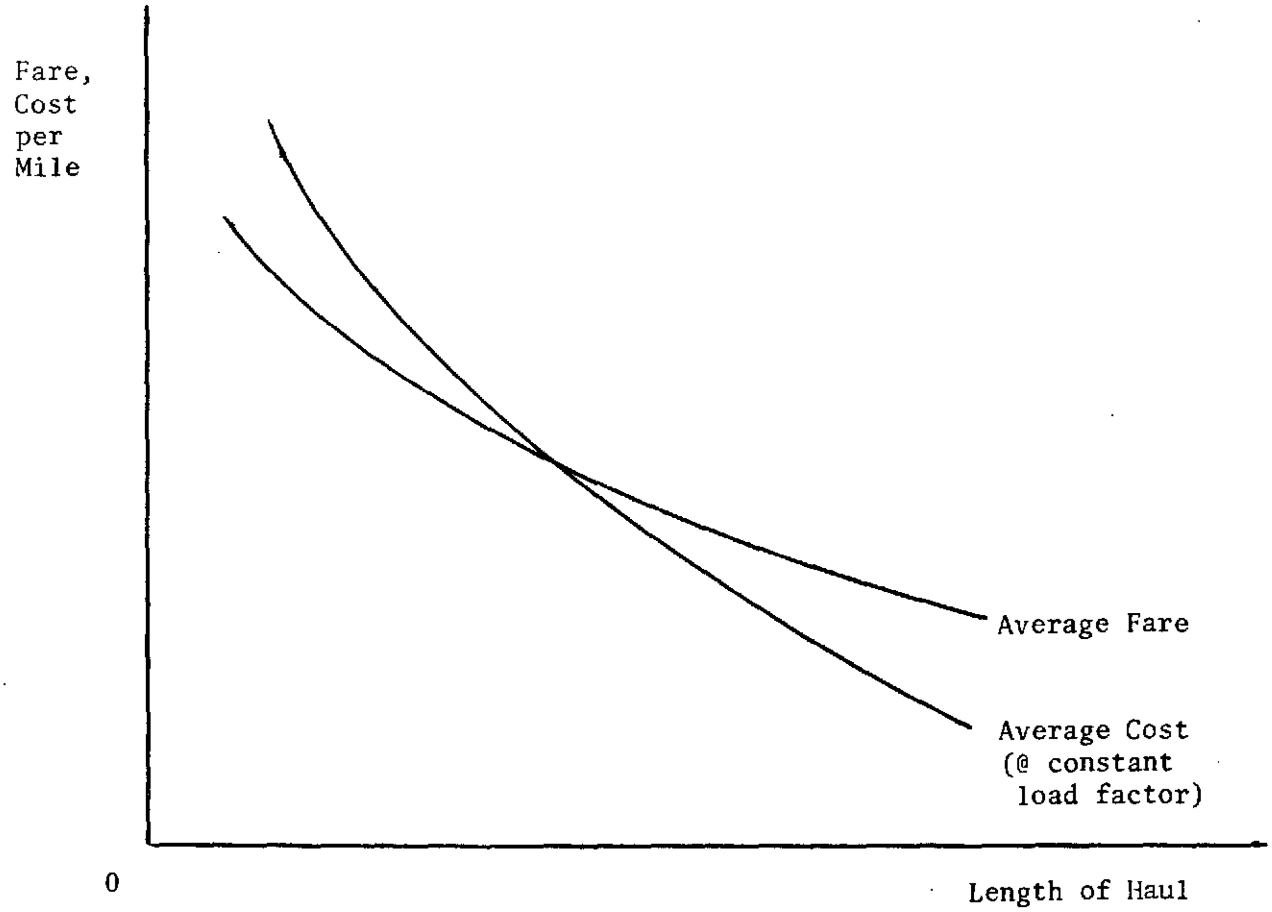
Fare,
Cost
per
Mile
Average Fare
Average Cost
(@ constant
load factor)
0
Length of Haul

Figure 3

Table 1: 1969 Coach Load Factors by Length of Haul

Miles	Load Factor	Miles	Load Factor
100	50.7	1,300	53.8
200	53.1	1,600	52.5
300	53.6	1,900	52.2
400	54.6	2,200	49.9
500	55.6	2,500	46.0
700	55.4	2,800	45.9
1,000	54.8	Average	50.0

Source: CAB Docket 21866-9, BC-4808.

Economists have often suggested using the price mechanism to "internalize" pollution costs and thus, ceteris paribus, bringing about a more efficient level of pollution output. We shall assume that pollution is a monotonic, increasing function of the number and size of aircraft making take-offs and landings, and thus, as a proxy, the narrow policy objective is to decrease the number of seats scheduled by commercial operators.

The industry behavioral model described in the previous section may be sketched out as follows. Quantity of air service demanded (ex ante and supplied ex post) is a function of both price and the number of seats scheduled: $D = D(P, X)$. Average and marginal costs are of two kinds: first, those associated with passengers (C_d), and second, those related to seats (C_x).[1] Assuming constant returns to scale in both categories, the total cost function is given by $C = C_dD + C_xX$. Finally,

$$\pi = D(P - C_d) - C_xX = 0, \qquad (10)$$

where π is profit, and any excess profit (or loss) "slack" is taken up by variations in X.

As discussed below, the important policy variables are P, C_d, and C_x. We wish to know their individual effects on X. Equation (10) may be differentiated to yield,

$$\frac{dX}{dP} = \frac{D[1+e_d(1-C_d/P)]}{C_x-(\partial D/\partial X)(P-C_d)}, \qquad (11)$$

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[1] This corresponds generally to the conventional distinction between "direct" and "indirect" airline costs.

$$(12) \qquad \frac{dX}{dC_d} = \frac{-D}{C_x-(\partial D/\partial X)(P-C_d)}, \text{ and}$$

$$(13) \qquad \frac{dX}{dC_x} = \frac{-X}{C_x-(\partial D/\partial X)(P-C_d)},$$

where e_d is the price elasticity of demand. Also, we note that,

$$(14) \qquad dX = \frac{D[1+e_d(1-C_d/P)]dP-DdC_d}{C_x-(\partial D/\partial X)(P-C_d)}, \text{ and}$$

$$(15) \qquad \frac{\partial D}{\partial X} < \frac{D}{X}.$$

Equation (15) simply states a necessary condition for market equilibrium, namely that as carriers put on additional capacity, load factors fall (i.e., "marginal load factor" is less than average load factor). (Otherwise scheduling would increase without limit.)

Public policy to restrain aircraft pollution through market incentives may be initiated by two groups. First, the CAB may effectuate a change in the level of fares. For example, one presumes that a fare increase would have a depressing effect on aircraft pollution. (But read on!) Second, the local-government airport authority may impose some form of "user charges" to curtail total pollution output.[1] Let us consider the following alternatives: (1) a fare increase imposed by the CAB, (b) an increase in landing fees imposed by local authorities, (c) a "head tax" paid by passengers, (d) a head tax paid by the air carriers, and

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[1] Most major commercial airports are owned and operated by local governments. The exceptions include the two Washington, D.C., airports, National and Dulles, owned and operated by the Federal Government. (It has been proposed that these be sold to the highest bidder.) Some airports are privately owned and operated, the largest being Burbank, California.

(e) a head tax paid by the carriers where the CAB allows them to pass along the cost increase in the form of higher fares.[1]

From equation (11) we may determine that an increase in the price of air service will actually increase X if $e_d > -1$. The denominator of the right-hand side of (11) [and also of (12), (13), and (14)] is positive by reference to (10) and (15). The numerator is negative only when demand is sufficiently elastic that $e_d(1 - C_d/P) < -1$.[2] This is an important result, inasmuch as the CAB, at least, judges air travel demand to be inelastic.[3] If true, then a corollary of the above result is that the Board could bring about a reduction in pollution by lowering fares.

An increase in landing fees would be tantamount to an increase in C_x.[4] From equation (13) we see that the effect would be a reduction in X since the right-hand side is negative.

A head tax on passengers would be similar to an increase in fares, but the difference is decisive. Whether demand is elastic or inelastic, carriers' total revenue would be reduced (i.e., quantity demanded would fall because of the perceived higher price), and thus scheduling would have to contract.[5]

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[1] Of course, there are other alternatives (e.g., flight quotas, price discrimination, etc.), but these are not considered here.

[2] Roughly this would require that $e_d < -2$, since in practice $C_d/P \approx .5$.

[3] The CAB has found demand elasticity to be -.7 (CAB Order 71-4-59, 71-4-60, April 9, 1971, p. 50.). While many researchers disagree with this assessment, few would maintain that $e_d < -2$.

[4] Landing fees are typically in proportion to the gross weight of the aircraft.

[5] The application of a head tax would mean an unambiguous decrease in D. Referring to equation (10), since $C_d < P$ and C_x is unchanged, X must decrease.

If the carriers pay the head tax, this would mean an increase in C_d. Since the right-hand side of equation (12) is negative, the result would be a diminution of X and thus a decrease in pollution.

Finally, a head tax paid by the carriers which is passed along in the form of higher fares would likewise have a depressing effect on X. Note that in this case $dP = dC_d$ in equation (14) Since $e_d < 0$, the numerator is always negative.

Thus, in one case what would seem like a straightforward policy action to control pollution (i.e., higher fares to choke off demand) would be likely to have the reverse result, owing to the industry behavior pattern that has developed under Federal regulation.

Pricing and the Demand for Aircraft

A related issue is the effect of airline pricing on the derived demand for aircraft. In other words, how would changes in fare levels (everything else equal) affect airlines' requirements for new aircraft?

First, it is notable that many economists and others have recommended that the airlines be "deregulated." Based on the available experience with a deregulated airline environment (e.g., the California intra-state market[1]), the presumption is that fares would fall substantially. Carriers generally oppose fare reductions, but with increasing pressure from charters and the imposition of the Board's higher load factor standards, prospects for significant fare reductions must be seriously considered.

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[1] On this see Jordan, ibid.

Anyway, the normal reaction to the fare-aircraft demand issue goes something like this: lower fares would mean greater travel and thus a greater demand for aircraft. However, it should be recognized that lower fares mean an increase in break-even load factor. The question is whether the rise in break-even load factor is more or less than sufficient to offset the increase in passenger demand.

The answer is given by equation (10), and this result comes as something of a surprise. That is, a decrease in fares (ceteris paribus) would likely curtail airlines' requirements for new aircraft. Given this result, I would expect Boeing, McDonnell-Douglas, Lockheed and even NASA to be ardent supporters of CAB regulation!

J.B. Gebhardt

United Air Lines, Inc.

I have been asked to discuss differential pricing policy in the airline industry. I plan to confine my remarks to the passenger pricing although there is no question but what cargo is also an important part of this industry. Further, I think the principles that apply to passenger pricing also apply to cargo pricing and most of you are more familiar and more experienced with passenger pricing practices.

Differential pricing policy really has its beginnings I suppose in monopolistic theory which says that if the monopolist can successfully discriminate among markets and not permit revenue dilution to occur in his major market as a result of discriminatory pricing in secondary markets, he can increase his total profits as long as he does not increase his investment base or in more pragmatic terms expand his plant size or capacity. That same theory holds true with respect to airlines' differential pricing policy and the rather tenuous relationship between the theoretical application of differential pricing and its actual practice is what I plan to discuss today.

Of our two major methods of differential pricing the first, most difficult and some might say the most sophisticated, is that which discriminates among markets. The second, simpler, less sophisticated perhaps, but at least in practice - frequently the more effective is that of matching peak

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Of our two major methods of differential pricing the first, most difficult and some might say the most sophisticated, is that which discriminates among markets. The second, simpler, less sophisticated perhaps, but at least in practice - frequently the more effective is that of matching peak price with peak demand. Although I've chosen to treat these two practices separately they are conceptually the same. In practice one usually precedes the other, however.

Before I begin a discussion of the application of differential pricing policy, I would like to make mention of one other factor which is a major consideration in the airline industry and makes us act differently than private industry. That is the presence of our regulatory agency - the Civil Aeronautics Board. The CAB, as you all know, plays a large role in the pricing policy of airlines. It is one of the few regulatory agencies which has the responsibility to promote its industry but coupled with that responsibility is an additional responsibility for passing judgement on the pricing practices of certificated air carriers. The CAB is required to guard against what we might call overly zealous price differentiation. Carriers are not able to maintain pricing practices which the Board judges to be unjustly discriminatory or unduly preferential or that give an unfair advantage to certain customers. Our prices are also totally public knowledge as a result of the requirement that we publish and maintain tariffs. So, within these constraints, we are reasonably free to differentiate our prices and in so doing attempt to increase our overall profitability.

Let's move now to the practice of discrimination among markets. First of all we must identify those markets. There are probably hundreds of ways to define markets, but as most of you know, in the airline industry we tend to break them down into two basic categories. The business market and the pleasure market.

The business market is the simplest of these two to deal with. It is the market to which we gear our prime product, convenient, reasonably frequent schedules between most major cities in the United States. It is this market that is considered to be basic, and it is to this market that we direct our prime price. It is this market that demands our prime product. The business market then really only splits into two pieces - the first class market and the coach market; and each of these markets has a basic, full, non-discounted price. In the case of first class a premium is applied because the first class passenger receives a premium service in terms of both inflight amenities and the amount of space he is permitted to consume during the time he is on board. The coach market sets the standard for all airline pricing and indeed it is the coach fare which is the basic fare in the industry.

The pleasure market is far more complex than the business market. It is a market which has led to the practice of differential pricing and which we like to think at least is the most responsive to differential pricing. The pleasure market is as some are fond of saying - - where the action is, and it is the market that we generally consider to hold the most opportunity for the future growth of this industry. It is a discretionary market. People who are spending their dollars on air transportation are spending dollars that they are not required to spend for the basic essentials of life...food, shelter, clothing, education and some form of transportation to and from their place of work. In order to compete for these dollars, we must compete effectively with many other products and services. Automobiles, for example, particularly the second car; color television perhaps; vacations which do not require a great deal of travel; vacation homes, another growing competitor for discretionary dollars. In one respect we have a product disadvantage. Our product is an intangible, once it is consumed it is gone, and the pleasures of a vacation trip can only be preserved on film and in memories, and on cold winter nights a memory may not be nearly as satisfying as sitting in front of a tangible, visible and sometimes entertaining color television set. These are some of the factors we must contend with and compete with as we seek to reach this market. Nevertheless, as I mentioned, this is where most of us believe the action is and are trying to use price as a means to compete.

It is quite easy to characterize our major markets as business and pleasure. As I mentioned the business market quickly subdivides into the coach and first class markets. But when we consider the pleasure market we find that we are dealing with a large, very heterogeneous and very complex category. We must deal with each of these submarkets and must thoroughly understand them. For example, the bulk of people traveling for what we would consider to be basically pleasure purposes are traveling to visit their friends and relatives. However, another large sector of this market plans to use commercial facilities during the entire trip; that is, they will not only use air transportation as a means of getting there, but they will be staying at a resort area, eating in restaurants, etc. There is a warm weather market; places like Florida, California and Hawaii have a great attraction for pleasure travelers. And a cold weather market, the ski areas for example. There is a young market - we are all familiar with the youth fares, controversial although they may be. And there is an old market which has been demanding equal treatment with youth. There is a market for group fares, and this market too can be subdivided into at least two categories - some who travel with groups are with the group because they enjoy the security of the group, they appreciate the fixed price nature of most group travel, they want someone to make the arrangements for them, to handle the administrative details and to ensure that everything goes right. The other part of this market, typically a younger part of the market, is very budget conscious. They are there because the price is right - they don't care at all about the security factors. There is a market for package tours, people who want everything planned in advance. Again, this can be either on a group or individual basis, but they like the fixed price aspects of a package tour. They like knowing in advance what they are going to see and where they are going to be, and they may save by buying a package, save both in terms of ground arrangements and air transportation. And finally there is foreign pleasure travel and domestic pleasure travel. And in many cases domestic carriers have an opportunity to participate in the pleasure travel with those going to international destinations.

My reason for discussing these various markets or submarkets is to acquaint you with the fact that almost everyone can be categorized into one or more of these different pleasure market classifications. In fact, most people at any given time, may fit into more than one of these categories. And this is where the difficulty begins when we attempt to practice differential pricing.

I suppose the first attempt made to differentiate prices in the airline industry was made in the late 1930's with the introduction of the family plan, which I might add is still part of the basic price structure in this industry. But the theory was then, and it is now, that offering a price difference would fill seats that would be flown and would not otherwise have been filled. The execution of this theory is simplicity itself, and the theory itself is certainly simple. You don't need a PHD in economics to understand that if you can get more revenue than your variable cost, without diluting current revenue or increasing fixed costs, you will improve your overall profitability. And to put this into practice in this industry, or for that matter, I guess, almost any industry, is quite easy.

First, you identify the market both demographically and geographically.

Next, you determine precisely what price that market will pay for your product. Too much and you lose the market, too little and you lose profits.

Then, you structure your product offering so that it just fits this market and cannot be purchased by anyone that is part of a market that would pay more. Because if it could be purchased by someone that is willing to pay more, once again you have eroded your profitability.

In our case, we will review our product to be sure that it will meet all the regulatory tests, and on the assumption that it will we will file it with the CAB. 30 to 45 days later we can take it to market where we will sell our product, sit back and smile benignly and enjoy our profits.

Oh, and let's not forget that as time passes we will be ever vigilant and not increase the size of our plant (investment base) because if we do our product then must bear its full share of cost and it hasn't been priced at a level which will permit it to do that.

This then is the underlying theory and hypothetical practice of the most common application of differential pricing policy in the airline industry today. Now let's look at the "real world" as we are often fond of saying. The first example I would like to direct your attention to is the Discover America fare. This fare, introduced in 1966, was designed to encourage discretionary spending on air travel. It carried a discount from normal coach fares of 25%, required round trip, required that the individual not depart and return in the same calendar week, he could not be gone more than 30 days, could not travel on Fridays or Mondays, generally peak business travel days, and could not travel during the peak periods of the summer or at peak holidays. All of these restrictions were created to differentiate this product from the basic coach product and to discourage discount travel during prime demand periods as well as discourage those who were able and willing to pay the full coach price from shifting to this discounted fare. The assumption was that no additional capacity would be added and the revenue from this fare would far more than exceed the variable cost of carrying the traffic. Yet, in only two short years after its introduction, changes were made. The discount was still 25%, a round trip was still required, you still had to be gone 7 days and had to return within 30 days, but Fridays and Mondays were no longer blacked out. Now the blackout was from Friday noon to Friday midnight, and from Sunday noon to Sunday midnight. In other words, 24 hours during the week were excluded as opposed to 48 hours at its inception. But perhaps the most important difference was that this fare was now valid on a year round basis; so, even in the summer when demand peaked the discounted price was still available.

The Discover America fare is still part of our fare structure, it has changed again in its characteristics from 1969 but it is still far more liberal in terms of periods of applicability than it was at the outset.

The second example I would like to touch on is a group fare filed originally to compete for traffic carried by supplemental carriers who were serving Hawaii from the East Coast, offering low cost transportation predicated on high load factors through group travel. At the outset in order to qualify for this group fare you had to be part of a group of 88 to 154 people and as the group got larger the price got lower. You could only depart from Chicago, Detroit, Cleveland or New York. And from a practical standpoint most of the business was done from New York. The group had to travel together during the entire trip, both coming and going. They had to buy a tour package so that it was truly an all inclusive tour and they had to stay for a minimum of 14 days. Each of these restrictions was applied to prevent diversion from higher fares to this lower group fare on the part of those who were able and willing to pay a higher fare in order to achieve greater personal travel flexibility and more comfortable travel. Today, the same group fare is available for groups beginning at 40 persons. It is national in scope rather than applying to the major population centers of the east from where the participating airline was virtually guaranteed a long flight where it could achieve maximum efficiency of operation. First, passengers were permitted and encouraged to consolidate in Chicago by providing a lower price on air transportation from their home to Chicago. Next the West Coast was picked as a consolidation point, and today passengers can originate any place in the United States, travel on an individual basis to or from the West Coast, stopover and spend whatever time they wish on the West Coast, then continue on to Hawaii as a part of a group. In many instances no tour package is required and the minimum stay is now a short 7 days, which is no problem for anyone going to Hawaii for virtually any purpose.

The point I am trying to make with these two illustrations is that all too frequently the best of intentions and the best applications of true differential pricing theory soon are completely lost in practice. What starts out to be a highly effective, valid attempt to add traffic to existing capacity becomes nothing more than a generally available discount price available to virtually anyone.

Let's look back now to the execution of differential pricing policy which I have described as simplicity itself. I mentioned that all you needed to do was identify the market, arrive at a price, structure the product offering so that it would just fit the market, make sure you met your regulatory requirements, and be sure that you didn't at some time in the future add capacity for this product. It is easy to describe what should be done but it is extremely difficult in actual practice to measure the precise impact of various price levels and the real effect of the restrictions which are frequently applied to promotional or differential pricing.

I think I can say without reservation that everyone in the industry attempts to make these measurements and find these price levels but I doubt that anyone would be sufficiently bold as to claim that they were able to do so with great precision and anything approaching 100% accuracy. Differential pricing is still far too much of an art and not enough of a science in the airline industry.

Of an even greater concern, there is ample evidence that the industry has not been successful in keeping short run variable costs from turning into long run fully allocated costs. And differential pricing will not support fully allocated costs. There is considerable evidence that capacity has been added for incrementally priced traffic, and it is this addition of capacity and the addition of staff and capital investments required that defeats the concept of differential pricing, particularly as it applies on a selective market basis.

A secondary method of differential pricing and one in which there may be more short term promise is that of matching peak price with peak demand. Again the theory here is so basic that it almost needs no explanation. That is, you charge the most when the demand for your product is highest. This can be done on a time of day basis and is, it can be done on a day of week basis and is, and it can be done on a seasonal basis and is. I think the best examples of this type pricing can be found in the international market place, but that doesn't make it any less valid for domestic application.

This type of pricing also has the virtue that one needn't worry about the present price structure, for matching peak price with peak demand is merely an attempt to improve the present structure - not to change it. It's workable and we have some good examples of its workability in the Hawaiian market, and more recently in the major midwestern and eastern markets to Las Vegas, which has some very unique demand characteristics as I am sure you can imagine. The only danger in application of this type of pricing is the temptation to cut the price in the off-peak as opposed to increasing it during the peak period. If one yields to the temptation to cut the price, then we become subject for the same need for precision and infallible judgement as we find when we differentiate on a selective market basis. It may work, but the risks are far higher.

Increasing the price during the peak period on the other hand carriers little risk except that if your action is too bold or too steep you may discourage the market entirely during those periods. Fortunately, this is something that you will learn very quickly and something which is very easy to correct. It is always easier to adjust price on the downside than it is on the upside. So, in my judgement at least, the application of differential pricing in a fashion which applies peak price to the peak demand period is sound in both theory and practice, provided that those of us who are practitioners do not yield to the temptation to put too much faith in our crystal ball.

I might add, too, that this is an area where the CAB has typically given us a fair degree of freedom so that we have been able to experiment with price differentials and adjust them to some degree of reasonableness, so long as we do not get beyond the basic coach level and so long as we do not make a change of a radical nature at a time when a substantial number of the traveling public are affected. So with a certain amount of guarded optimism I think there is an opportunity for some successful practice of differential pricing as it relates to matching peak demand and peak price.

Let's go back now and talk for a few more minutes about the more difficult problem of selective or differential pricing on an individual market basis. There is no question but what this too is a valid pricing technique - if it is properly applied. The difficulty is how to bring theory and practice together. And I think that that becomes the mutual responsibility of the carriers and their regulators. First of all, the carriers must use caution and restraint both in the development of promotional or differential price offerings and the application of those offerings in the marketplace.

Carriers must stop and realize that long term planning means more than a week from today and that some of the actions that are taken for short term expediency can have some serious long term effects. Experiments must be treated as experiments by both the carriers and the CAB, and when a filing is described as an experiment, the results of that experiment must be evaluated and its success or failure judged so that only the successful experiments can be allowed to continue.

Differential pricing can be a valid means of improving profits, keeping [redacted] the total cost of air transportation down, and making it possible for more people to use air transportation. However, until we can truly put theory into practice we must be very critical of differential pricing proposals.

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THE
ECONOMIC EFFECT OF COMPETITION
IN THE
AIR TRANSPORTATION INDUSTRY

by

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Presented at the MIT/NASA Workshop on "Air Transportation Systems Analysis and Economics," Waterville Valley, New Hampshire

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This paper is subject to revision. The statements and opinions advanced are the author's and are his responsibility; they do not necessarily reflect the official views of United Air Lines.

Abstract

The air transportation industry has been described as a highly-competitive, regulated oligopoly or as a price-regulated cartel with blocked entry, resulting in excessive service and low load factors. The current structure of the industry has been strongly influenced by the hypotheses that increased levels of competition are desirable per se, and that more competing carriers can be economically supported in larger markets, in longer-haul markets, with lower unit costs, and with higher fare levels. An elementary application of competition/game theory casts doubt on the validity of these hypotheses, but rather emphasizes the critical importance of the short-term non-variable costs in determining economic levels of competition.

THE ECONOMIC EFFECT OF COMPETITION IN THE AIR TRANSPORTATION INDUSTRY

by Herbert B. Hubbard, United Air Lines

Introduction

Airlines are regulated and controlled by the government as public utilities because their services are deemed essential from the public standpoint and, accordingly, must be rendered efficiently. Furthermore, the economies of large-scale production and decreasing unit costs tend to increase the size of the business unit, and government regulation is designed to prevent the potential attendant unreasonable or unfair rates or inferior or inadequate service. However, unlike most other public utilities, few airlines enjoy monopoly situations with exclusive franchises for a number of years. Airlines are highly-regulated public utilities, but are also highly competitive.

Economists have defined airlines as "a blocked-entry, price-controlled, non-price-competing cartel," or as highly competitive but regulated oligopolies, with their products essentially undifferentiated, with entry of new competitors into a market difficult because of the entrance fee in terms of government regulation and capital costs, and in which the actions of each competitor (who supplies significant portions of the total product) can have a marked effect on the plans and actions of the other competitors. The classical economic theories for monopolies and pure competition do not apply to the air transportation industry, because there are generally more than one competitor in a market, but there are only a limited number of competitors. However, the economic situation of the airlines (that is, the imperfect competition of oligopolies) lends itself less easily to theoretical analyses than do monopolies and pure competition.

It is the purpose of this paper to investigate the economic effect of competition in the air transportation industry in terms of the efficient allocation of resources. The paper will include a discussion of competition, certain basic economic factors in the industry, the types of scheduling decisions made, the importance of flight share in determining market share, an illustration of the application of competition/game theory by means of a simplified example, and a summary of the apparent results of competition with conclusions. The derivation of the various mathematical relationships are included in the appendices.

COMPETITION

Competition is considered to be healthy and desirable in the American economy. There is competition in the transportation industry (1) between the various segments or modes of the industry and (2) within the various segments as certificated by governmental agencies. In the first case, we have a "natural" variety of competition in which technological improvements are paramount and which often results in substantial benefits to the public in the form of improved service and/or lower rates. On the other hand, the second type of competition, with multiple (more than 2 or 3) competitors, has tended to depress the economic viability of the carriers with negligible benefits to the public.

The expansion of route awards in the air transportation industry has made the government policy in this area well known. The amount of competition among the airlines has been increased substantially during recent years. In most cases, the Civil Aeronautics Board has not recognized nor fully considered the probable impact of such awards on the economic viability of the established carriers.

There is a fundamental question as to the amount of competition within the air transportation industry that is desirable and supportable from an economic efficiency point of view:

Federal Aviation Act, Section 102 — Declaration of Policy

> "....the Board shall consider....as being in the public interest.... Competition to the extent necessary to assure the sound development of an air transportation system....without....unfair or destructive competitive practices."

Bermuda Capacity Principles

> "....strong adherence of the United States....authorizing designated carriers to conduct their operations without predetermined limits on capacity, but subject to ex post facto review to require elimination of unjustified capacity....other countries are less enamored of the Bermuda capacity principles and wish to follow more restrictive policies than we in controlling capacity and scheduling."

C.A.B. Statement in the Southern Service to the West Case (1951)

> "....accumulated experience strongly suggests that we may have reached, and in some cases even exceeded, the optimum number of certificated services that can be economically supported by the available traffic."

Honorable Charles S. Murphy, Chairman, C.A.B., November 16, 1967

> "....the American economy is generally a competitive economy. For the most part, we depend upon free competition among private business enterprises to achieve the most efficient use of resources.... belief that vigorous competition is a good thing — even in the airline industry."

Honorable Secor D. Brown, Chairman, C.A.B., August, 1970

> "The cardinal sins of the regulators have been in legislating, in effect, wasteful, ruinous over-competition along our routes and then intervening unwisely to forestall the natural adjustments for over-competition — merger, statesmanlike agreement, or business failure."

Critical Hypotheses

There appear to be several hypotheses that gained rather wide acceptance among members within the industry and among observers and analysts of the industry, and that have influenced the current structure of the industry and level of competition:

1. Increased levels of competition are deemed desirable per se.
2. More competing carriers can be economically supported:
    a. In larger passenger markets (in terms of passengers per day),
    b. In longer-haul markets (with greater revenues per passenger),
    c. With lower unit costs (in terms of cents per available seat mile),
    d. With higher fare levels (in terms of cents per revenue passenger mile), and,
    e. With newer technology (with resulting economies of scale).
3. Increases in market share will result in greater profits.

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BASIC ECONOMIC FACTORS

An evaluation of the air transportation industry must recognize economies of scale, the lumpiness (large incremental step-functions) of various types of costs, and marginal analysis for determining the efficient economic allocation of resources.

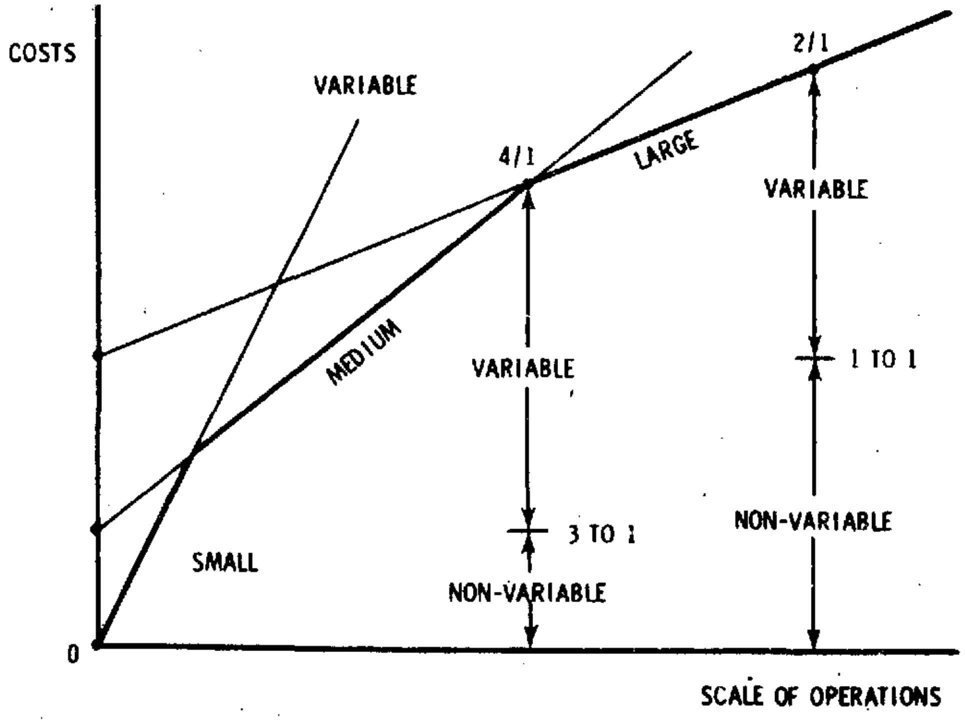

CHART 1

Economies of Scale

Chart 1 shows a theoretical variation in total costs as a function of the scale of operations. A small firm might have essentially no fixed costs but relatively high variable costs. A medium-sized firm may have some non-variable fixed costs and, as a result, somewhat lower variable costs, in which the total variable costs might be three times the non-variable costs, or, in other words, the total costs might be four times the total non-variable fixed costs. An even larger firm might have significantly higher non-variable fixed costs, with even lower unit variable costs such that the total costs might be only two times the non-variable fixed costs. These relationships show a decreasing total unit cost with increasing scale of operation.

Because various costing methodologies tend to be rather subjective, it is difficult to categorize certain costs as totally variable and others as completely fixed or non-variable in the short term of six months to one year. (Over the longer term, all costs must be considered as variable.) However, in contrast to some economists' contentions, our analyses and detailed costing models have shown the above economies of scale (decreasing unit costs) with great accuracy for United and other carriers, with total costs ranging from 2 to 3 times the non-variable fixed costs. (Such economies of scale have led to the establishment of "natural" monopolies in other industries.)

Lumpiness of Costs

There are four different levels of costs which must be recognized: costs per unit, costs per production lot, costs for capital equipment, and overhead costs. Certain airline costs tend to vary directly with the volume of passengers served (i.e., tickets, meals, insurance, reservations costs, etc.) and can be handled as a deduction to obtain the net fare yield per passenger. Other costs are quite lumpy, such as the marginal operating costs for a given flight (principally fuel, crew, and direct maintenance costs) which are essentially independent of the passenger loads. The capital costs of the equipment vary with the number of airplanes, each of which is used on one or more trips per day. Other airline costs are established on the basis of the planned scale of operations and do not vary with individual scheduling decisions.

Marginal Analysis

For economic efficiency, a firm should expand its volume of operations until the marginal revenues just equal marginal cost, in order to maximize its profits or minimize its losses, as shown in Chart 2.

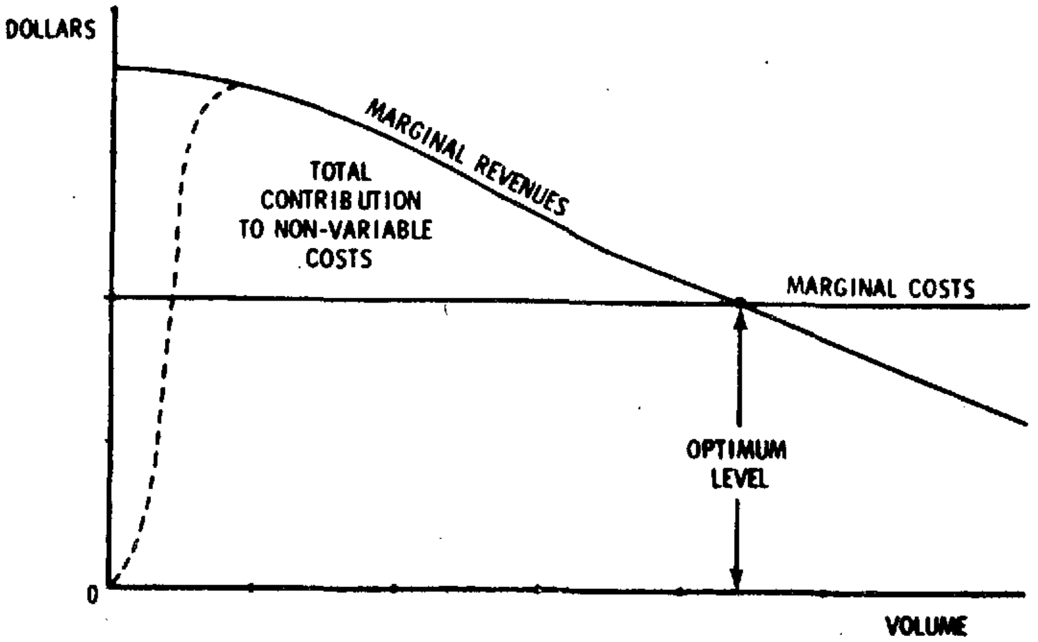

CHART 2

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Although a certain minimum volume of operations might be required to realize the marginal revenue curve shown, the area between the marginal revenue line and the marginal cost line represents the total contribution to non-variable costs. It should be noted that the marginal cost curve has not been assumed to turn up with increasing volumes in accordance with the classical economists' theory, but rather shows no dis-economies of scale.

SCHEDULING DECISIONS

Analyses have shown that the basic schedule pattern for an airline determines 80-90% of its revenues, determines 70-90% of its costs, and also establishes 85-95% of its total capital investment. The basic schedule pattern is established on the basis of a series of scheduling decisions for all of the various airport-pair time markets, together with their interrelationships. For the purpose of simplification, but without distorting the basic factors, there are really only three types of scheduling decisions for an airport-pair time market:

1. Decision to add or subtract a flight, which is an integer number. (It is relatively easy to add a flight in a market, but quite difficult to reduce service, in view of various community pressures.)
2. Decision to change the type of airplane providing the service.
3. Decision to move a flight earlier or later during the day.

MARKET SHARE

Accurate forecasts of market share are essential for the schedule planning and equipment purchase decisions, and for the resulting workforce planning, facilities planning, etc. Experience has shown that an increase in frequency in a major competitive market is generally accompanied by an increase in market share and an attendant increase in revenue. In fact, frequency of service is probably the strongest competitive tool in the airlines' "bag of tricks.'

A carrier in search of an increased part of the total industry revenues may act in a rational manner by adding one flight on a segment. His competitors, seeing their share of the market slip and their revenues decline, may act in an equally rational manner by adding one flight in an attempt to retain their market share and profits. After some "settling" time, each carrier could be back to its original market share, so that its operating revenues would be unchanged. However, each carrier would have increased its operating costs by the expense of the additional flight. It can been seen that by changing a relatively stable two-carrier market into a three, four, and sometimes five-carrier market, it becomes more volatile, with the possibility that one carrier will set off a chain-like reaction.

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The increase in frequency (capacity and costs), with a resulting reduction in load factor, due to the competitive nature of the industry has been explained by Mr. Joseph V. Yance, consultant to the Office of the Secretary of Transportation (CAB Docket 21866-6, Exhibit DOT-RT-1, pages 6 and 7):

> "As we noted earlier, American, United, and TWA argue that the number of competitors in a market has an impact on load factors. In general, the more competitors in a market, the lower the load factors of carriers serving that market. Our theoretical analysis of carrier behavior supports this view.
>
> "The reasoning is as follows. What is critical to an airline in making its schedule decision is the number of "new passengers" attracted by an additional flight. (By "new passengers," we mean passengers the airline is not already carrying on its existing flights.) In either a monopoly or a competitive market, the number of new passengers required to sustain a flight is the same. But the relation between new passengers and average load on board varies significantly between the two types of markets. In a monopoly market, apart from passengers who are flying because of the additional service and who would not fly absent such new service, all of the passengers on board a new flight are drawn from other flights of the (same) airline; hence unless the number of persons who would first fly because of the new service is large enough to cover the costs of a new flight, the flight will not be added.
>
> "The situation is very different in a competitive market. There, new passengers will consist of (1) those persons first traveling because of the additional service (as in the case of a monopoly market), and (2) passengers diverted from existing flights of <u>other</u> airlines. It may thus be profitable for a carrier to add a flight, even though overall load factors in the market decline. On the basis of this analysis, one cause for the decrease in load factors one observes over time is the increasing competitiveness of markets."

"S" Curve Relationships

Many analyses have been made to relate the market share (or percentage participation in the total passenger market) to the flight share (or relative number of flights per day), as shown in Chart 3. The relationship line will obviously pass through the origin and the (100,100) end point, and in a two-carrier market, will generally pass through the (50,50) point. Some analysts have concluded that there is an "S"-shaped curve effect, since a majority of the points in the 15-35% range are below the diagonal regression line, while a majority of the points in the 65-90% range are above it. Such an "S"-shaped curve would imply that the carrier with the highest frequency share would get a disproportionate market share, and that therefore the way to make greater profits is to be the schedule leader. Such reasoning might lead a carrier to emphasize market share and growth to the neglect of the profit objective.

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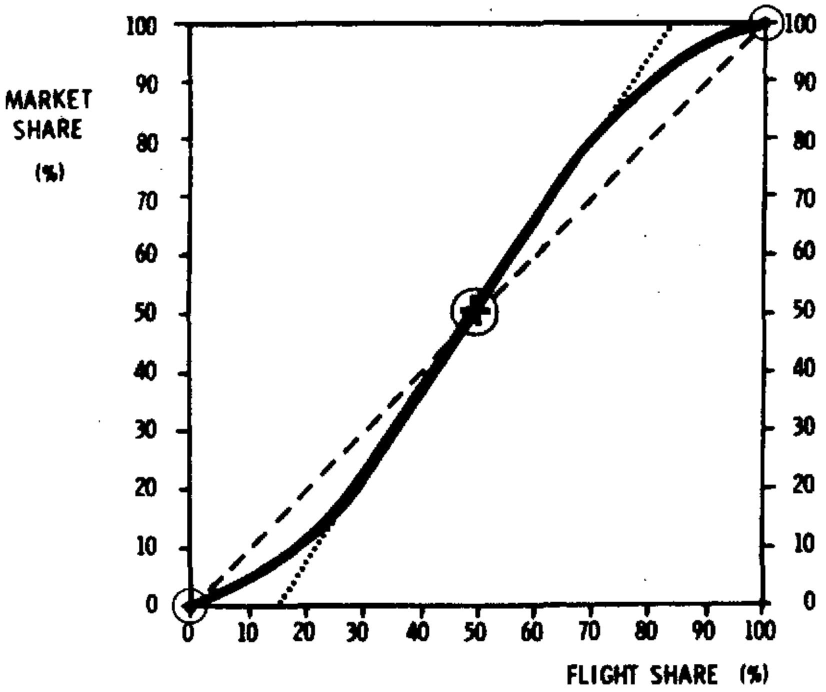

CHART 3

The Civil Aeronautics Board released on July 21, 1970 (CAB 70-96, 382-6031), the first of a projected series of staff studies evaluating route awards made by the Board in recent years. It was their first attempt to determine whether the carriers have actually performed in accordance with the anticipation and intent of the Board. Some of the conclusions reached in the pilot study included:

> "2. The total number of flights and the proportionate share of non-stop flights were greater under competition.
>
> "4. There appears to be generally a close relationship between the share of flights provided by each carrier and the share in traffic."

In order to analyze the effect of competition, it is not necessary to assume an "S"-shaped curve but to merely recognize that a change in the frequency share by one carrier will effect its market share. High correlation coefficients in the regressions of market share against flight share have been interpreted as proving the validity of the "S" shape. However, in most analyses, the regression hypothesis is actually whether greater frequency means greater market share, not whether greater frequency means a disproportionate market share.

Linear Regression Analysis

As part of United's rebuttal testimony in Phase 6 of the General Domestic Passenger Fare Investigation (Docket 21866-6, Exhibits UR-T-1, pages 12 and 13, and Exhibits UR-8 and 9), the results of a linear regression analysis of all of the basic data contained in the C.A.B. Bureau of Economics Exhibits BE 6502 (Columns 8 and 10) for all competitive sample markets were summarized:

Market Share = 1.09 x Flight Share - 3.7
(in %) (in %)

280 Observations*

Coefficient of Determination (R^2) = 91.4% of Total Variance

Standard Error of Estimate = 6.48 percentage points

F level = 30.05

* In order to avoid the inherent auto-correlation among the data for all carriers in a market, only one data point was used for a two-carrier market, two data points for a three-carrier market, etc.

These results show the extremely high correlation which actually exists between market share and flight share, based on the extensive basic data assembled by the C.A.B. Bureau of Economics. Furthermore, an analysis made of the exceptional variances, between the actual and the predicted values for the various city-pair markets included in the regression analysis, highlighted the practical aspects of on-line, through, and connecting service and the factor of market identity. By recognizing these differences, the relationship between market share and flight share would have become even greater than that indicated in the correlation analysis. It would be very difficult to improve these simple linear regression results (with a nominal threshold value) by more complicated and sophisticated curvilinear relationships to approximate the "S" curve. Accordingly, the following analysis is based initially on the simple diagonal relationship (that is, market share = flight share), and later extended to cover a linear regression with a threshold value and a possible curvilinear relationship.

BASIC ASSUMPTIONS

The following competition/game theory analysis is based on two basic assumptions:

1. There is no collusion, overt or tacit, among competitors.

2. Each carrier purchases and schedules equipment in its own self-interest, i.e.:

    a. Each carrier expands its production (schedules) up to the limit of capacity whenever marginal revenues exceed marginal costs, and,

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b. Each carrier purchases additional equipment if the marginal contribution exceeds marginal capital costs.

The second assumption would preclude an airline from seeking growth or increased market share at the expense of profit.

EXAMPLE OF COMPETITION

The following simplified example is based on a reasonably typical airport-pair time market:

Potential Market (If 3 or More Flights)	200 passengers per day
Net Fare Yield	$67.20 per passenger
Airplane Seating Capacity	100 seats
Variable Costs	$1,400 per flight

By simple arithmetic, it can be seen that if this were a monopoly market with only Airline "A" certificated, that carrier would probably operate three (or possibly four) flights.

	3 Flights	4 Flights
Revenues Per Day	$13,440	$13,440
Variable Costs Per Day	4,200	5,600
Net Contribution Per Day	$ 9,240	$ 7,840
Passenger Load Factor	67%	50%

Two Carriers

If Airline "B" were to be certificated as a new competitor in this market, with three flights already operated by Airline "A", it would be faced with the marginal economic analysis shown in Chart 4, based on the direct diagonal relationship of market share against flight share. For example, if Airline "B" operates one flight out of a total of four flights, the marginal revenue for that flight would be one-fourth x $13,440, or $3,360. Airline "B", accordingly, would probably operate two flights in the market, because the total contribution for these two flights would be $2,580 per day, $60 greater than if it operated three flights.

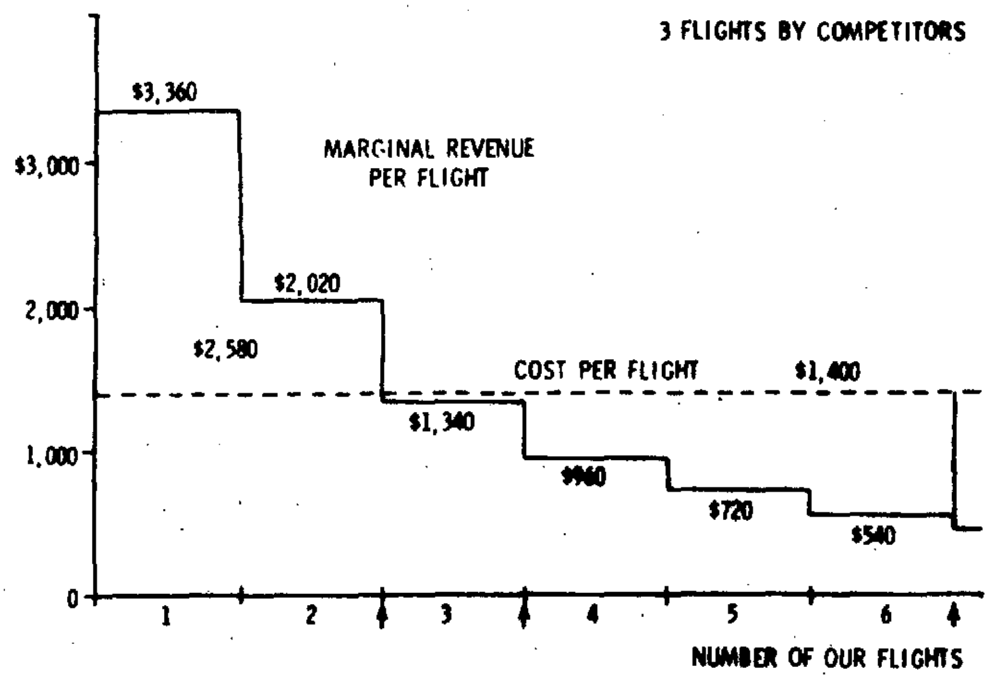

CHART 4

However, Airline "A" would now find that its contribution from the market could be increased by $60 if it cut back to two flights per day. The net result would be four flights in the market (two by "A" and two by "B"), with an average passenger load factor of 50%. However, if each airline hoped to increase its share of the market from 50% to 60% at a daily cost of $60, the net result might be six flights in the market (three by "A" and three by "B"), with an average passenger load factor of 33% and with each airline realizing $1,400 per day less contribution than if each airline operated only two flights in the market. Chart 4 also demonstrates graphically the potential impact of attempting to increase market share at the expense of profit.

Three Carriers

If a third carrier, Airline "C", were to be authorized, with four flights already serving the market (two by "A" and two by "B"), Airline "C" would operate at least one flight with a contribution of $1,290 per day, but probably two flights with a total contribution of $1,680 per day. A third flight by "C" would have a negative contribution. Neither "A" nor "B" could improve its own contribution by either increasing or decreasing its frequency. The net result would be six flights in the market (two each by "A", "B", and "C"), with an average passenger load factor of 33%.

Four Carriers

In a similar manner, the authorization of a fourth airline, "D", would tend to result in eight flights in the market, with an average load factor of 25% and a contribution of only $560 per airline, which probably would be inadequate to cover the allocated capital costs and those cost factors not directly related to this market.

Scheduling Strategy

Chart 5 illustrates the results of various scheduling strategies for the example case, based on the simplified (and most favorable) relationship that market share equals flight share.

Market Share
Revenue
Cost
Contribution
P.L.F.

MARKET SHARE = FLIGHT SHARE

		NUMBER OF FLIGHTS BY COMPETITORS						
		0	1	2	3	4	5	6
NUMBER OF OUR FLIGHTS	1	100% $ 5,040 -1,400 $ 3,640 75%	50% $ 5,040 -1,400 $ 3,640 75%	33% $ 4,480 -1,400 $ 3,080 67%	25% $ 3,360 -1,400 $ 1,960 50%	20% $ 2,690 -1,400 $ 1,290 40%	17% $ 2,240 -1,400 $ 840 33%	14% $ 1,920 -1,400 $ 520 29%
	2	100% $10,080 -2,800 $ 7,280 75%	67% $ 8,960 -2,800 $ 6,160 67%	50% $ 6,720 -2,800 $ 3,920 50%	40% $ 5,380 -2,800 $ 2,580 40%	33% $ 4,480 -2,800 $ 1,680 33%	29% $ 3,840 -2,800 $ 1,040 29%	25% $ 3,360 -2,800 $ 560 25%
	3	100% $13,440 -4,200 $ 9,240 67%	75% $10,080 -4,200 $ 5,880 50%	60% $ 8,060 -4,200 $ 3,860 40%	50% $ 6,720 -4,200 $ 2,520 33%	43% $ 5,760 -4,200 $ 1,560 29%	37% $ 5,040 -4,200 $ 840 25%	33% $ 4,480 -4,200 $ 280 22%
	4	100% $13,440 -5,600 $ 7,840 50%	80% $10,730 -5,600 $ 5,130 40%	67% $ 8,960 -5,600 $ 3,360 33%	57% $ 7,680 -5,600 $ 2,080 29%	50% $ 6,720 -5,600 $ 1,120 25%	44% $ 5,970 -5,600 $ 370 22%	40% $ 5,380 -5,600 $ -220 20%

CHART 5

The horizontal rows, for various number of flights that we might operate, show the results when faced by various number of flights operated by our competitor(s). The entries in each box show our market share, our resulting revenue based on that market share, our variable costs at $1,400 per flight, our contribution from the market, and the passenger load factors for our flights and for the industry. For example, if we expect our competitors to operate four flights, our greatest contribution from the market would be $1,680 by our operating two flights.

The results for the industry may be summarized as follows:

Market Revenues	$13,440 per day
Variable Costs	$ 1,400 per flight

Number of Carriers (Q)	1	2	3	4
Flights/Carrier	3	2	2	2
Total Flights	3	4	6	8
Passenger Load Factor	67%	50%	33%	25%
Industry Revenues	$13,440	$13,440	$13,440	$13,440
Industry Costs	4,200	5,600	8,400	11,200
Industry Net	$ 9,240	$ 7,840	$ 5,040	$ 2,240

This summary can be extended to show the industry profits resulting if the variable costs represent only 67% or 50% of the total costs:

If Variable = 67% Total Costs

Non-Variable Charge	2,100	2,800	4,200	5,600
Industry Profit	$ 7,140	$ 5,040	$ 840	$-3,360

If Variable = 50% Total Costs

Non-Variable Charge	4,200	5,600	8,400	11,200
Industry Profit	$ 5,040	$ 2,240	$-3,360	$-8,960

For this illustrative airport-pair time market, four competitors would incur significant losses and three competitors would have either inadequate returns on their investments or losses.

The results of the simplified example can be generalized by the use of micro-economic analysis combined with an elementary form of competition/game theory. However, this application is really not the classical game theory, as developed by J. Von Neumann and Oskar Morgenstern, but rather is derived by the simple application of high school partial differential equations. Appendix A-1 shows that if each carrier adds flights as long as the marginal revenues equal or exceed the marginal cost, and if the market share equals the flight share:

$$\begin{pmatrix}\text{Optimum Number}\\ \text{of Flights for}\\ \text{Each Carrier}\end{pmatrix} = \frac{\text{(Industry Market Revenues)}}{\text{(Variable Costs Per Flight)}} \times \left(\frac{Q-1}{Q^2}\right)$$

$$\text{For } Q = 2, \quad \left(\frac{Q-1}{Q^2}\right) = \frac{1}{4}$$

$$\text{For } Q = 3, \quad \left(\frac{Q-1}{Q^2}\right) = \frac{2}{9}$$

$$\text{For } Q = 4, \quad \left(\frac{Q-1}{Q^2}\right) = \frac{3}{16}$$

In this relationship, Q represents the number of equal competitors in a particular airport-pair time market, with equal drawing power for each competitor's flights. The industry market revenues per day are available to all competitors in the market. In the short term, the variable costs per flight might represent only the costs for fuel, crew, and direct maintenance, but over the longer term would have to include the capital costs for additional equipment. This equation also assumes that the industry market revenue forecasts made at the time of equipment purchase actually materialize when the equipment is placed into service. If not, the number of trips scheduled will exceed the optimum number, making the resulting contributions and profits lower than this equation would suggest.

Application of the above equation to the illustrative example results in the following comparison of the theoretical optimum number of flights for each carrier versus the number determined previously:

	Number of Carriers (Q)			
	1	2	3	4
Equation: $\frac{\$13,440}{\$\ 1,440} \times \frac{Q-1}{Q^2}$	-	2.4	2.1	1.8
As Determined Previously In Example	3	2	2	2

Total Industry Relationships

Appendix A-2 extends the above relationship to the total industry by simple algebraic manipulation:

- $$\text{Total Flights} = \frac{\text{(Industry Market Revenues)}}{\text{(Variable Costs Per Flight)}} \times \left(\frac{Q-1}{Q}\right)$$

$$\text{Total Costs} = g \times \text{(Industry Market Revenues)} \times \left(\frac{Q-1}{Q}\right)$$

$$\text{Where} \quad g = \frac{\text{(Total Costs)}}{\text{(Variable Costs)}}$$

$$\text{Operating Ratio} = g\left(\frac{Q-1}{Q}\right)$$

- $$\text{Profit Margin} = 1 - g\left(\frac{Q-1}{Q}\right)$$

- $$\text{For Breakeven} \quad g\left(\frac{Q-1}{Q}\right) \equiv 1$$

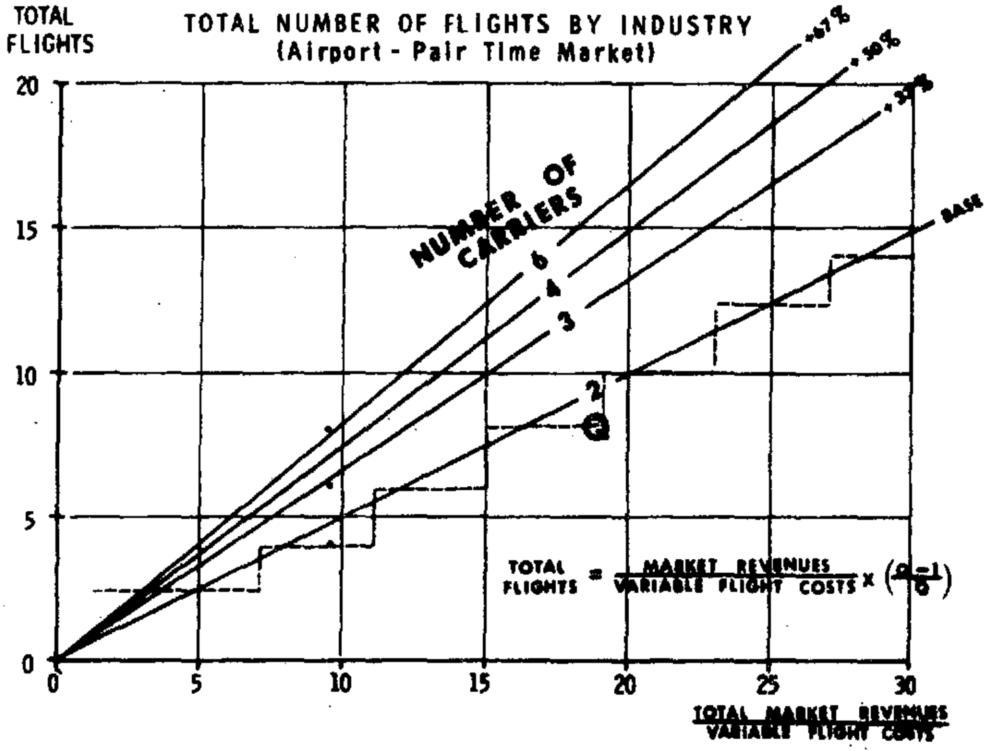

CHART 6

Total Industry Flights

Chart 6 shows the total number of industry flights as a function of the ratio of total market revenues to variable costs per flight for various numbers of carriers in an airport-pair time market. It can be seen that the total number of industry flights tends to vary directly with the market size and fare level, and varies inversely with the variable costs per flight. It also increases with the number of carriers. However, it will tend to follow a stepped function because of the requirement of an integer number of flights by each carrier.

The service to the traveling public may be improved by the increased number of flights, but it should be recognized that the costs and capital investments vary also with the increased number of flights, resulting in a deterioration of the return on investment for each carrier. Similarly, the actual passenger load factor realized will be decreased with an increased number of competitors.

On the other hand, the service to the traveling public may not be improved with an increase in the number of competitors. A monopoly carrier could provide good service with five flights, spaced at desirable departure times throughout the day; whereas three carriers in the same market might operate three flights each for a total of nine flights, but with three competing flights peaked at the three largest-demand periods of the day, since this can be shown to be the "best" strategy for each competing carrier.

Profit Margin

Chart 7 shows that the profit margin for the industry is a function of the ratio of total costs to variable costs and the number of carriers, covering a representative range of values.

$$\text{PROFIT MARGIN} = 1 - \left(\frac{\text{TOTAL COSTS}}{\text{VARIABLE COSTS}}\right)\left(\frac{Q - 1}{Q}\right)$$

WHERE Q — NUMBER OF CARRIERS CERTIFICATED

TOTAL COSTS/VARIABLE COSTS	NUMBER OF CARRIERS (Q)				
	2	3	4	5	6
2.00	0	-33%	-50%	-60%	-67%
1.50	25%	0	-12%	-20%	-25%
1.33	33%	11%	0	- 6%	-11%
1.25	37%	17%	6%	0	- 4%

CHART 7

It is enlightening to see that the profit margin is apparently not sensitive to the absolute levels of costs, but is quite sensitive to the ratio of total costs to variable costs. The higher this ratio becomes, the lower the air transportation industry's profits will be. Unfortunately, the trend of this ratio over time has been definitely upward in the air transportation industry as a result of greatly increased capital investments for new aircraft, ground equipment, and facilities. In addition, the annual charges by local airports have risen substantially during recent years. Furthermore, labor contracts are tending in various ways toward greater job security in one form or another, which has the effect of converting variable costs into more fixed, longer-term commitments to the employees. Since the variable cost of flying a jet a certain distance is not substantially greater than that for a piston aircraft over the same distance, the end result of the jet technology has been that higher fixed costs must be allocated over relatively fewer units of production.

Chart 7 shows that, regardless of the size of the market and regardless of the fare level, a three-competitor market can be little better than a break-even operation, and that for healthy profits, only two competitors may be tolerated in any market.

Break-even Operation

Chart 8 shows that the maximum number of carriers in any market is equal to the ratio of total costs to non-variable costs and is independent of market size, length of haul, unit cost, and fare level.

FOR BREAK-EVEN, OPERATING RATIO = 1.0

$$\left(\frac{\text{TOTAL COSTS}}{\text{VARIABLE COSTS}}\right)\left(\frac{Q-1}{Q}\right) = 1.0$$

MAXIMUM NUMBER OF CARRIERS (Q*)

$$Q^{*} = \left(\frac{\text{TOTAL COSTS}}{\text{TOTAL COSTS} - \text{VARIABLE COSTS}}\right) = \frac{\text{TOTAL COSTS}}{\text{NON-VARIABLE COSTS}}$$

CHART 8

TOTAL COSTS/NON-VARIABLE COSTS	MAXIMUM NUMBER OF CARRIERS
2	2
3	3
4	4
5	5

INDEPENDENT OF MARKET SIZE, LENGTH OF HAUL, UNIT COSTS, AND FARE LEVEL

This rather simple relationship, easy to understand, might also be applicable to other industries and firms which have relatively high fixed costs, such as the fertilizer, plastic, steel, and automotive industries, and possibly even applicable to the number of filling stations at a busy intersection.

Further Extensions

The preceding derivation and results were based on certain simplified assumptions, but what would be the result if the various carriers in a market are not equal and have different drawing powers (or relative load factors), or what if there is a threshold point in the market share versus flight share relationship, or what if an airline's competitors operate more or fewer flights than they really should for maximum profit?

The assumption that all competitors in a market were equal may seem to be a severely limiting assumption, in that there are few markets where all competitors are truly equal. Upon closer inspection of the equations, however, it is clear that we are not bound by this assumption, and that the model can easily be made to apply to unequal competitors. Since industry profits in a market are determined by the number of flights actually scheduled, the value of "Q" can be adjusted to conform to the actual number of trips scheduled in the market. This new "Q" is the number of "equivalent" equal competitors and may be a continuous variable. For example, if three airlines operate in a given market, but one dominates the market, we may be dealing with an effective "Q" of 2.2 rather than 3. By adjusting "Q" in this way, it is possible to use the various equations shown above to describe the actual situation. Furthermore, as shown in Appendix A-3, if the drawing power of one carrier's flights is 10% greater than those of its competitors, the optimum integer number of flights for that carrier and its competitors probably would remain unchanged.

As shown in Appendix A-4, if there were a threshold value in the market share versus flight share relationship (e.g., market share equals 1.10 times flight share minus 5), the optimum number of flights for each carrier would be increased by the slope of the line (10% for the assumed relationship). Unfortunately, the total number of flights, costs, and investment would be increased to the extent that the airline managements assumed this slope to be greater than 1.0.

Appendix A-4 also shows that the optimum number of flights, costs, and investment would be increased directly by the exponent in an assumed (or empirically derived) curvilinear relationship of market share as a function of flight share, for example

$$(\text{Market Share}) = K(\text{Flight Share})^2$$

As shown in Appendix A-5, the optimum number of flights for a carrier to operate is quite insensitive to the actual number of flights operated by its competitors, for the basic diagonal linear relationship of market share = flight share.

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RESULTS OF COMPETITION

The customer-oriented competitive nature of the air transportation industry has resulted in a frequency battle with more carriers providing more non-stop flights to more destinations at more times of the day from multiple-airports serving the major metropolitan areas. These new flights may have improved the service and convenience for the traveling public, but at lower load factors and higher costs.

Technological developments have resulted in an equipment battle that has further compounded the economic impact of the competitive frequency battle. The engineers and manufacturers have designed and developed faster, bigger, and more expensive types before the airlines have recouped their capital investments in existing fleets. As soon as one airline buys a new design, competitive pressures force the others to follow, with marked increases in total industry indebtedness. New technology large jet aircraft have been introduced to both replace the smaller first-generation jets and to permit a reduction in seat-mile costs in spite of the inflationary cost pressures. However, this growth in seating capacity has exceeded the normal growth in passengers, also resulting in lower load factors.

Sensitivity Analysis

Chart 9 summarizes the probable impact on flight frequency, costs, capital investment, and passenger load factors as the result of changes in passenger volume, fare level, variable costs per flight, and number of carriers certificated. It can

NUMBER OF INDUSTRY FLIGHTS
(AIRPORT-PAIR TIME MARKET)

PERCENTAGE CHANGE IN CONDITIONS		PROBABLE PERCENTAGE CHANGE IN:	
		FREQUENCY & COSTS	P.L.F.
PASSENGERS	+10	+10	0
	-10	0	-10
FARE	+10	+10	-10
	-10	0	+10
COST PER FLIGHT	+10	0	0
	-10	+10	-10
NUMBER OF CARRIERS CERTIFICATED			
1 → 2		+50 to +100	-43
2 → 3		+33 to +50	-29
3 → 4		+12 to +33	-18
4 → 5		+7 to +25	-14

CHART 9

be seen that under most changes in conditions, the number of flights and costs will tend to be increased and the passenger load factor depressed. Only if the fare elasticity of demand were -1.0 or more might the passenger load factor increase as indicated. Obviously, from a sensitivity standpoint, the number of carriers certificated is most critical in determining the increase in flights, costs, and capital investment, with a resultant depressant of passenger load factor.

Case in Point

This summary has been derived from a rather straightforward analysis, but it might be considered theoretical or abstract. One specific example from actual operations might be mentioned: in 1969, United's service to and from Hawaii produced a pre-tax profit of more than $26 million; the next year, after five additional carriers were granted Hawaiian routes, United's Hawaiian service had a pre-tax loss of more than $17 million; a change on this one route of more than $43 million per year. No carrier is currently earning a reasonable return in the Hawaiian service.

CONCLUSIONS

From the foregoing analysis, we may conclude that:

1. The hypotheses which have influenced the current structure of the industry and level of competition, as stated earlier, have not led to the most efficient allocation of resources for either the traveling public or the air transportation industry.

2. The competitive, economic, regulatory, and technological environment for the air transportation industry has resulted in over-competition with resultant:

    a. Excessive numbers of flights, costs, and capital investments, which must be supported by the fare levels.

    b. Low utilization of productive capacity — low load factors.

    c. Marginal or loss operations.

3. The maximum number of fully-competitive carriers possible in any market can not exceed the ratio of total costs to non-variable costs, and is not a function of the market size, length of haul, unit costs, fare level, or aircraft type. With the inherent increases in fixed costs which have occurred over time, the ratio of total costs to non-variable costs in the air transportation industry appears to range from 2 to 3.

BASIC DERIVATION
for
EACH CARRIER

Let M = Industry Passengers
F = Net Fare per Passenger
C = Variable Costs per Flight
P_A = Contribution for Carrier A, similarly for B and C
N_i = Optimum Number of Flights for Each of i Carriers

x = Flights by A
y = Flights by B
z = Flights by C
Q = Number of Carriers
$g = \dfrac{\text{Total Costs}}{\text{Variable Costs}}$

CONDITION A

1. Each carrier schedules for maximum contribution, that is, marginal revenues $\geq$ marginal costs.

2. Market Share = Flight Share.

For $Q = 2$ Competing carriers A and B

$$P_A = \left(\frac{x}{x+y}\right) MF - xC \quad , \quad P_B = \left(\frac{y}{x+y}\right) MF - yC$$

For maximum contribution, $\dfrac{\partial P_A}{\partial x} = 0$ and $\dfrac{\partial P_B}{\partial y} = 0$

$$\frac{\partial P_A}{\partial x} = \left[\frac{(x+y) \cdot 1 - x}{(x+y)^2}\right] MF - C = 0 \quad , \quad \frac{\partial P_B}{\partial y} = \left[\frac{(x+y) \cdot 1 - y}{(x+y)^2}\right] MF - C = 0$$

Solving simultaneous equations,

$$X_{OPT} = Y_{OPT} = N_2 = \frac{MF}{C} \times \frac{1}{4} = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) *$$

For $Q = 3$ Competing carriers A, B, and C

By similar analysis

$$X_{OPT} = Y_{OPT} = Z_{OPT} = N_3 = \frac{MF}{C} \times \frac{2}{9} = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right)$$

For Q carriers, by extension

(1) $$N_Q = \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) \quad \text{for each carrier}$$

---

* In order for the first derivative of P to result in a maximum value for P, the second derivative must, of course, be negative. This will be the case when Q is greater than 1.

BASIC DERIVATIONS
for
TOTAL INDUSTRY

CONDITION A (Continued)

For the total industry,

(2) $$\text{Total Flights} = QN_Q = \frac{MF}{C}\left(\frac{Q-1}{Q}\right)$$

$$\text{Total Variable Costs} = C \times \frac{MF}{C}\left(\frac{Q-1}{Q}\right) = MF\left(\frac{Q-1}{Q}\right)$$

(3) $$\text{Total Costs} = gMF\left(\frac{Q-1}{Q}\right)$$

$$\text{Operating Ratio} = \frac{\text{Total Costs}}{\text{Total Revenues}}$$

(4) $$= g\left(\frac{Q-1}{Q}\right),$$ independent of M, F, and C

(5) $$\text{Profit Margin} = 1 - g\left(\frac{Q-1}{Q}\right),$$ independent of M, F, and C

For break-even, Operating Ratio = 1.0

$$g\left(\frac{Q-1}{Q}\right) = 1.0$$

Maximum number of carriers Q* possible

$$Q^* = \frac{g}{g-1}$$

(6) $$= \frac{\text{Total Costs}}{\text{Non-variable Costs}}$$

Again, independent of M, F, and C

FURTHER EXTENSIONS

CONDITION B

1. Each carrier schedules for maximum contribution, and
2. Competitors in market are not equal, such that the drawing power of A's flights = 110% of competitors' flights.

For $Q = 3$ Competing carriers A, B, and C

$$P_A = \left(\frac{1.1x}{1.1x+y+z}\right) MF - xC \quad , \quad P_B = \left(\frac{y}{1.1x+y+z}\right) MF - yC$$

$$\frac{\partial P_A}{\partial x} = \frac{(1.1x+y+z - 1.1x)}{(1.1x+y+z)^2}\ 1.1MF - C$$

$$\frac{\partial P_B}{\partial y} = \frac{(1.1x+y+z - y)}{(1.1x+y+z)^2}\ MF - C \quad , \quad \text{similarly for } P_C$$

Solving for maximum contribution, simultaneously,

$$X_{OPT} = \frac{2.4}{(3.2)^2}\ \frac{MF}{C} = 1.05\ \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) = 1.05\ N_3 \tag{7}$$

$$Y_{OPT} = \frac{2.2}{(3.2)^2}\ \frac{MF}{C} = 0.97\ \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right) = 0.97\ N_3$$

$$Z_{OPT} = \frac{2.2}{(3.2)^2}\ \frac{MF}{C} = 0.97\ N_3$$

That is, a reasonably significant difference in drawing power (or relative load factor) generally will not affect the optimum integer number of flights to be operated.

CONDITION C

1. Each carrier schedules for maximum contribution, and
2. Market Share = 1.10(Flight Share) - 0.05

$$P_A = \left[1.1\left(\frac{x}{x+y+z}\right) -.05\right] MF - xC, \quad \text{similarly for B and C}$$

$$\frac{\partial P_A}{\partial x} = 1.1 \frac{(x+y+z - x)}{(x+y+z)^2} MF - C, \quad \text{similarly for B and C}$$

Solving for maximum contribution, simultaneously

$$X_{OPT} = Y_{OPT} = Z_{OPT} = 1.10\ N_Q \quad , \text{ and} \tag{8}$$

$$\text{Total Industry Flights} = 1.10\ QN_Q = 1.10 \frac{MF}{C}\left(\frac{Q-1}{Q}\right)$$

That is, the optimum number of flights for each carrier, and the total number of flights (and costs) for the industry are increased directly by the slope of the regression line of market share against flight share.

CONDITION D

1. Each carrier schedules for maximum contribution, and
2. $\text{Market Share}_A = K\left(\frac{x}{x+y+z}\right)^2$, similarly for B and C

$$= \frac{x^2}{x^2+y^2+z^2} \quad , \text{similarly for B and C}$$

$$P_A = \left(\frac{x^2}{x^2+y^2+z^2}\right) MF - xC \quad , \text{similarly for B and C}$$

$$\frac{\partial P_A}{\partial x} = \frac{(x^2+y^2+z^2)\,2x - x^2 \cdot 2x}{(x^2+y^2+z^2)^2} MF - C \ , \text{similarly for B and C}$$

Solving for maximum contribution, simultaneously,

$$X_{OPT} = Y_{OPT} = Z_{OPT} = 2\,N_Q \quad , \text{ and} \tag{9}$$

$$\text{Total Industry Flights} = 2\,Q\,N_Q = 2\ \frac{MF}{C}\left(\frac{Q-1}{Q^2}\right)$$

That is, the optimum number of flights for each carrier, and the total number of flights (and costs) for the industry are increased directly by the exponent in the curvilinear relationship of market share as a function of flight share.

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CONDITION E

1. Carrier A schedules for maximum contribution, but
2. Carrier B actually operates K times N_2 flights

$$y = KN_2 = K\frac{MF}{C}\left(\frac{2-1}{2^2}\right) = K\left(\frac{MF}{4C}\right)$$

3. Market Share = Flight Share

$$P_A = \left(\frac{x}{x+KN_2}\right) MF - xC$$

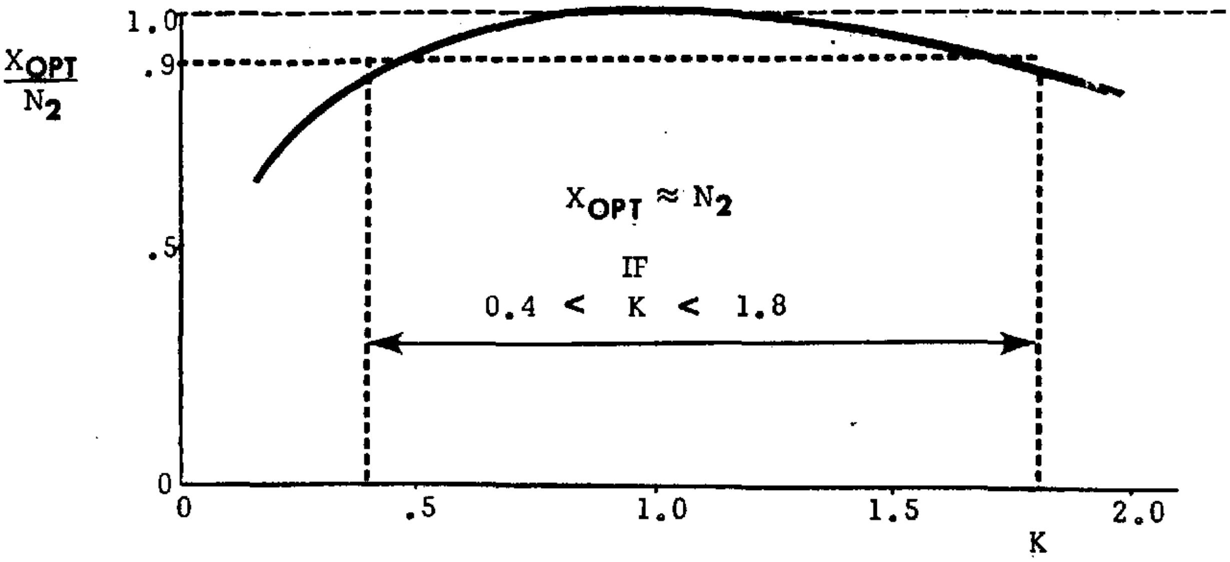
$$\frac{\partial P_A}{\partial x} = \frac{(x+KN_2 - x)}{(x+KN_2)^2} MF - C$$

Solving for maximum contribution,

$$X_{OPT} = \left(KN_2 \frac{MF}{C}\right)^{1/2} - KN_2$$

$$= \left(\frac{K\ MF}{4C} \times \frac{MF}{C}\right)^{1/2} - K\left(\frac{MF}{4C}\right)$$

(10) $$= (2K^{1/2} - K)\ N_2$$



The flatness of this curve means that the optimum number of flights for a carrier is quite insensitive to the actual number of flights operated by its competitor(s), for the simple linear relationship of market share = flight share.

BASIC FINANCE

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July 11, 1972

Abstract

A discussion of the basic measures of corporate financial strength, and the sources of the information--the Balance Sheet, Income Statement, Funds Flow and Cash Flow, Financial Ratios.

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Before an airline can buy new aircraft, it must be able to pay for the plane. The carrier can do this by using its own funds. However, few have enough cash on hand to purchase one aircraft much less a fleet. Therefore, the carrier must rely on outside sources for financial support.

What are the factors that a financial source investigates before deciding to invest or not? The basic information on the health of a carrier can be found from its balance sheet and income statement. If this information is coupled with a knowledge of the carrier's working capital and cash flow statements, an investor can compute some key financial ratios that will allow him to determine his potential risks and rewards from financing a carrier's operations.

ACCOUNTING PRINCIPLES

What are the basic indicators of corporate health, and how are they constructed? This is the area of the accountant so a basic knowledge of his techniques will be helpful.

Through the years, certain general rules or guides have been developed that accountants follow in preparing financial documents. These principles do not specify every detail of accounting practice, so the accountant has a great deal of freedom in tailoring his practices and procedures to the particular industry and company he serves. However, there are some generally accepted standards.

The Basic Accounting Conventions

Although the accountant does have a great deal of freedom in how he sets up and keeps accounts, there are several widely accepted conventions. The most important are:

1. Consistency - Once the accountant has decided how he will set up the accounts and handle particular transactions, the Consistency Convention requires him to handle all future events of the same type in the same fashion. Thus, similar transactions in different accounting periods can be compared, on a consistent basis.

Since circumstances change, accounting procedures may be altered to meet new developments. However, this is not done often, and when it is, the changes must be throughly described and documented.

2. Conservatism - This convention is often stated as "Anticipate no profits and provide for all possible losses." If there is an option in how a resource is to be evaluated, the accountant will ordinarily select the method that yields the lower value. For example, he would show the value of securities held by the firm at the lower of cost or market value. Although this procedure is often criticized as inconsistent, it is still widely in use and is important.

3. Materiality - often the recording of an event would cost considerably more than the information obtained in the process. Therefore, accountants will draw a line based on their experience and common sense between what is important enough to require close attention, and what can be considered immaterial and handled in a less detailed way. For example, an accountant would not require daily reports on how much fuel remains in the tanks of the aircraft in the fleet, but would use some simplifying assumption such as, "fuel is considered used when it is pumped from storage".

The Basic Accounting Concepts

In addition to the Accounting conventions, there are several basic concepts that underlie the keeping of accounts:

1. Business Entity Concept - Accounts are kept for businesses, and not for the people associated with them. The accounts reflect how transactions affect the business. This is true whether the business is a giant corporation or a sole proprietorship, totally merged with the personal finances of the owner. In the latter case, the law views both the business and personal transactions of the individual as his own personal property for which he is personally liable. However, the accountant treats the two separately. If the owner takes five dollars from the cash drawer to buy food, the accounts for the

business show a five dollar decrease in cash.

Since a corporation has a totally separate legal existance, corporate activities are easily distinguished from the personal actions of the owners or operators. However, there may still be areas of confusion. To keep tighter controls of activities, a corporation may treat various aspects of its operations as separate business entities and keep separate accounts. Or there may be several distinct corporations linked by stock interests. In this case, a "consolidated" accounting statement could be prepared, treating the whole group as one business entity. Because of these techniques it is sometimes difficult to separate out the information needed about a particular part of the firm.

2. Going Concern Concept - Under normal circumstances, accounting assumes that the business entity will exist for an indefinite period into the future. This eliminates the need to constantly compute the worth of the company as if it were to be liquidated, and instead concentrate on measuring performance by estimating the value of production. Market values of machinery and resources acquired, but not yet consumed are ignored since resale value is not important. Their value to the firm is through the creation of future output.

3. Cost Concept - Since the Going Concern Concept elimi-

nates the need to value the resources of a company at their going market price, the books of the company will record their worth at initial cost. This value is never changed to reflect market influences, (unless the Conservatism Convention is applied when market value is below cost). Therefore, the dollar amounts on the books of business should not be confused with the actual value of the company's holdings. Some resources such as cash or securities that could rapidly be disposed of will have a book value very close to market value. However, items such as land or equipment may be shown at values considerably below their worth in the market place.

The Cost Concept serves to remove subjective influences in evaluating the company. Two people may disagree widely on the value of a piece of property. By using original cost, a consistent measure is obtained.

4. <u>The Money Measurement Concept</u> - Closely allied to the Cost Concept is the Money Measurement Concept -- accounting records only include factors that can be expressed in monetary terms. Thus, a large number of diverse aspects of the firm can be reduced to a common denominator and added, subtracted or compared.

Since accounting records only reflect things that have monetary value, they will not disclose factors that cannot be expressed in dollars. The accounts will not show potential contracts, the health of a crucial officer or internal management conflicts.

5. The Dual-Aspect Concept - The tangible and intangible resources of a business are its "assets". Claims against the business and its assets are called "equities", perhaps because they are often enforced in courts of Equity. The equities are divided into the claims of creditors -- "Liabilities" and the claims of the owners -- "Owners' Equity" (called Shareholders' Equity in a Corporation). The claims of the creditors have first priority, with the owners being entitled to everything that is left. Since the creditors' and owners' claim all the assets and since claims cannot exceed the assets, the Dual-Aspect Concept can be stated as:

ASSETS = EQUITIES = LIABILITIES + OWNERS' EQUITY

The true implication of the concept is perhaps more clearly shown by rewriting this equation as:

OWNERS' EQUITY = ASSETS - LIABILITIES

The owners are entitled to what is left of the assets after creditors' claims are satisfied.

Since any change in assets must be accompanied by a similar and offsetting change in the equities, the assets and equities are said to "balance." This balance is shown by the "Balance

Sheet".

THE BALANCE SHEET

The balance sheet is the basic accounting report of a business entity showing the financial status of the firm at a given point in time. Every accounting transaction can be reported as a change of the balance sheet. Figure 1 shows the form of a typical although simplified, balance sheet for a small corporation. The categories are defined as follows:

Assets

Earlier, we defined an asset as being a tangible or intangible resource of a business. For an asset to qualify as a balance sheet entity, it must also have value, be owned by the business, and have been acquired at some measurable cost. Assets are categorized as:

1. Current Assets - Used to designate cash and other resources reasonably expected to be either consumed, sold or converted to cash during the normal accounting period -- usually one year. The most common items are:

Cash: Funds available for immediate disbursement without restriction.

Marketable Securities: Investments which can be readily sold and will be disposed of during the coming year. They are normally the types of short-term investments used to earn

FIGURE 1

TECH AIRWAYS INC.

Balance Sheet as of June 30, 1972

ASSETS			EQUITIES		
Current Assets:			Current Liabilities:		
Cash			Accounts Payable		
Marketable Securities			Estimated Taxes		
Accounts Receivable			Accrued Expenses		
Inventory			Deferred Income		
Prepaid Expenses	____			____	
Total Current Assets		____	Total Current Liabilities		____
Fixed Assets:			Other Liabilities:		
Land, Buildings and Equipment	____	____	Bonds Payable	____	
Total Fixed Assets		____	Total Other Liabilities		____
Other Assets:			Stockholders' Equity:		
Investments			Common Stock		
Intangibles	____	____	Retained Earnings		
			Capital Surplus	____	____
Total Assets		====	Total Equities		====

interest on cash not immediately needed for business purposes.

Accounts Receivable: Money owned to the business and expected to be collected. The money is usually owed by customers, but it could be owed by employees or others. Where a note or other writing has been executed in conjunction with the transaction, it would appear under a separate category -- Notes Receivable.

Inventory: Inventory items are tangible personal property which is either held for sale in the ordinary course of business or is somewhere in the production process and will be converted into such goods. For example, aircraft awaiting delivery or on the production line would be intentory, as would stocks of sheet metal or rivets. But if the manufacturer uses one of those planes as a corporate aircraft, it is no longer an inventory item, but a fixed asset since it is actually used by the business.

Prepaid Expenses: These are often intangible assests such as insurance policies, which have limited life. Once paid, they represent value to the company. Normally, the item will be totally consumed within three to five years at most, and sometimes sooner. An example of a prepaid expense that is tangible would be heating oil purchased for the coming winter.

2. Fixed Assets - Fixed assets are tangible resources with a relatively long life expectancy. These are usually resources used in the production process such as land, buildings

and equipment. Fixed assets (except land) are gradually reduced in value through ware or obsolescence. However, they are still shown on the books at their cost with a separate entry made to show the depreciation or loss of value since acquisition. This concept will be discussed in more detail in a later section.

Note that an asset which has a potentially long life that is held for resale is not a fixed asset but an inventory item and would be listed under current assets.

3. Other Assets - All other assets are placed in this section. Two major categories are investments and intangible assets. Depending on the policy of the firm, these items could be account groupings on the balance sheet, but here we have listed them as classes of Other Assets.

Investments: Long-term holdings of securities, deposits, etc. that are not to be coverted back to cash within the year (unlike Marketable Securities which will be converted).

Intangibles: Includes patents, copyrights, licenses or goodwill. In keeping with our basic definition of an asset, they must have value, be owned and have been acquired at a measurable cost. Therefore, goodwill that a company builds up through its own operations is not entered on the balance sheet. Only goodwill acquired through the purchase of another firm can be listed.

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Equities

The equities of a firm are of two types -- "Liabilities" and "Owners' Equity." In a corporation, Owners' Equity is called Stockholders' Equity.

1. Current Liabilities - Like Current Assets, Current Liabilities refer to short-term transactions. This includes long-term liabilities that will mature in the coming year as well as obligations arising from the operations of the business. The major accounts are:

Accounts Payable: The claims of suppliers, creditors and others are recorded in this account. These claims are usually unsecured. If there is a note or other written evidence of the claim, it would be listed under "Notes Payable" or a similarly titled account.

Estimated Taxes: Since taxes can be a relatively large account, they are listed separately. It is shown as an estimate since the exact amount may not be known at the time the balance sheet is prepared.

Accrued Expenses: This account represents obligations incurred by the firm but not yet paid (such as wages owed for work performed). If there is an invoice submitted, or other tangible evidence of the debt, it would be listed under Accounts Payable instead of here.

Deferred Income: If the company has received payments in advance, it is under an obligation to perform its part of the bargain or repay the advance. Therefore, such sums are shown as a Current Liability until the obligation is fulfilled.

2. Other Liabilities - These are long-term liabilities of the firm (such as bonds) which will not come due in the next year.

3. Stockholders' Equity - All the resources left after the liabilities are satisfied equal the Stockholders' Equity. This is sometimes called the residual interest, since the owners only get what remains after the interests of the creditors have been covered.

Capital Stock: In a corporation, the shares of ownership have an initial value called the "stated value" that represents either the price at which it was sold or a "par value" established in advance, or some other value reasonably fixed by the board of directors of the firm. The total represents the paid-in interest of the owners. (This is not necessarily related to the market value of the stock which is determined by owners selling their interests to new owners on the open market.)

Retained Earnings: If the company has profitable operations, it has "earnings". These are either paid out to shareholders as dividends or retained by the company for corporate uses. The

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difference between the total earnings of a company from the date of incorporation to the date of the balance sheet and all dividends ever paid is shown in the retained earnings account. If this difference is negative, it is called a "deficit".

Capital Surplus: Sometimes the Owners' Equity is changed by transactions unrelated to the company's operations. Perhaps a town interested in attracting new business donates land for a site. The value of the land is shown in the Capital Surplus Account.

EXAMPLE

Andy Aviator has established Tech Airways Inc. to operate an air-taxi service. The corporation has authorized the issuance of 100,000 shares of common stock at a par value of $1 per share. Only 10,000 shares have actually been issued, all purchased by Andy for $10,000. Figure 2 shows the balance sheet at this time.

Andy's first step as president and general manager is to buy a plane for $60,000. He uses $5,000 of the cash as a down payment and finances the remaining $55,000 through a $5,000 short-term note and a long-term $50,000 mortgage on the aircraft. Figure 3 shows the balance sheet after these transactions.

Since the remaining $5,000 cash is not sufficient to start operations, Andy decides to issue bonds for $20,000 and issue another 10,000 shares of stock. He finds a friend who is will-

FIGURE 2

TECH AIRWAYS INC.

Balance Sheet as of June 30, 1972

ASSETS			EQUITIES		
Current Assets:			Current Liabilities:		
Cash	$10,000				
Total Current Assets		$10,000			
Fixed Assets:			Other Liabilities:		
Other Assets:			Stockholders' Equity:		
			Common Stock	$10,000	
Total Assets		$10,000	Total Equities		$10,000

(ASSETS ($10,000) = EQUITIES ($10,000))

FIGURE 3

TECH AIRWAYS INC.

Balance Sheet as of ~~June 30~~ July 5, 1972

ASSETS			EQUITIES		
Current Assets:			Current Liabilities:		
Cash	~~$10,000~~ + $5,000 from note + $50,000 mortage − $60,000 for plane = $5,000		Notes Payable	$5,000	
Total Current Assets		~~$10,000~~ $5,000			
			Total Current Liabilities		$5,000
Fixed Assets:			Other Liabilities:		
1 Airplane	$60,000		Aircraft Mortgage	$50,000	
Total Fixed Assets		$60,000	Total Other Liabilities		$50,000
Other Assets:			Stockholders's Equity:		
			Common Stock	$10,000	
			Total Stockholder's Equity		$10,000
Total Assets		$65,000 ~~$10,000~~	Total Equities		~~$10,000~~

(ASSETS ~~($10,000)~~ $65,000 = EQUITIES $65,000 ~~($10,000)~~)

ing to pay $1.50 per share for 5,000 shares, and Andy himself buys the other 5,000 at the same price. Andy uses $10,000 to buy fuel, $5,000 for a two-year insurance policy, and $5,000 to purchase a selection of snacks to be sold on board to passengers. Andy invests the remainder of the new capital in government short-term bonds since it is not presently needed to cover operational costs. Figure 4 reflects the effects of these transactions on the balance sheet.

Tech airways is now ready to start operations. Pete Pilot is hired as chief pilot, and flys 5 flights carrying 15 passengers over the next few weeks. Ten of the passengers pay cash for a total of $5,000, and 5 charge their tickets to Diner's Press Cards for $250. One of the passengers pays $50 for a return flight he has not yet taken. In addition, Pete sold $100 worth of snacks for $200.

$300 worth of fuel is used during these operations, and Pete's salary for the period is $250 which has not yet been paid. (See Figures 5 and 6)

Tech Airways operates profitably. By June of the following year, its balance sheet looks like Figure 7.

Since there is a healthy cash balance, Tech Airways pays off the $5,000 note. Andy also decides that the company should buy out Avonic Airways, its only competitor for $25,000--$10,000 in

FIGURE 4

TECH AIRWAYS INC.

Balance Sheet as of ~~July 5,~~ July 8 1972

ASSETS

Current Assets:		
Cash	$5,000	+ $20,000 from Bonds + 15,000 from Stock
Marketable Securities	15,000	− $10,000 fuel
Inventory (Snacks)	5,000	− $ 5,000 for snacks
Prepaid Expenses		− $ 5,000 for insurance
fuel	10,000	− $ 15,000 for securities
Insurance	5,000	− $ 5,000 Cash
Total Current Assets		~~$5,000~~ $40,000
Fixed Assets:		
1 Airplane	$60,000	
Total Fixed Assets		$60,000
Other Assets:		
Total Assets		$100,000 ~~$65,000~~ $100,000

EQUITIES

Current Liabilities:		
Notes Payable	$5,000	
Total Current Liabilities		$5,000
Other Liabilities:		
Aircraft Mortgage	$50,000	
Bonds Outstanding	$20,000	
Total Other Liabilities		$70,000 ~~$50,000~~
Stockholders' Equity:		
Common Stock	$20,000 ~~$10,000~~	
Capital Surplus	5,000	
Total Stockholder Equity		$25,000 ~~$10,000~~
Total Equities		$100,000 ~~$65,000~~

(ASSETS ~~($65,000)~~ $100,000) = EQUITIES (~~$65,000~~ $100,000))

FIGURE 5

TECH AIRWAYS INC.

Balance Sheet as of ~~July 8~~ July 21, 1972

ASSETS

Current Assets:	+$500 from tickets	
Cash	$ 5,000 +$200 snacks	
Marketable Securities	15,000 =Cash=$5,700	
Accounts Receivable $250		
Inventory (Snacks)	~~5,000~~ $4,900	
Prepaid Expenses		
fuel	~~10,000~~ 9,700	
insurance	5,000	
Total Current Assets		~~$40,000~~ 40,550
Fixed Assets:		
Airplane	$60,000	
Total Fixed Assets		$60,000
Other Assets:		
Total Assets		~~$100,000~~ $100,550

EQUITIES

Current Liabilities:		
Notes Payable	$ 5,000	
Accrued Expenses (salary)	250	
Deferred Income (Advanced Sale)	50	
Total Current Liabilities		$ ~~5,000~~ $5,300
Other Liabilities:		
Aircraft Mortgage	$50,000	
Bonds Outstanding	20,000	
Total Other Liabilities		$ 70,000
Stockholders' Equity:		
Common Stock	$20,000	
Capital Surplus	5,000	
Retained Earnings	$250	
Total Stockholder's Equity		$ ~~25,000~~ $25,250
Total Equities		$~~100,000~~ $100,550

(ASSETS ($~~100,000~~ $100,550) = EQUITIES ($~~100,000~~ $100,550))

FIGURE 6

TECH AIRWAYS INC.

Balance Sheet as of July 21, 1972

ASSETS			EQUITIES		
Current Assets:			Current Liabilities:		
Cash	$ 5,700		Notes Payable	$ 5,000	
Marketable Securities	15,000		Accrued Expenses	250	
Accounts Receivable	250		Deferred Income	50	
Inventory (Snacks)	4,900				
Prepaid Expenses					
fuel	9,700				
insurance	5,000				
Total Current Assets		$ 40,550	Total Current Liabilities		$ 5,300
Fixed Assets:			Other Liabilities:		
Airplane	$60,000		Aircraft Mortgage	$50,000	
			Bonds Outstanding	20,000	
Total Fixed Assets		$ 60,000	Total Other Liabilities		$ 70,000
Other Assets:			Stockholders' Equity:		
			Common Stock	20,000	
			Retained Earnings	250	
			Capital Surplus	5,000	
			Total Stockholder's Equity		$ 25,250
Total Assets		$100,550	Total Equity		$100,550

(ASSETS ($100,550) = EQUITIES ($100,550))

FIGURE 7

TECH AIRWAYS INC.

Balance Sheet as of June 1, 1973

ASSETS			EQUITIES		
Current Assets:			Current Liabilities:		
Cash	$ 74,500		Notes Payable	$5,000	
Marketable Securities	15,000		Accrued Expenses	2,000	
Accounts Receivable	25,000		Deferred Income	2,500	
Inventory	5,000				
Prepaid Expenses					
fuel	20,000		Total Current Assets		$ 9,500
insurance	5,000				
Total CurrentAssets		$144,500			
Fixed Assets:			Other Liabilities:		
Airplane	60,000		Aircraft Mortgage	$50,000	
			Bonds Outstanding	20,000	
Total Fixed Assets		$ 60,000			
			Total Other Liabilities		$ 70,000
Other Assets:			Stockholders' Equity:		
			Common Stock	$ 20,000	
			Retained Earnings	100,000	
			Capital Surplus	5,000	
			Total Stockholders Equity		$125,000
Total Assets		$204,500	Total Equities		$204,500

(ASSETS ($204,500) = EQUITIES ($204,500) cash and $15,000 in stock at the stated par value of $1.00 per share. Avonic has assets of 1 airplane worth $10,000 and a $10,000 hanger. The extra $5,000 paid is for the goodwill Avonic has gained by its record of service (See Figure 8).

Tech Airways, Inc. still looks profitable. With the end of the year approaching, Andy estimates Tech Airway's tax liability, based on projected operations and $6,000 depreciation on the first aircraft. The short-term bonds are sold to increase cash.

Since a year of the prepaid insurance has been used up, its value is decreased on the balance sheet. Since prospects for the company are still bright, a $1 per share dividend is paid to build stockholder confidence. (See Figure 9).

Because of his huge success, Andy decides he wants to become a regularly scheduled interstate carrier and applys and receives a Civil Aeronautics Board Certificate of Public Convenience and Necessity. If Andy receives the certificate he will have to comply with CAB reporting requirements. Figure 10 shows the balance sheet accounts used by the Board and published in Title 14, Part 241 of the Code of Federal Regulations (CFR). The details of this document can be found in the CFR where each Account Grouping and each Account is described in great detail.

Figure 11 shows a typical Balance Sheet for an airline, as published in its annual report. Although it follows the C.A.B.

FIGURE 8

TECH AIRWAYS INC.

Balance Sheet as of ~~June 1~~ June 15, 1973

ASSETS

Current Assets:		
Cash	$74,500	−$5,000 for Note −$10,000 for Avonic = Cash $59,500
Marketable Securities	15,000	
Accounts Receivable	25,000	
Inventory	5,000	
Prepaid Expenses		
fuel	20,000	
insurance	5,000	
Total Current Assets		$~~144,500~~ $129,500
Fixed Assets:		
Airplane	$60,000	
Airplane	10,000	
Hanger	10,000	
Total Fixed Assets		$~~60,000~~ $80,000
Other Assets:		
Goodwill	$5,000	
Total Other Assets		$5,000
Total Assets		$~~204,500~~ $214,500

EQUITIES

Current Liabilities:		
~~Notes Payable~~	~~$5,000~~	
Accrued Expense	2,000	
Deferred Income	2,500	
Total Current Assets		$~~9,500~~ $4,500
Other Liabilities:		
Aircraft Mortgage	$50,000	
Bonds Outstanding	20,000	
Total Other Liabilities		$70,000
Stockholders' Equity:		
Common Stock	$ ~~20,000~~ $35,000	
Retained Earnings	100,000	
Capital Surplus	5,000	
Total Stockholders Equity		$~~125,000~~ $140,000
Total Equities		$~~204,500~~ $214,500

(ASSETS ($~~204,500~~ $214,500)) = EQUITIES ($~~204,500~~ $214,500))

FIGURE 9

TECH AIRWAYS INC.

Balance Sheet as of June ~~15~~ 30, 1973

ASSETS

Current Assets:	+$15,000 from Securites	
Cash	$59,500 -$35,000 Dividends	
~~Marketable Securities~~	~~15,000~~ =$39,500 Cash	
Accounts Receivable	25,000	
Inventory	5,000	
Prepaid Expense		
Fuel	20,000	
Insurance	~~5,000~~ $2,500	
Total Current Assets		$~~129,500~~ $92,000
Fixed Assets:		
Airplane (Depreciation $6,000)	~~$60,000~~ $54,000	
Airplane	10,000	
Hanger	10,000	
Total Fixed Assets		$~~80,000~~ $74,000
Other Assets:		
Goodwill	$ 5,000	
Total Other Assets		$ 5,000
Total Assets		$~~214,500~~ $171,000

EQUITIES

Current Liabilities:		
Accrued Expenses	$ 2,000	
Deferred Income	2,500	
Estimated Taxes	$ 40,000	
Total Current Liabilities		$ ~~4,500~~ $44,500
Other Liabilities:		
Aircraft Mortgage	$50,000	
Bonds Outstanding	20,000	
Total Other Liabilities		$ 70,000
Stockholders' Equity:		
Common Stock	$ 35,000	
Retained Earnings	~~100,000~~ $16,500	
Capital Surplus	5,000	
Total Stockholders' Equity		$~~140,000~~ $56,500
Total Equities		$~~214,500~~ $171,000

(ASSETS ($~~214,500~~ $171,000) = EQUITIES ($~~214,500~~ $171,000))

FIGURE 10

BALANCE SHEET CLASSIFICATIONS

Section 3—Chart of Balance Sheet Accounts

Name of account	General classification
Current assets:	
Cash	1010
Special deposits	1030
United States Government securities	1110
Other temporary cash investments	1120
Accounts receivable—U.S. Government	1220
Accounts receivable—foreign governments	1230
Accounts receivable—general traffic	1240
Notes and accounts receivable—associated companies	1250
Notes and accounts receivable—company personnel	1260
Notes and accounts receivable—other	1280
Reserve for uncollectible accounts	1290
Flight equipment expendable parts	1310
Obsolescence and deterioration reserves—expendable parts	1311
Miscellaneous materials and supplies	1330
Short-term prepayments	1410
Other current assets	1420
Investments and special funds:	
Investments in associated companies	1510
Investments in subsidiary companies	1510.1
Investments in other associated companies	1510.2
Advances to nontransport divisions	1520
Other investments and receivables	1530
Special funds—self-insurance	1540
Special funds—other	1550
Property and equipment	1600–1700

	Operating	Nonoperating
Airframes	1601	1701
Aircraft engines	1602	1702
Aircraft propellers	1603	1703
Aircraft communications and navigational equipment	1604	1704
Miscellaneous flight equipment	1606	1706
Improvements to leased flight equipment	1607	1707
Flight equipment rotable parts and assemblies	1608	1708
Airframe parts and assemblies	[1] 1608.*1*	[1] 1708.*1*
Aircraft engine parts and assemblies	[1] 1608.*5*	[1] 1708.*5*
Other parts and assemblies	[1] 1608.*9*	[1] 1708.*9*
Flight equipment	*1609*	*1709*
Reserve for depreciation—airframes	1611	1711
Reserve for depreciation—aircraft engines	1612	1712
Reserve for depreciation—aircraft propellers	1613	1713
Reserve for depreciation—aircraft communication and navigational equipment	1614	1714
Reserve for depreciation—miscellaneous flight equipment	1616	1716
Reserve for depreciation—improvements to leased flight equipment	1617	1717
Reserve for depreciation—flight equipment rotable parts and assemblies	1618	1718
Airframe parts and assemblies	[1] 1618.*1*	[1] 1718.*1*
Aircraft engine parts and assemblies	[1] 1618.*5*	[1] 1718.*5*
Other parts and assemblies	[1] 1618.*9*	[1] 1718.*9*
Reserve for depreciation—flight equipment	1619	1719
Flight equipment airworthiness reserves	[2] 1629	[2] 1729
Passenger service equipment	1630	1730
Hotel, restaurant and food service equipment	1631	1731
Ramp equipment	1632	1732
Communication and meteorological equipment	1633	1733
Maintenance and engineering equipment	1634	1734
Surface transport vehicles and equipment	1635	1735
Furniture, fixtures and office equipment	1636	1736
Storage and distribution equipment	1637	1737
Miscellaneous ground equipment	1638	1738
Buildings and other improvements	1640	1740
Maintenance buildings and improvements	1640.*1*	1740.*1*
Other buildings and improvements	1640.*9*	1740.*9*
Ground property and equipment	*1649*	*1749*
Reserve for depreciation—passenger service equipment	1650	1750
Reserve for depreciation—hotel, restaurant and food service equipment	1651	1751
Reserve for depreciation—ramp equipment	1652	1752
Reserve for depreciation—communication and meteorological equipment	1653	1753
Reserve for depreciation—maintenance and engineering equipment	1654	1754
Reserve for depreciation—surface transport vehicles and equipment	1655	1755
Reserve for depreciation—furniture, fixtures and office equipment	1656	1756
Reserve for depreciation—storage and distribution equipment	1657	1757
Reserve for depreciation—miscellaneous ground equipment	1658	1758

See footnotes at end of tables.

BALANCE SHEET CLASSIFICATIONS—Continued

Section 3—Chart of Balance Sheet Accounts—Continued

Name of account	Operating	Nonoperating
Property and equipment—Continued		
Reserve for depreciation—buildings and other improvements	1660	1760
Maintenance buildings and improvements	1660.*1*	1760.*1*
Other buildings and improvements	1660.*9*	1760.*9*
Reserves for depreciation—ground property and equipment	*1669*	*1769*
Land	1679	1779
Construction work in progress	1689	1789

	General classification
Deferred charges:	
Long-term prepayments	1820
Developmental and preoperating costs	1830
Unamortized discount and expense on debt	1840
Unamortized capital stock expense	1850
Property acquisition adjustment	1870
Other intangibles	1880
Other deferred charges	1890
Current liabilities:	
Current notes payable	2010
Accounts payable—general	2020
Collections as agent—traffic	2030
Collections as agent—other	2040
Notes and accounts payable—associated companies	2050
Accrued personnel compensation	2110
Accrued vacation liability	2120
Accrued Federal income taxes	2131
Other accrued taxes	2130
Dividends declared	2140
Air travel plan liability	2150
Unearned transportation revenue	2160
Other current liabilities	2190
Noncurrent liabilities:	
Long-term debt	2210
Advances from associated companies	2240
Advances from nontransport divisions	2245
Pension liability	2260
Company stock purchase plan liability	2260
Other noncurrent liabilities	2290
Deferred credits:	
Unamortized premium on debt	2330
Deferred Federal income taxes	2340
Deferred investment tax credits	2345
Reserve for self-insurance	2350
Other deferred credits	2390
Stockholder equity:	
Preferred stock	2820
Common stock	2840
Capital stock subscribed and unissued	2860
Other paid-in capital	2890
Premium on capital stock	2890.*1*
Discount on capital stock	2890.*2*
Other capital stock transactions	2890.*3*
Miscellaneous paid-in capital	2890.*9*
Appropriations of retained earnings	2930
Unappropriated retained earnings	2940
Treasury stock	2990

[1] Prescribed for Group II and Group III air carriers only.

[2] At the option of the air carrier these accounts may be assigned numbers 2629 and 2729, respectively, for accounting purposes.

NOTE: Digits to right of decimals and italicized codes established for CAB control purposes only.

[ER–327, 26 F.R. 4222, May 16, 1961 as amended by ER–425, 30 F.R. 745, Jan. 23, 1965; ER–546, 33 F.R. 18696, Dec. 18, 1968]

FIGURE 11

Continental Air Lines, Inc.

Balance Sheet December 31, 1968 with comparative figures for 1967

Assets	**1968**	**1967**
Current assets:		
Cash	$ 17,063,705	$ 12,463,157
United States Government and other securities	2,019,632	16,766,068
Accounts receivable:		
United States Government	5,268,613	6,431,546
Airline traffic	14,405,401	11,123,574
Other, net	2,564,214	2,420,910
Total accounts receivable	22,238,228	19,976,030
Spare parts and supplies, at average cost	11,602,801	8,608,378
Prepaid expenses	3,014,443	928,766
Total current assets	55,938,809	58,742,399
Investments and special funds:		
Advance payments on equipment purchase contracts (note 5)	14,439,276	32,899,273
Investment in subsidiaries and affiliates, at cost	3,984,760	3,540,310
Other investments and deposits	2,010,427	1,399,558
Total investments and special funds	20,434,463	37,839,141
Property and equipment, at cost (note 1):		
Flight equipment	323,554,928	208,717,681
Less accumulated depreciation	58,690,271	37,964,497
Flight equipment, net	264,864,657	170,753,184
Other property and equipment	47,420,672	29,012,781
Less accumulated depreciation	13,593,176	10,836,234
Other property and equipment, net	33,827,496	18,176,547
Construction in progress	935,558	5,115,712
Net property and equipment	299,627,711	194,045,443
Deferred charges:		
Contribution to the development of supersonic aircraft, net of amortization, $600,000	2,400,000	—
Other	1,125,935	604,250
Total deferred charges	3,525,935	604,250
	$379,526,918	$291,231,233

Liabilities and Stockholders' Equity	**1968**	**1967**
Current liabilities:		
Long-term debt, portion due within one year	$ 22,694,131	$ 9,131,722
Accounts payable:		
General	10,532,205	11,584.054
Airline traffic	8,384,589	7,491,016
Transportation taxes and payroll deductions	2,831.582	1,499.621
Total accounts payable	21,746,376	20,574,691
Accrued liabilities	5,259,556	4,278,505
Federal income taxes	690,635	486,549
Unearned transportation revenue	1,385,399	785,320
Total current liabilities	51,778,097	35.258,767
Long-term debt, less portion due within one year (note 2)	219,832,298	151,265,390
Reserves for overhaul of flight equipment, net	8,807,338	7,395.223
Deferred income taxes	10,340,723	6,639,408
Unamortized investment tax credits (note 3)	9,737,975	11,061,076
Other deferred credits and non-current liabilities	1,400,862	1,467,783
Stockholders' equity:		
Common stock of $0.50 par value per share. Authorized 15,000,000 shares; issued 10,050,867 shares, 1968; 10,015,907 shares, 1967 (notes 2 and 4)	5,025,434	5,007,953
Capital in excess of par value	19,202,794	18,848,260
Retained earnings (note 2)	53,401,397	54.237,353
Total stockholders' equity	77,629,625	78,143,566
	$379,526,918	$291,231,233

classifications, the accounts have been condensed for ease of reading by the stockholders.

THE INCOME STATEMENT

Before the Income Statement can be explained, a few more accounting concepts must be mentioned.

The Accounting Period

The Balance Sheet reflects the status of a business at a point in time. Balance Sheets are prepared on a periodic basis, usually once per year. This is called the Accounting Period. The Income Statement reports flows during the Accounting Period rather than status at a point in time. Since management needs information updated more frequently than annually, there may be "interim" reports prepared at the required time intervals.

The Accrual Concept

Income is associated with a change in Stockholders' Equity and not necessarily with changes in the cash account of the business. In our earlier example, one of the transactions was the sale of $100 worth of snacks for $200. Since the business did not incur additional liability by the sale, the changes in assets must be balanced by changes in the Stockholders' Equity. When the Cash Account is increased by $200, Stockholders' Equity is increased by the same amount. Likewise, Stockholders' Equity is decreased by $100 to offset the removal of $100 worth of goods from the Inventory Account.

Any increase in the Stockholders' Equity from the operation of the business is called "revenue." Any decrease is an "expense". "Income" is the excess of revenue over expenses. If expenses are greater than revenue there is a "loss". The sale of the snacks thus represented $200 of revenue, $100 worth of expenses and $100 income. The cash change and the income are not the same.

1. <u>Expense vs. Expenditure</u> - An Expenditure occurs when an asset is obtained either by the payment of cash, by the exchange of another asset or by the assumption of an additional liability. An Expense arises when an asset is used up and reflects a corresponging decrease in Stockholders' Equity. When $5,000 cash is used to purchase an inventory of snacks, there is an "Expenditure" of one asset for another -- cash for inventory. There is no "Expense" since there is no change in equity. When $100 worth of snacks are removed from inventory, there is no "Expenditure" since no new asset is acquired. However, there is an "Expense" since the decrease in assets must be reflected by a decrease in Stockholders' Equity Account.

2. <u>Revenue vs. Receipts</u> - A "Revenue" arises when Stockholders' Equity increases. A "Receipt" occurs when one asset is received in place of another. When an air ticket is sold on

credit, Accounts Receivable are increased. This is a "Revenue" since Stockholders' Equity is increased by a corresponding amount. When the obligation is paid, there is a "Receipt" but no "Revenue" since equity stays the same. The only transaction is an increase in Cash offset by a decrease in Accounts Payable.

The Accrual Concept holds that income is measured as the difference between revenues and expenses and not between receipts and expenditures.

The Realization Concept

The Realization Concept is closely connected with the Actual Concept. Broadly stated, a revenue is recognized when it is realized, that is when the product is delivered or the service performed. The revenue and expense accounts are updated, not when the contract is signed or the goods manufactured, but when the actual transfer of value takes place.

Since the Accrual Concept requires revenues and expenses to be compared, expenses are recognized in the same accounting period that the revenue arises. (The Matching Principle) Thus, the costs of manufacturing an item for inventory are not expenses until the item is sold. They are then recorded as "Cost of Goods Sold."

Some expenses cannot be connected to a particular revenue transaction. These are entered into the accounts during the period when they are incurred--which is not necessarily when they are actually paid for.

Figures 12 and 13 demonstrate these principles. In the first transaction, goods manufactured in January are sold on credit in February, and actually paid for in March. Following the principles outlined, all bookkeeping entries are made in February, the month when the goods were transferred.

In the second case (Figure 13), the goods are paid for in advance in January, and manufactured in February. But all bookkeeping entries are made in March when actual transfer takes place.

The Income Statement

The Income Statement (or Profit and Loss Statement or Statement of Earnings) reports on the revenues and expenses which have accrued during the accounting period. Normally, the preceeding year's information is also given for comparison purposes. Figure 14 shows a sample of a carrier statement of Earnings from an annual report. Like the Balance Sheet shown in Figure 11, the major categories follow the Civil Aeronautics Board regulations, but the subaccounts have been condensed and show less detail than the statements filed with the Board.

Figure 12

ACCRUAL CONCEPT

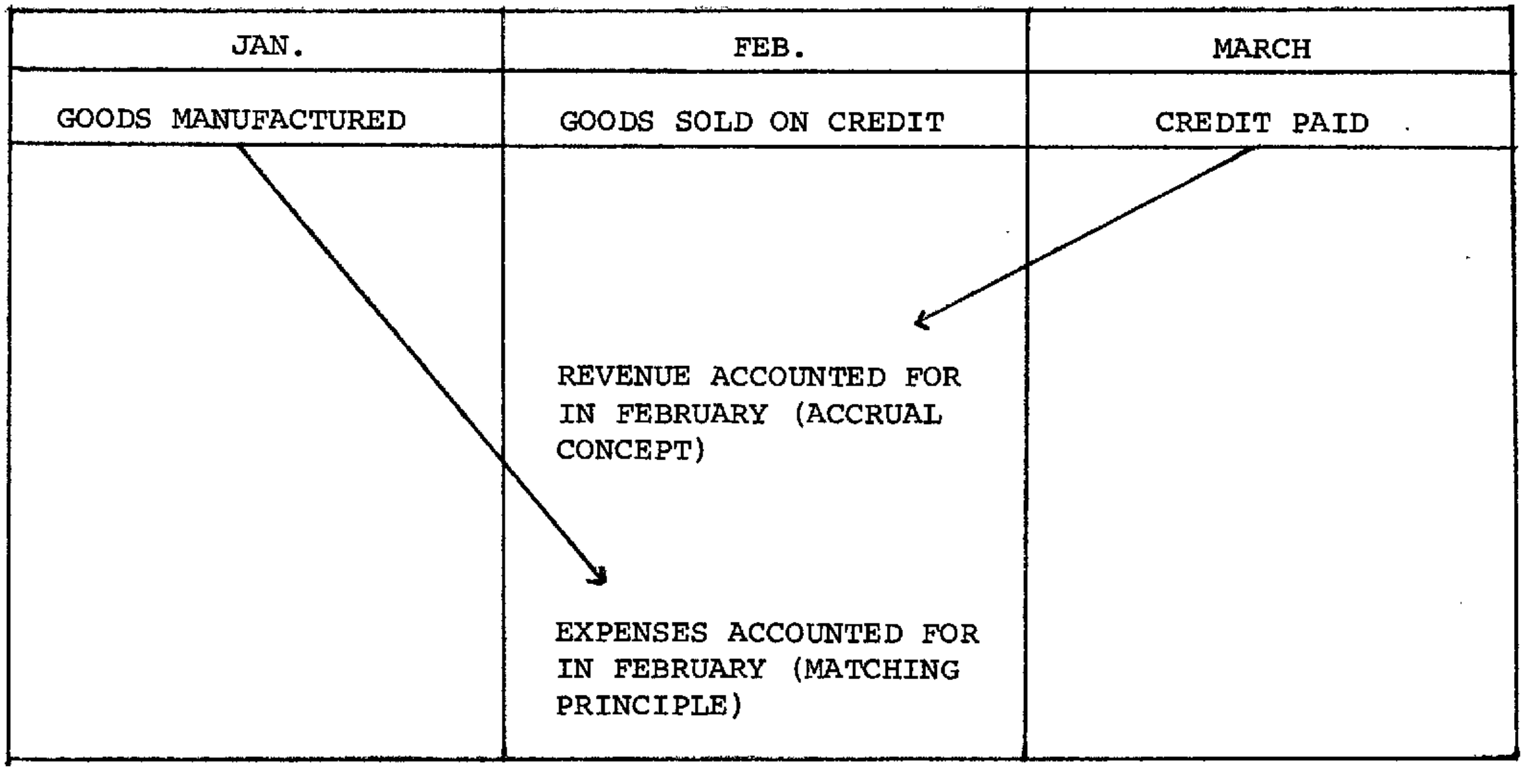

Figure 13

ACCRUAL CONCEPT

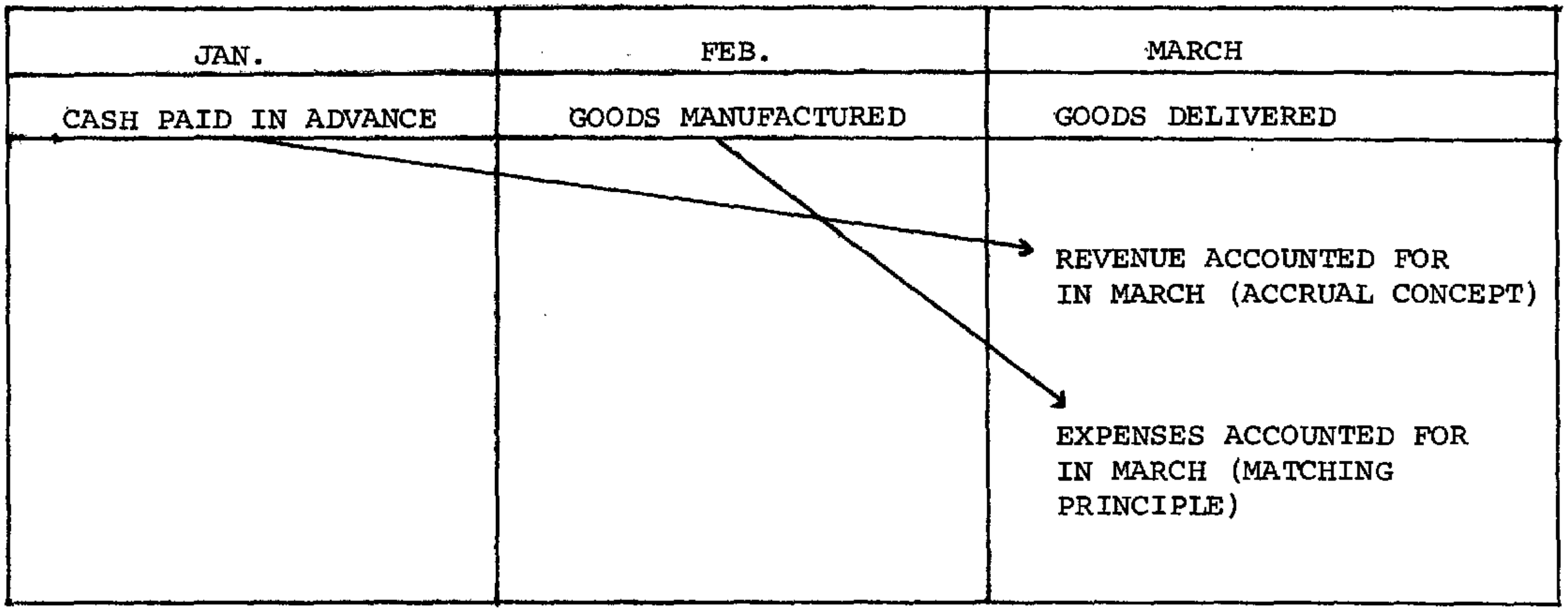

Figure 14

Continental Air Lines, Inc.

Statement of Earnings

Year ended December 31, 1968 with comparative figures for 1967

	1968	1967
Operating revenues:		
Passenger	$138,769,984	$107,101,678
Mail	2,689,949	2,155,930
Express	713,771	683,806
Freight	6,354,749	5,038,256
Excess baggage	266,140	178,655
Aircraft interchange rentals, net	—	45,200
Charter and contract services	57,865,758	71,263,689
Miscellaneous, net	1,534,240	1,700,627
Total operating revenue	208,194,591	188,167,841
Operating expenses:		
Flying operations	54,410,014	44,367,712
Ground operations	23,174,429	20,083,117
Maintenance and repairs	37,045,607	31,081,921
Passenger service	21,662,004	17,995,883
Reservations and sales	10,922,710	8,204,667
Advertising and publicity	8,397,102	5,017,587
General and administrative	9,262,464	8,004,931
Depreciation and amortization	28,367,869	21,028,121
Total operating expenses	193,242,199	155,783,939
Operating income	14,952,392	32,383,902
Non-operating expenses and income:		
Interest expense	10,129,202	6,208,524
Other, net	(275,598)	(327,624)
Total non-operating expenses and income	9,853,604	5,880,900
Earnings before Federal and State income taxes and extraordinary items	5,098,788	26,503,002
Federal and State income taxes	966,684	11,572,061
Earnings before extraordinary items	4,132,104	14,930,941
Extraordinary items — gains on major dispositions of flight equipment, less income taxes, $2,329,407	—	2,376,466
Net earnings	$ 4,132,104	$ 17,307,407
Net earnings per share of common stock:		
Before extraordinary items	$0.41	$1.49
Extraordinary items	—	0.24
Total	$0.41	$1.73

FUNDS FLOW STATEMENTS

Funds can be defined in general terms as economic values, or in specific terms as cash. The latter is a subset of the former. The balance sheet shows the financial position of the firm at a gross point in time and reflects the firm's investments (assets) and the claims against it (equities). In general the assets side of the balance sheet shows how funds have been used, while the equities side refelcts their source.

The Funds Flow Concept

An understanding of the flow of funds through the business enterprise is essential to sound financial management and proper allocation of available resources. The financial manager must know where he can obtain funds on the best terms and how to allocate them within his company to maximize the return on the investment.

The process of funds flow analysis compares two successive balance sheets. The differences between individual accounts shows the flows of funds resulting from management decisions. Analysis will indicate where management has decided to connect funds (uses), to liquidate assets (sources), to acquire additional funds (sources), and to reduce claims against the firm (uses).

Circulating Capital and Working Capital

Figure 15 shows day to day cycle of funds flow in a company. Sales are made from inventory. In return, the company receives either a direct cash payment, or extends credit which is shown as an addition to Accounts Receivable. In turn, the company buys supplies to produce more inventory. It makes cash payments or shows its debts in Accounts Payable. Eventually, cash transfers occur that close out either Accounts Receivable or Payable.

This process is on a continuous state of flux. For some purposes, it is easier to lump current assets and current liabilities and refer to these accounts as the "Circulating Capital" of the firm. The difference between the current assets and current liabilities of the firm is referred to as "Working Capital" and is an important indicator of the firm's ability to meet short term obligations.

Cash Flow Statement

A Cash Flow Statement is a detailed breakdown of the changes in Working Capital. In particular, it concentrates on those transactions that affect the Cash Account. Figure 16 shows these various transactions grouped as operational transactions that arise from the day to day business; financial transactions that raise funds and retire debts; and other transactions. The latter includes discretionary transactions not necessary to the operation or regular finances of the firm.

CIRCULATING CAPITAL FLOW

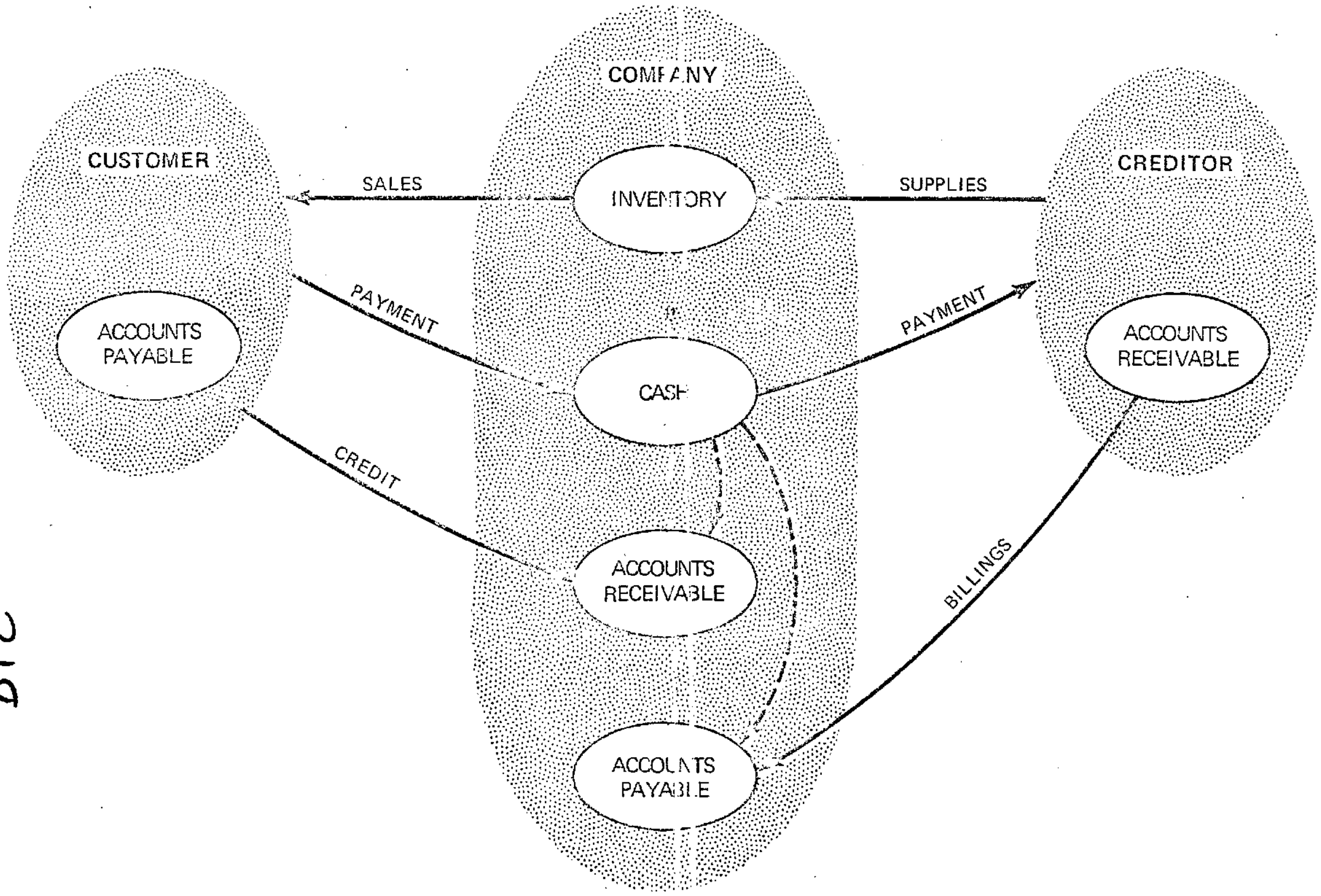

FIGURE 15

CASH FLOW

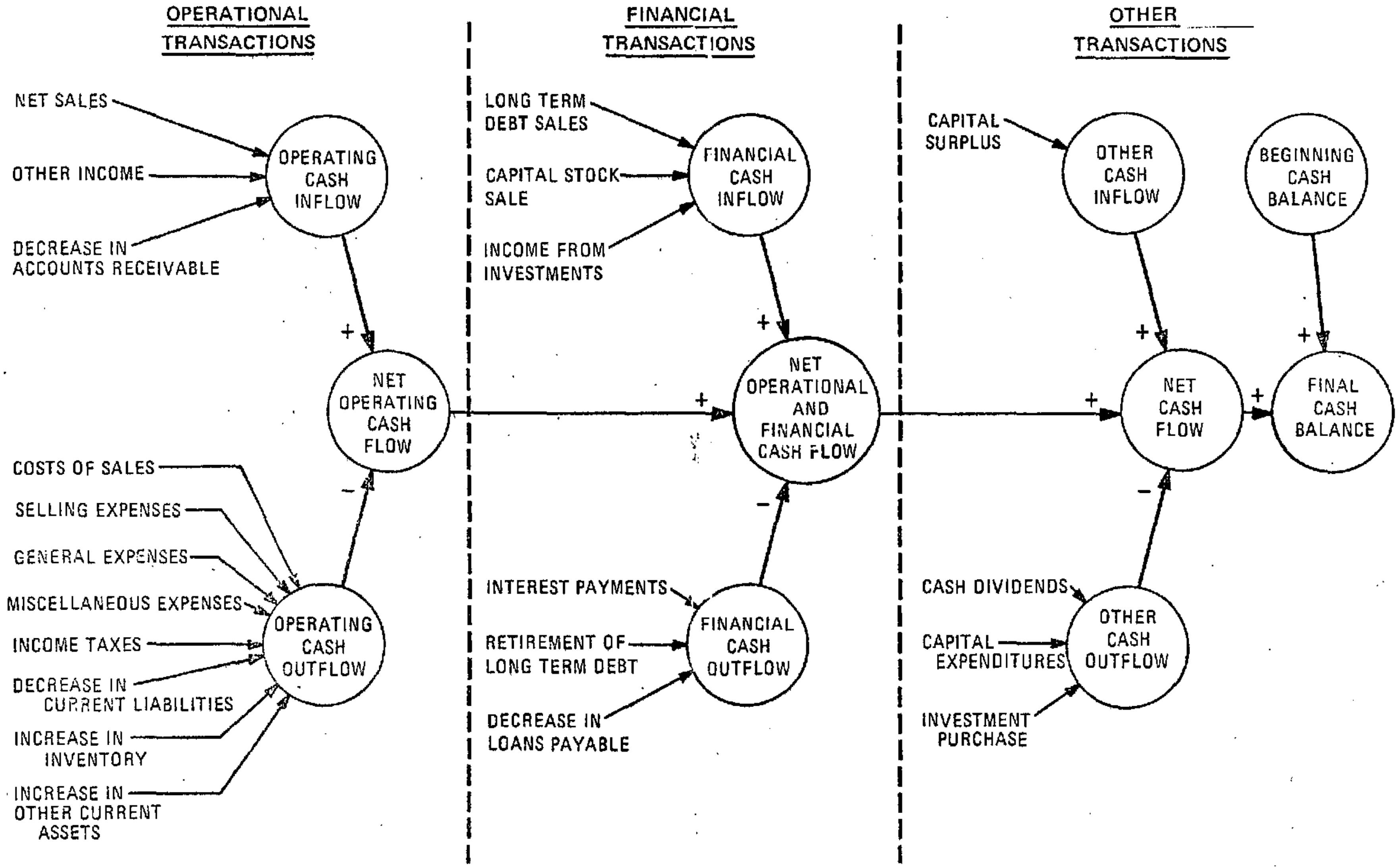

FIGURE 16

The Funds Flow Statement

The Funds Flow Statement concentrates on the sources and uses of capital in a more aggregate sense. Rather than concentrating on fluctuations in working capital, it reflects changes in long term capital commitments in both the assets and equities of the firm. Only the net change in working capital over the accounting period is shown.

Figure 17 shows a typical funds flow statement. Sources of funds come from increase in equities, (e.g., issue of new stock) or decreases in assets (e.g., depreciation). The uses of funds decrease equities (e.g., retirement of bonds), or increase assets (e.g., purchase of aircraft). Since the dual aspect concept requires assets and equities to balance, sources must equal uses, or

Equity Increases + Asset Decreases = Equity Decreases + Asset Increases

Figure 18 diagrams the Funds Flow Concept.

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FIGURE 17

ABC INC.
FUNDS FLOW STATEMENT

YEAR ENDED JUNE 30, 1972

SOURCES OF FUNDS:		
NET INCOME	$ 20,000	
ADD BACK: DEPRECIATION	6,000	
FUNDS FROM OPERATIONS		26,000
CAPITAL STOCK ISSUED		20,000
BONDS ISSUED		10,000
TOTAL FUNDS ACQUIRED		$56,000
USES OF FUNDS:		
PURCHASE OF HANGER		$10,000
PURCHASE OF AIRCRAFT		10,000
RETIREMENT OF BONDS		10,000
CASH DIVIDENDS PAID		10,000
NET ADDITION TO WORKING CAPITAL		16,000
		$56,000

SCHEDULE OF WORKING CAPITAL CHANGES

	1971	1972	INCREASE (DECREASE)
CURRENT ASSETS	100,000	98,000	(2,000)
CURRENT LIABILITIES	50,000	32,000	18,000*
WORKING CAPITAL			$16,000

*NOTE: Since a decrease in liabilities is an increase in working capital, it is shown as an increase and not a decrease as it would on a comparative balance sheet.

SOURCES AND USES OF FUNDS

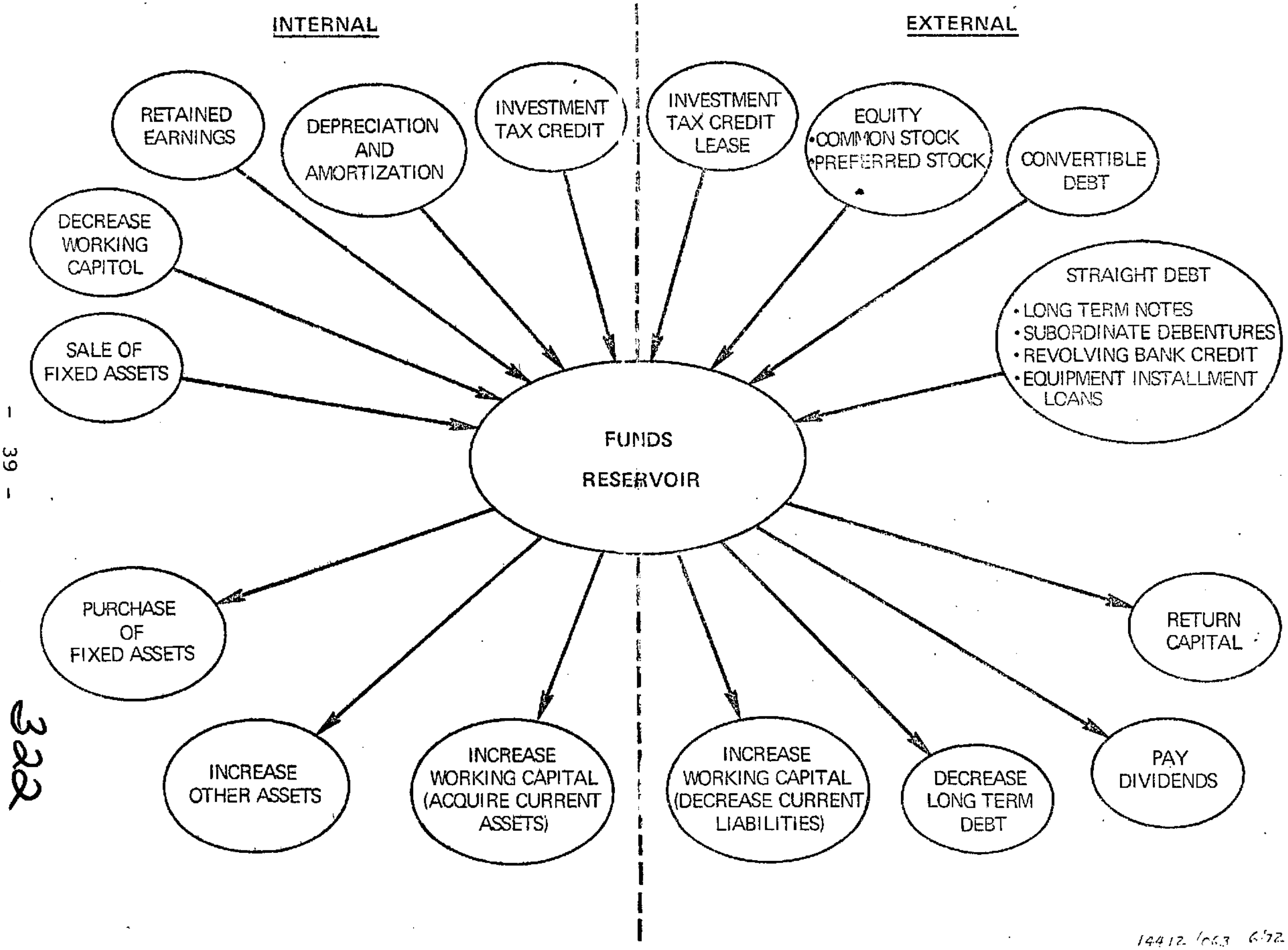

FIGURE 18

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Sources and uses of funds can be divided into "internal" and "external" categories. External transactions affect the relationships between the firm and other parties. The firm incurs debt from lenders, it makes payments to its shareholders, etc. In contrast, internal transactions depend solely on management decisions and do not affect liability to outside parties. For example, management can decide to use cash to purchase assets. This does not affect the external debts of the firm.

Most categories of Figure 18 are self-explanatory. However, some need further clarification.

Internal Sources

1. Depreciation and Amortization. Many assets are used for years after they are paid for. It is common practice to spread the cost over the entire lifetime rather than show a one-time large expense. In fact, tax laws require a long term write off in many instances. But, in fact, payment has already been made. So when depreciation or amortization appears as an expense, it does not actually represent a funds outlay. So these amounts which lower accounting income (profits) must be added to other sources of funds to see how much is actually available for use. (See figure 17).

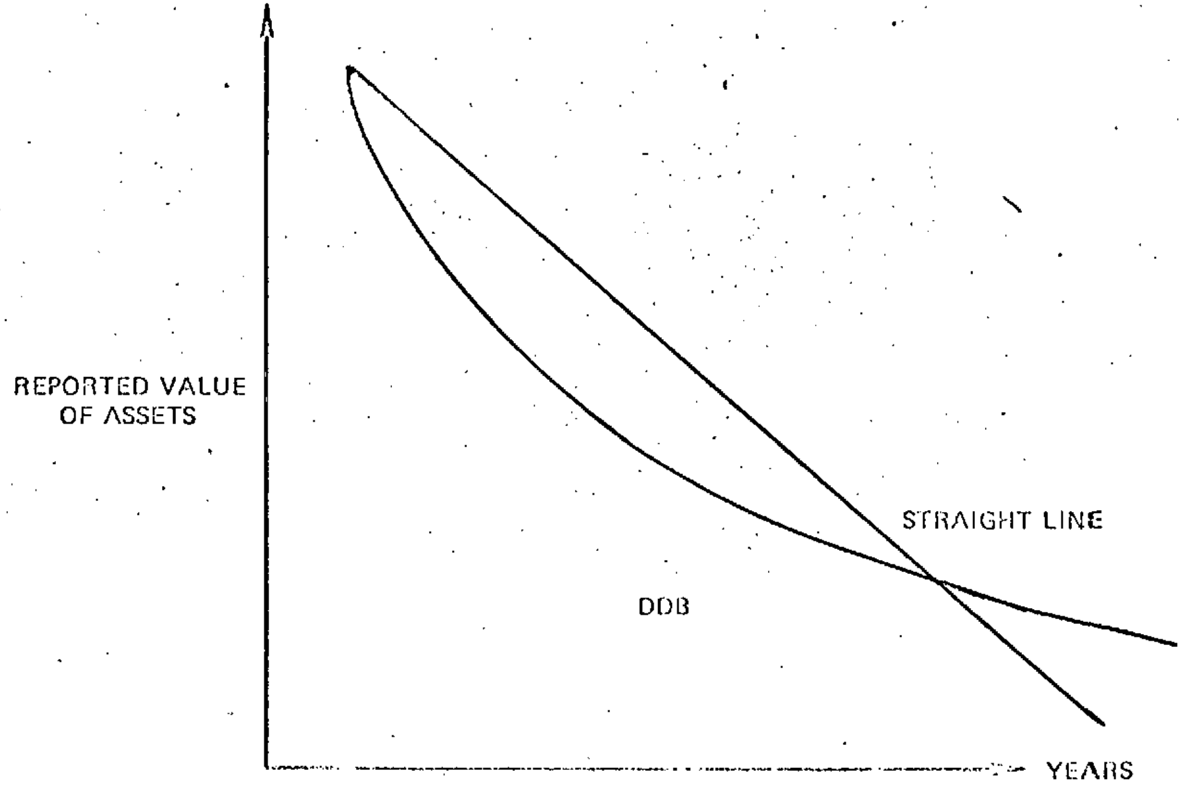
Depreciation refers to the write off of tangible assets such as flight or group equipment, while Amortization applies to the write off of intangibles such as pilot training or good will. Together, depreciation and amortization amount to almost 40% of the total financial resources of major U.S. carriers in 1969.

The straight-line method is used by almost all of the major U.S. airlines to depreciate their flight equipment for bookkeeping purposes. The residual value and the period of depreciation varies within the range of 10-15% and 10-15 years. Recently some of the carriers have increased the depreciable life of their flight equipment for several reasons: first, certain aircraft have longer useful lives than was first assumed; second, an increase in the depreciable life improves reported earnings in future years since from an accounting point of view, it costs the carrier less to provide the same service; and third, the resulting short term higher profits can be offset against the carrier's accumulated investment tax credits.

For tax purposes, major airlines use accelerated depreciation in their accounting for the Internal Revenue Service. A typical accelerated depreciation is the double declining balance method. The carriers depreciate their assets over 8 years to a 5% residual value. During the early years, a greater proportion of the asset is expended on the books kept for tax purposes than in

FIGURE 19

METHODS OF DEPRECIATION
STRAIGHT LINE VS. DOUBLE DECLINING BALANCE



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those kept for the general operations the stockholders reports, which use a straight line method. This insures that the income, as reported to IRS, is lower and hence the taxes actually paid are less than those stated in the stockholders reports. Later on, the trend reverses, and more taxes have to be paid than reported to the stockholders. This eventuality is provided for by the liability account "deferred taxes." (See figure 19). Under this system, a carrier has the use of the cash credited to Deferred Taxes until that cash is actually needed. However, since fleet acquisition is a continuous process, deferred taxes are a relatively permanent source of funds for the industry.

In cases where there are no before-tax-profits, or actual before tax losses, there would be no expense. Consequently there would be no difference between publicly reported tax payments and actual IRS tax liability. In this case, therefore, no deferred tax "source" of funds. Unless there are profits, there will be no deferred tax "source."

(In the case of an actual loss, there could be a tax loss credit that could be used to offset future tax liability but only if and when there are positive earnings.) In addition to tax and internal depreciation methods, a third scheme is imposed by the Civil Aeronoutics Board for rate-making purposes. When the Board computes the rate of return on investment, it uses a straight line method to determine the investment value of the equipment (owned by the carrier. Table 1 shows the service life and residual values used by the Board).

2. Investment Tax Credit - The investment tax credit was initiated in 1962 to provide an incentive for the industry to modernize its facilities through the purchase of capital equipment. Carriers were allowed to claim a tax deduction of up to 7% of their investment in qualifying property. The qualifications were; first, the property had to be tangible, depreciable and have a useful life of at least four years; and second, the property had to be placed in service during the year in which the tax credit was claimed. The credit is 7% on assets with useful lives of at least 8 years, 4.7% for assets having useful lives of 6 to 7 years, and 2.3% for assets with a 4 to 5 year useful life.

Up until October 10, 1966, when the ITC was suspended for 5 months, the tax deduction could be used to offset tax liability dollar-for-dollar for the first $25,000, but only at 25¢ to the dollar above that level. Unused credits could be carried back 3 years and forward five. On March 10, 1967, the ITC was restored with expanded provisions. Effective January 1, 1968, the limit on the amount of tax liability that could be offset above $25,000 was raised from 25 to 50 ¢ on the dollar and the carry-forward period was extended to seven years.

TABLE 1

FLIGHT EQUIPMENT DEPRECIATION AND RESIDUAL VALUES AS SET BY THE CAB FOR RATE-MAKING PURPOSES

	SERVICE LIFE IN YEARS	RESIDUAL VALUE AS % OF COST
TURBO-FAN EQUIPMENT		
4-ENGINE	14	2
3-ENGINE	14	2
2-ENGINE	14	2
TURBO-JET EQUIPMENT		
4-ENGINE	10	5
2-ENGINE	10	5
TURBO-PROP EQUIPMENT		
4-ENGINE	12	5
2-ENGINE	10	15
WIDE-BODY EQUIPMENT		
4-ENGINE	14	10
3-ENGINE	16	10

SOURCE: CAB, "PART 399 - STATEMENTS OF GENERAL POLICY: TREATMENT OF FLIGHT EQUIPMENT DEPRECIATION AND RESIDUAL VALUES FOR RATE PURPOSES," APRIL 9, 1971

There are two options for handling investment tax credits. The first is the "flow-through" method that allows the entire amount of the credit to be taken in the year the capital expenditures are made. The second is "service-life flow-through" which reduces the tax liability over the service lives of the related assets. The first method concentrates the full effect of the credit in one year, while the "service-life" method provides for a more even distribution.

The investment tax credit can only be used if there is tax liability. Whereas the 25% limitation prevented full utilization of the ITC before 1966, in recent years the downward trend in profits has limited its usefulness.

Table 2 summarizes the major internal sources of funds for the major U. S. carriers, and their amounts.

External Sources

1. Straight Debt - There are four basic types of straight debt financing employed by the airlines: long-term notes, subordinated debentures, revolving credit and equipment installment loans.

1.1 Long Term Notes

Senior long term notes are by far the most widely used debt instruments in the airline industry. They are typically sold to institutional investors (banks and insurance companies) and have

TABLE 2

INTERNAL SOURCES OF FUNDS
MAJOR U.S. AIR CARRIERS - 1969

SOURCE	FUNDS ($MILLIONS)	PERCENTAGE
EARNINGS AFTER TAXES BUT BEFORE ITC	318	21.1
DEPRECIATION & AMORTIZATION	808	53.7
DEFERRED TAXES	341	22.7
INVESTMENT TAX CREDIT	37	2.5
TOTAL	1504	100.0

SOURCE: ATA, "MAJOR U.S. AIRLINES, ECONOMIC REVIEW AND FINANCIAL OUTLOOK", JUNE, 1969 maturities of 20 to 40 years. Some of these notes are secured by specific equipment pledged as collateral. Holders of unsecured notes have priority against unpledged assets of the carrier in case of bankruptcy, but no specific assets are mentioned in the terms of the loan agreement. All long term notes have indentures specifying the details to the financial agreement, and any protective covenants that exist.

1.2. Subordinated Debentures

A subordinated debenture is an unsecured debt. In the event of liquidation, the holder has a claim on the assets left after the unsubordinated or senior debt is satisfied. Banks and insurance companies supplying senior debt often require subordination of other debts in order to protect their investment. In contrast to senior debt subordinated debentures are often sold in the securities markets in comparatively small denominations ($1000).

1.3. Revolving Credit

Revolving credit loans are short term credit arrangements between the carrier and bank or group of banks. The financial source guarantees that it will provide up to some amount of dollars to the carrier on demand. In return, the carrier may pay a basic service charge, or more often, a premium rate for the funds it actually uses.

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1.4. Equipment Installment Loans

Equipment installment loans are similar to automobile financing arrangements. They provide the smallest contribution to the air carriers' debt. These notes represent the willingness of the various manufacturers to participate in the financing of equipment orders and are usually secured by the equipment purchased.

2. Equity - In equity financing, the carrier sells additional shares in its own ownership through the issuance of preferred or common stock.

2.1. Preferred Stock

Preferred stockholders usually have the first option on dividends when available, and a preference over the common shareholders if the company is liquidated. The disadvantages of holding preferred stocks are first, that the dividend, when paid, is usually fixed and not proportional to corporate profits: and second, that the preferred stock usually has no voting rights.

Unlike interest payments on debt, preferred stock dividends are not deductable from income before taxes which is one reason that it is seldom used by airlines today.

2.2. Common Stock

Common stock offers many advantages as a source of funds. First, there are no fixed charges, interest or dividends that must be paid. Second, there is no maturity date when the debt must be retired. Third, common stock provides an "equity cushion" against losses for senior creditors since it is subordinate to their claims. Fourth, common stock may be more appealing than bonds to certain investor groups, since it has the potential of high dividends and rapid appreciation if the company is successful.

The disadvantages are that a new issue of common stock further divides ownership in the airline. Second, the new owners expect to share in the profits, which can put pressure on management to reduce retained earnings by dividend payments. Third, the cost of underwriting and distribution common stock is usually higher than for an equal dollar amount of bonds. Finally, like preferred stock, dividends paid are not deductible from pre-tax income.

3. Convertible Debt - A convertible debenture is a hybrid security having characteristics of both straight debt and common equity. It is issued as a subordinate debenture carrying a fixed interest provision. In addition, the holder is given the option of converting his debenture into a specified number of shares of the airline's common stock at a specified price (usually considerably above the present market price of the common stock). Because

of the conversion privilege with its potential for capital appreciation, the bond carries a lower interest rate than comparable straight debt obligations. (See Table 3). On the other hand, convertible debentures provide greater present income and security than common stock.

The airlines have found this type of financing very attractive. Since the debenture is a debt,interest payments are tax deductable until the bond is converted. Because of the conversion privilege, the airline can get a lower interest rate than if it were forced to use straight debt financing. And once conversion takes place, the carrier's obligation to pay interest and repay principle is over. The book value is shifted to the common equity account, reducing the carrier's debt/equity ratio which improves the chances of further borrowing on more favorable terms.

4. <u>Investment Tax Credit Lease</u> - A financial intermediary with a high marginal tax rate (usually a large commercial bank or a group of wealthy investors) purchases an aircraft and simultaneously leases it on a long term basis to an airline. Normally the intermediary itself provides only 20% of the aircraft's purchase price selling equipment trust certificates to finance the remaining 80%. In the event of default, the equipment trust certificates are secured by the aircraft in question which can be repossessed by the certificate holders. They do not have a claim against the

TABLE 3

COST OF EMBEDDED DEBT CAPITAL AS OF 12/31/69 (%)

	CONVERTIBLE	NONCOVERTIBLE	TOTAL
AA	4.68	5.06	4.90
EA	5.07	6.04	5.84
TW	4.71	6.08	5.62
UA	4.70	5.93	5.61
DL	-0-	7.99	7.99
NW	-0-	6.97	6.97
CO	3.63	5.87	5.48
NA	6.00	6.90	6.90

SOURCE: CAB DOCKET 21866-8, "DOMESTIC PASSENGER-FARE INVESTIGATION-RATE OF RETURN," APRIL 9, 1971.

financial intermediary under these circumstances. Generally the trust certificates are purchased by a syndicate of life insurance companies or in some cases, a bank or a group of banks will simply pay the full price of the aircraft without creating the equipment trust at all.

By leasing the aircraft, the air carrier usually pays a lower effective interest rate. The rental payments need only cover the repayment (interest + principal) of the equipment trust certificates, which represent only 80% of the cost of the aircraft. (However, the airline has no claim to any residual value at the end of the lease). The intermediary, being the legal owner of the aircraft, receives the full investment tax credit and depreciation tax shield in return for his 20% investment. In addition, he gets title to the aircraft at the end of the lease, although the airline often has the option to purchase the airplane for its residual value.

Table 4 summarizes the major external sources of funds for the major U. S. carriers and their amounts, while Table 5 shows the capital structure of several specific airlines.

TABLE 4

EXTERNAL SOURCES OF FUNDS
MAJOR U.S. AIR CARRIERS - 1969

	FUND	PERCENTAGE
SENIOR DEBT	2626.6	39.3
REVOLVING CREDIT		
AVAILABLE 1710.0		
USED 503.2	503.2	7.5
STRAIGHT SUBORDINATED DEBT	153.3	2.3
EQUIPMENT NOTES	108.7	1.6
CONVERTIBLE SUBORDINATED NOTES	1484.4	22.2
ESTIMATED CAPITAL VALUE OF LEASED AIRCRAFT	1806.9	27.0
TOTAL IMPUTED DEBT	6683.1	100.0

TABLE 5

COMPONENTS OF CAPITAL STRUCTURE AS OF 12/31/69 (MILLIONS OF $)

	TOTAL BOOK	DEBT			TOTAL
	EQUITY	CONVERTIBLE	NONCONVERTIBLE	TOTAL	CAPITAL
AA	403.3	282.8	398.4	681.2	1084.5
EA	225.0	127.4	498.7	626.1	851.1
TW	361.8	250.0	507.2	757.2	1119.0
UA	588.1	230.2	649.9	880.1	1468.2
DL	241.4	-0-	236.3	236.3	477.7
NW	426.8	-0-	112.0	112.0	538.8
CO	96.3	35.0	164.8	199.8	296.1
NA	130.5	0.5	65.7	66.2	196.7

SOURCE: CAB DOCKET 21866-8, "DOMESTIC PASSENGER-FARE INVESTIGATION-RATE OF RETURN," APRIL 9, 1971.

COMPONENTS OF CAPITAL STRUCTURE AS OF 12/31/69 (%)

	TOTAL BOOK	DEBT		
	EQUITY	CONVERTIBLE	NONCONVERTIBLE	TOTAL
AA	37.2	26.1	36.7	62.8
EA	26.4	15.0	58.6	73.6
TW	32.3	22.3	45.7	67.7
UA	40.1	15.7	44.2	59.9
DL	50.5	-0-	49.5	49.5
NW	79.2	-0-	20.8	20.8
CO	32.5	11.8	55.7	67.5
NA	66.3	0.3	33.4	33.7

SOURCE: CAB DOCKET 21866-8, "DOMESTIC PASSENGER-FARE INVESTIGATION- RATE OF RETURN", APRIL 9, 1971

FINANCIAL RATIOS

The various financial statements discussed contain a great deal of information. A large amount of additional information can be gained by studying the relationships between the items in the basic statements. Financial analysts often find that these relationships are best expressed as ratios which provide additional insight into the operations of the firm. Ratios can also provide a method of quick analysis that isolates a problem area for further study.

Any ratio in itself is meaningless. There must be a standard of comparison. Often these standards are based on the historical trends of the firm. Often the performance of competing firms can be used. Other standards can be derived from industry performance, or performance of the economy as a whole. Another valuable source of comparison comes from the general background and experience of the analyst and his feelings for what various financial ratios ought to be.

Although innumerable ratios could be formed from the various items on the financial statements, several of particular value have been standardized through usage and experience. In general, these can be grouped into those that are useful in making short term financial decisions, long term financial decision and investment decisions. Ratios may also be an aide in evaluating management performance or market performance of a firm's stock.

Short Term

Before a financial source makes a short term loan, it must determine the liquidity of the firm - its ability to repay on a short term basis. The lender is not concerned with the overall assets of the firm, but with its ability to pay its bills without liquidating long term holdings. Some of the ratios commonly used to evaluate debt paying ability to potential creditors are:

1. Current ratio - The current ratio is a very rough measure of the ability to meet short term obligations. It is defined as current assets divided by current liabilities. As a rule of thumb for industry on the average, a healthy firm should have a current ratio of about 2 to 1. However, industries with a large fixed investment like utilities or hotels have satisfactory working capital at a current ratio of 1. The airlines typically have a current ratio of 1.2 to 1.5.

2. Acid Test Ratio - Since current assets include monitories which may be hard to sell in an emergency, the current ratio may not really reflect liquidity. The acid test ratio is often used as a better measure. It is defined as current assets minus monitories, divided by current liabilities. For an airline, it would be computed on the basis of current assets minus spare parts and supplies, and might run between .8 and 1.

3. Cash and Equivalent Ratio - This ratio only compares cash on hand and assets quickly convertable to cash (such as government securities) to current liabilities. This may be too extreme a measure of ability to repay a short term obligation since it is doubtful that all current liabilities would fall due at once. For an airline, this ratio might typically fall between .3 and .5.

Long Term

An investor who considers purchasing a long term obligation from an airline is not as concerned with liquidity as he is with his overall security. This is typically measured by the Debt Ratio, long term debt divided by stockholders equity. Table 6 shows typical debt ratios for the airlines and for other transportation firms. In general, the lower the ratio, the more secure the investment.

Investment

Investment in this context is the original purchase of stockholder's equity in the firm, contrasted with market transactions between stockholders. It applies to original issues only. In deciding whether or not to buy a new stock, the investor is concerned with the potential rate of return, and the risk involved.

Rate of return is a ratio of net income to total equity - that is, liabilities plus stockholder's equity. Tables 7 and 8 show

TABLE 6

LONG-TERM DEBT/TOTAL STOCKHOLDER'S EQUITY FOR 1969

INDUSTRY	RATIO
AIRLINES:	
ALL TRUNKLINES	1.50
BIG 4 (AA,EA,TW,UA)	1.87
LITTLE 4 (CO,DL,NA,NW)	0.69
TRUCKING:	
CONSOLIDATED FREIGHTWAYS	1.04
McLEAN TRUCKING COMPANY	0.92
RAILROADS:	
PENN CENTRAL TRANSPORTATION COMPANY	0.59
CHESAPEAKE AND OHIO RAILWAY COMPANY	0.27
BUSSING:	
GREYHOUND	0.83

SOURCE: <u>MOODY'S TRANSPORTATION MANUAL</u> (NEW YORK, 1971) CAB

TABLE 7

RATES OF RETURN ON INVESTMENT (CAB)

	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961
TOTAL TRUNKS, DOMESTIC	1.07%	5.28%	5.67%	8.85%	10.36%	12.04%	9.62%	4.20%	4.10%	1.46%
BIG 4, DOMESTIC	-1.58	4.87	3.84	7.35	7.48	9.76	7.79	2.97	2.66	1.32
OTHER TRUNKS, DOMESTIC	5.72	6.05	9.92	12.74	17.58	18.50	15.10	7.74	8.48	1.92
PASS./CARGO, INT'L & TERR.	2.58	4.42	10.82	14.21	15.02	16.28	13.29	13.11	8.69	3.14

TABLE 8

RETURN ON INVESTED CAPITAL FOR THE 500 LARGEST INDUSTRIAL CORPORATIONS (INDUSTRY MEDIANS)

	1968	1967	1966
PHARMACEUTICALS	17.9%	18.0%	18.4%
SOAPS, COSMETICS	16.9	15.9	15.7
MINING	16.8	16.4	16.2
DOMESTIC TRUNKLINES*	10.0	15.0	20.0
TABACCO	14.7	13.4	13.2
PUBLISHING, PRINTING	14.1	12.5	14.8
APPAREL	13.0	12.3	14.5
MEASURING, SCIENTIFIC, PHOTOGRAPHIC EQUIPMENT	13.0	14.3	14.7
METAL PRODUCTS	12.4	13.0	13.3
AIRCRAFT AND PARTS	12.2	12.0	14.8
FARM, INDUSTRIAL MACHINERY	12.2	12.0	14.5
FOOD AND BEVERAGE	12.1	10.0	11.1
SHIPBUILDING AND RAILROAD EQUIPMENT	12.0	10.5	12.6
PETROLEUM REFINING	11.8	11.2	12.3
APPLIANCES, ELECTRONICS	11.7	11.6	13.3
MOTOR VEHICLES AND PARTS	11.6	10.4	14.3
OFFICE MACHINERY (INCLUDES COMPUTERS)	11.3	14.2	14.0
RUBBER	11.3	9.1	11.2
PAPER AND WOOD PRODUCTS	10.0	9.0	10.4
METAL MANUFACTURING	9.9	8.8	10.8
CHEMICALS	9.7	10.0	12.6
GLASS, CEMENT, GYPSUM, CONCRETE	8.7	8.3	11.0
TEXTILES	8.3	7.2	11.4
ALL INDUSTRY	11.7	11.3	12.7

* APPROXIMATE VALUES

SOURCE: "THE FORTUNE DIRECTORY OF THE 500 LARGEST INDUSTRIAL CORPORATIONS," FORTUNE, 1968, 1969 rates of return for airlines and for various other industries over a several year period. An investor would be interested in both the trend and size of returns in the firm he is considering as well as what would be available to him from other firms in the same or other industries.

The mixture of debt and equity financing is very important in determing the risk. This is measured by the Debt Ratio previously mentioned. The ratio of debt to stockholder's equity determines the leverage of the firm. Leverage involves the use of borrowed funds in expectation that the earned rate of return will be higher than the cost of those funds.

Table 9 shows the effect of different debt ratios on the stockholder's return on investment. In all cases, a total investment of $1,000,000 and a 10% cost of servicing the debt is assumed. The higher the debt ratio, the more sensitive is the stockholder's return to the overall rate of return of the firm.

Management Performance Ratios

Financial ratios can be used to compare the effectiveness of management. The better the management, the more profits it can make on the investment and the lower the expenses with respect to revenues. Table 10 shows some of the ratios used to evaluate management performance and some typical values for the airline industry.

TABLE 9

LEVERAGE EXAMPLE

TOTAL INVESTMENT	DEBT RATIO	DEBT	SHAREHOLDERS EQUITY	RATE OF RETURN	NET INCOME BEFORE INTEREST	INTEREST (at 10%)	NET INCOME	RETURN ON STOCKHOLDERS EQUITY
$1,000,000	1	$500,000	$500,000	12%	$120,000	$50,000	$70,000	14%
$1,000,000	1	$500,000	$500,000	15%	$150,000	$50,000	$100,000	20%
$1,000,000	1	$500,000	$500,000	7.5%	$ 75,000	$50,000	$25,000	5%
$1,000,000	3	$750,000	$250,000	12%	$120,000	$75,000	$45,000	18%
$1,000,000	3	$750,000	$250,000	15%	$150,000	$75,000	$75,000	30%
$1,000,000	3	$750,000	$250,000	7.5%	$ 75,000	$75,000	- 0 -	0%
$1,000,000	1.5	$600,000	$400,000	12%	$120,000	$60,000	$60,000	15%
$1,000,000	1.5	$600,000	$400,000	15%	$150,000	$60,000	$90,000	22.5%
$1,000,000	1.5	$600,000	$400,000	7.5%	$ 75,000	$60,000	$15,000	3.75%

TABLE 10

MANAGEMENT PERFORMANCE RATIOS (1968)

	INDUSTRY	BIG 4 (AA, EA, TW, UA)	LITTLE 4 (CO,DL,NA,NW)
TURNOVER = $\frac{\text{OPERATING REVENUES}}{\text{GROSS ASSETS}}$ (%)	60.9%	59.5%	63.9%
$\frac{\text{OPERATING EXPENSE}}{\text{OPERATING REVENUE}}$ (%)	91.2%	94.5%	82.3%

SOURCE = AIRLINE INDUSTRY DATA: DOUGLAS AIRCRAFT CO. SEPT. 1968

Internal Rate of Return

When management plans a financial investment, it has traditionally evaluated the potential rate of return on the investment base. This process can be confusing, however, particularly where the useful life of the investment and its depreciation period are not the same. As an alternative, airlines are starting to use the "Internal Rate of Return" method to evaluate investment alternatives. This method is based on discounted cash flows and not on the investment base, depreciation, etc.

If Ao is the initial investment, and Ai is the expected net cash flow, in or out during the ith time period, the equation can be formulated as:

$$A_o = \frac{A_1}{(1+r)} + \frac{A_2}{(1+r)} + \ldots + \frac{A_n}{(1+r)^n}$$

r then represents the rate of return on the initial investment, Ao, earned from the future total cash flow $\sum_{i=1}^{n} A_i$ discounted over the appropriate time periods. By comparing the various internal rates of return that can be expected from different investment strategies, the firm can decide which project offers the best return on the money presently available.

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Market Performance Ratios

Market performance is important when one purchases stock in the market from a prior stockholder, rather than from the company itself as part of an initial stock issue. The market investor is concerned with the health of the company whose stock he is buying. But he is also interested in how the stock compares with other stocks he might purchase in the market place.

1. Earnings Per Share - this is the ratio of the net income of the firm to the number of shares outstanding and gives some measure of the worth and earning power of the stock.

2. Price-Earnings Ratio - The market price of the stock is divided by the earnings per share as computed above. This relates the earning power of the stock to how much it costs.

3. Yield (Dividend Yield) - To determine the return on his investment, the stockholder is not only interested in how large a dividend is paid on a share, but how much the share costs. Yield is defined as dividends per share divided by the price per share and represents the percentage return on investment in the stock.

CAPITAL REQUIREMENTS FOR THE AIR TRANSPORT INDUSTRY

by George James

A. T. A.

July 20, 1972

Abstract

[redacted] the U.S scheduled airline industry has been involved in the largest re-equipment program in its history. This program which is still continuing involves the addition of hundreds of new wide-body and other aircraft to the airline fleet. Capital expenditures for the twelve major airlines alone during the past two years have amounted to nearly $4 billion. As of June 1, 1972, the U.S. scheduled airlines had orders for 243 aircraft for delivery in 1972 and beyond. The requirements for new aircraft and ground support equipment have come at a time when the industry has experienced very adverse financial conditions. The costs associated with the purchase of this new equipment along with the other costs involving such matters as the environment and security are presenting the carriers with significant financial challenges.

One of the problems in trying to forecast the capital requirements for the air transport industry, is that we have to make many assumptions. We try to put together the best assumptions and even then there can be a number of errors, and as you will see as we go through this series of slides, some of the assumptions are quite sensitive to the results. I will try to identify those and indicate to you how sensitive they may be.

This is a two part program this morning. I'm going to try to show what the needs are in the industry and then Don Lloyd-Jones will tell you how easy it is to raise the money to meet those needs.

Looking at the first slide. Now, all I'm trying to show here is the methodology and then to show you in very gross terms, what steps we took, and then some of the data we try to rely on as we made the forecast.

You have to begin with attempting to anticipate what the level of traffic growth would be in the period, in this case, between 1972 to 1980, and then give the traffic growth, as well as try to indicate what the present capacity is; and what the future capacity is likely to be; and the measurement of that capacity against the traffic growth, and some indication of the load factor that might be involved in the time period will give you then an idea of how much additional capacity you might need. From this cost estimate of capacity need, you can figure out your capital requirements.

On the traffic side, there are a number of groups which have made forecasts of airline traffic growth, throughout this period of 1972 to 1980 or even to 1985, and some even go out to the year 2000. What we have done, of course, within the industry itself is our own forecasts which we have developed in the last three or four years and have had one revision in that regard.

Now, if you just take the passenger growth from 1972 to 1980. One group that has forecast in this area is the FAA. They indicated about 10 ½% per year average annual growth in our domestic revenue passenger miles. The aviation Advisory Commission has worked with the figure of about 10% per year. Sam Brown from the Civil Aeronautics Board is giving a speech in Milwaukee today in which he will indicate that the figure for the CAB is approximately 8% per year average annual growth over this time period.

Now you see on this second slide the ATA forecast. The top figure that you see for domestic passenger growth average annual from 1972 to 1980 is 8.8% per year. The figure that we are using falls somewhere in this spectrum but more on the low side perhaps with CAB's at 8%, and to ourselves 8.8%, and to Aviation Advisory Commission's at about 10% and the FAA about 10 ½%. We are using our figure because we did it. And we have, through a committee composed of as many as a hundred representative personnel from the various carriers working two or three years hammering out this particular forecast and came up with 8.8%. So it is not the figure that is identified just with the staff of ATA, but with the industry as a whole. At the same time, the international passenger growth figure they used is 12.4%. The domestic cargo at 16.3% and the international cargo at 15.9%. The aggregate of this in terms of revenue ton mile growth will actually give you a figure of average annual growth of 10.5%.

Let me try to show you what the 8.8% per year means between 1970-1980. We have 95 billion passenger-miles in 1970, 144 by 1975 and 220 billion by 1980. So we are talking on the level of one and a half fold increase from '70 to '75 and about 2.3 fold increase from '70 to '80 between 95 and 220 billions. If you used the 8% figure that the CAB was using, they will have 2.2 fold increase between '70 and '80. So our figure is not too far away from this. In terms of enplaning passengers, this 8.8% per year domestic passenger growth that we have, would have 149 million passengers as a base in 1970, 214 by 1975, and 325 million by 1980.

So the ratio here is slightly less than the 1.5 and 2.3 from '70 to '80 which is largely do to forecast the increase in length of haul. So we're actually cutting down the number of passengers relative to the increase in revenue passenger miles.

Still though, you have 65 million more passengers in 1975 than you have in 1970. We have another 175 million more in 1980 over 1970. In other words, the increment of 175 million is actually greater than 149 million that you were carrying in 1970.

This 325 million is a lot of passengers, and all we are working at is an 8.8% growth which is not too far out of line. Given some of our growth factors in the latter part of the '60's which ranged as high as 19% to 20% in certain years and given the performance that we have had this year so far which is bordering on the level of about 11%, it seems very high compared with 1970. In 1971 we are showing a nearly flat growth, no change over 1970 however. Now, if we return to the particular methodology that we were talking about, we now have the traffic on one side and what we attempt to do now, given this traffic growth of 8.8% per year or the 10 ½% revenue ton mile figure when you make the composite with passenger and cargo, and domestic and international. We now try to measure against what the present fleet is, take out the anticipated retirements to get a net figure on that, add the planned additions that the carriers' plans show, and determine whether or not that is enough to carry that particular traffic at a particular load factor. And that if it does not we will have to go out to purchase some additional ATMs (available ton miles) in order to provide sufficient capacity to carry that amount of traffic, as you have just seen, something on the order of 325 million passengers by 1980. We get the information on the present fleet and the planned additions from two sources at this point. About 6 to 9 months ago, a comprehensive study was obtained by the ATA from the carriers on their present fleet and anticipated plane additions up to 1980, for environmental purposes, particularly with regard to anticipating the need for noise retrofit. And then each year, we get from the carriers, sometimes about twice a year, a survey on their new equipment they plan on purchasing over the next two or three years. So when we combine these two, we are able to get a figure within this block, if you will, to tell us what the capacity the carriers are planning over this time period at this time. Normally, a carrier has a more finite plan for the next three years than they might have for 1975 to 1980.

Let's take a look at the present fleet and the planned additions--the aircraft type 707, 727, 737, and so on down to DC10, L 10-11 and the 747; what the inventory was in 1970, what the carriers are planning for 1975, what are the plans for 1980. Notice that a number of these are being retired. The 707, with an inventory of 412 in 1970, dropping to 263 by 1980 is one example. The 720's will be phased out by 1980. The DC8's would drop from 258 to 172. On the other hand, there are some others growing, of course. The 747 from 40 up to 173, and we didn't have the 3-engine wide-body in the fleet in 1970, they will grow to 555 by 1980. Now, if you put all this together, you end up with an inventory of 2007 in 1970, 2110 in 1975, 2307 in 1980. So that you are adding about 300 from '70 to '80. But at the same time, you are retiring 458 in this process. These drops in 707's, 720's, DC 8's and so forth add up to 458 taken out of the fleet, but the addition, in the wide-bodies in particular, bring on additional 758. So you have a net growth of 300 in that time period. These do not include the new types of aircraft -- the A300, the Concord, or even the twin-engine DC 10 STOL. This is only the anticipated addition from the present aircraft that are now being manufactured. 707's will retire 149, 720's will retire 126, DC 8's will retire 76 over the time period of 1970 to 1980. In addition, we have in terms of new orders of aircraft, 243 are actually on order as of June 1 of this year. And you notice that 88 of those were scheduled to delivery in 1972, 78 next year, 52 in '74. They may have plans of adding additional aircraft which have not been decided yet. But as far as orders are concerned, as of June 1, 243 have been confirmed and are valued in today's dollars at $4 billion.

Now, most of these will be stretched 727 - 200's. On order are approximately 180 of the wide-body tri-jets: DC 10, L1011 and 6, at this point, 747's on order. 747's reached their peak of delivery last year, the DC 10's will reach peak this year, and L 1011 will kind of split as far as the peak of delivery is between '73 and '74, because of the stretch out of Rolls Royce engines.

What we have done then is we've taken a look at the traffic growth, the 8.8% passenger and 10 ½% revenue ton mile growth, and taken a look at the present fleet and the planned addition now, and how then to consider whether or not they have plans to meet this particular growth pattern.

We have to do it on a load factor assumption. So that we need a guideline then. Once more, incidentally, I should mention that throughout all of this we are attempting now to stick with basic forecasting that may have been done in one of the areas and try to remove the element of apparent judgement as much as possible. So here is the study that has lasted 2 or 3 years to give us that particular figure. This information is now coming from the surveys that ATA has done with the carriers. And what do you do here. Well, the one thing you can do is to assume that we will get the load factor standard that was laid down in the recent domestic passenger fare investigation by the CAB at 55%. We have attempted to see what would happen if this were set at 55%. But, on the other hand, we also said that it may be that you will reach a point in this growth pattern that you might even go higher than 55% before you trigger the need for additional ATMs or additional capacity for a number of reasons. One of these is that the carriers are under severe financial situations in recent years and they will look for every wedge they possibly can to minimize the additional capital cost and the additional capacity that might result from that. So, consequently, we have a triggered system here, that we will start ordering for more capacity at 55%, but we will go up to 57 ½% towards the end of the 1970's before we actually drew the line and said that we must have new capacity beyond that point. What I'm saying is if we move up of that 55% load factor, we begin to order some, but as we get to 57 ½%, we hold at that. We do not allow the load factor to rise beyond 57.5%.

What we now have then in this figure is we get here, with the assumption I just gave you for a cut-off at 57.5%. We have today in 1970 a ton mile load factor of 44.3% and by 1980 we would have a ton mile load factor of approximately 55.7%. This is almost a 25% increase in load factor alone, in terms of this particular model, before you actually go out and place market demand for new equipment.

As far as the principal characteristics are concerned, we will break it down to 2 time periods, '71 to '75 and '76 to '80. The domestic passenger growth we already indicated at 8.8% per year in '71 to '75 and '76 to '80 period, the load factor we are raising throughout this period from 48.5 to 55%, and from '76 to '80 it continues to grow from 55% to 57.5% cut-ff. The utilization we take at an average of 9 hours per day which is the utilization we were getting the '70 to '71 period, that is relatively low at this point in time, a lot of it due to the fact that we have to cut back during the '70 to '71 recession. One can expect us to increase utilization as the traffic grows. So we will increase it about 10% or about 10 hours per day in '76-'80 period.

Now for the seating configuration that we are using in the '71 to '75 period. The seating configuration that we had in the '70 to '71 period, that also is low. You can increase the seating capacity through elimination of lounges or reseating the present seating configuration in particularly the wide-bodies. So we assume that you hold the present base until this traffic grows to a point when you need to get additional capacity, hopefully without having to purchase. So you expect to expand seating configuration about 1974 and the expansion takes you for the next 3 years up to 1977, and it grows, gradually increasing from 10 to 15% depending upon whether you are working with a 727-200 standard jet or a wide-body 747. We use a different growth figure on the seating configuration depending upon the type of aircraft, but it runs about 10 to 15% in total. These are the characteristics that you are now getting in '71 to '75 and '76 to '80 period.

You notice the various assumptions that are built in to each of these time periods '71 to '75, '76 to '80. Now, when you take all of this growth against what the carriers had planned, you come up with insufficient amount of capacity. You now have to add capacity and there are some capital costs in that and then you cost out what they have already planned. You added the two, what they planned, what additional they will need. That factors out in the '71 to '75 period to a little under $6 billion of flight equipment alone in that 5 year period. Historically, we have run a factor of about 17% of our flight equipment that comes out in ground equipment. If we continue to use that 17% relationship, that's another billion dollars. And, of course, we have to assume that we aren't going to be able to purchase those in the future at the same dollar values of today. We have assumed a 4% per year inflation. That costs us in this time period another half billion dollars. So we end up with a little under 7 ½ billion dollars in the '71 to '75 time period. So for a five year basis, it is averaged at a billion and a half a year and that is about our present rate; we are running as high a 2.3 billion as in the latter part of the '60's and we cut back as you well know. So this assumed about a billion and a half rate.

The surprise then comes in the '76 to '80 period which as you see the flight equipment now goes up to $13 billion. A 17% ground equipment would account for another $2.2 billion and the inflation factor accounts for $5 billion on this 4% per year. So now you have a total of about $20 billion in this time period. And, of course, almost $28 billion in the decade for 1970-1980. What is this compared with history? Well, interesting enough, the schedules airlines' capital equipment expenditures from '61 to '65,$4 billion; from '66 to '70, $12 billion; '71 to '75, $7 billion; '76 to '80, $20 billion. You can see the extreme cycles that are going on which is hitting the bottom in the first half of the decade and hitting the peaks in the last half. The '71 to '75 figure is $3 B more than that from '61 to '65, and the $20 B for '76 to '80 is $8 B more than the $12 B for '66 to '70 period. It is interesting to look at this $12 B and increase it for the '76 to '80 period at 4% per year inflation. If you do and take the $12 B figure and run it up at 4% per year until you go to this time period, it comes up to about $19 ½ B. So in one respect this $20 B is only buying in constant dollars about $12 B worth in the '66 to '70 period. What I want to point out is, of course, that we have a lot of inflation to swallow in this '76 to '80 period.

Now, let me take the $20 B in the '76 to '80 period and break it down into $13 B of flight equipment without inflation; $15 B of flight and ground equipment without inflation, and then $20 B for flight and ground equipment with inflation. So the flight equipment alone in this time period -- $13 B -- is just slightly more than our total expenditures of $12 B in 1966 to 1970 period, and the $5 B of inflation between these 2 figures is actually greater than all of our expenditures in the period '61 to '65 which is $4 B. So we will have to pay more for inflation before we can get hold of our equipment, than we pay for equipment in '61 to '65.

Just how good is this forecast of capital requirements in 1960 to 1980 of some $20 B. We have to look more or less at the validity of assumptions on utilization, seating, load factor and traffic and retirement. We can say, as far as utilization of seating, since we have expected utilization up about 10%, and the seating configuration up between 10 to 15%, this is a pretty fair assumption, the rate at which you do it may be subject to some question. Some may feel the load factor may not get that high before it actually triggers the demand for equipment because you have that kind of growth and irregular competition among the carriers to get a larger share of market of capacity, before you get to 55% or 57 ½% load factor. The traffic may be subject to some question. But at this point, the spectrum of forecasts that have been done may be slightly on the low side, but the retirement is probably accurate because pressures have been put on to make the noise retrofit adjustment.

To give you some idea the sensitivity of it. If the load factor grows from 55 to 60%, that 5% of additional load factor in '76 to '80 period, this $20 B will be reduced by about $1.6 B. Or, if you can get another 10% of utilization, this is worth about $2 ½ B. If you didn't retire any of you aircraft which have been scheduled to retire between '76 to '80, that will be worth about $1 ½ B. If you took a combination of these: another 5% increase in load factor, and 10% increase of utilization, may be worth as much as $4 B. So you now have some trade-off. But even if you took the combination that I just indicated, worth $4 B, you still have about $16 B which is a significantly large amount for air carriers to finance.

You have a range in the change of cost of aircraft from 7 ½% to about 18%. Certainly, there is some quality improvement in the aircraft itself. You can't say that it is not exactly the same aircraft. But still these figures are more markedly above the 4% we have put into the assumption; so it is very possible that inflation will be greater than what we have indicated.

I would summarize by saying that it would appear to us and we've just now gone through this exercise and we still have some other adjustments that we have to make in order to shake it down some. I think we can conclude that the capital requirements on the industry in the latter half of the '70's with inflation would be greater than they were in the '76 to '80 period. This is going to put increasing pressure on the carriers to maintain an adequate level of earnings in order to finance themselves through this time period, hopefully providing an adequate public service without congestion problems, and so forth as in the latter half of the '60's.

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FINANCING THE AIR TRANSPORTATION INDUSTRY

D. J. Lloyd-Jones

Gentlemen: It is a pleasure to be here today to speak in such a lovely location and on a subject close to my heart. It is a particular pleasure to be on the same program with Dr. George James with whom I have had a warm association for many years. I say this in spite of the fact that Dr. James has just made some capital requirement forecasts substantially higher than I had anticipated. The $20 billion capital requirement that George is forecasting for the second half of the 1970's is final confirmation that the aerospace manufacturers have infiltrated the ATA.

I know you've spent a lot of time this week, and some of last week, on the basic characteristics of the industry. I want to touch on them briefly today to show how they affect the financing requirements and patterns of the industry.(Chart I) First of all, we are highly susceptible to the business cycle. This means that we have to choose our financial timing carefully in order to get the best possible interest rates available. There are in fact times when we cannot finance at all, when things are at the bottom. It also means that our investors, our lenders, tend to request higher interest rates or expect higher rates of return on their equity from us than they do from more stable industries, such as other utility industries whose earnings tend to be reasonably stable percentages.

Second, we are a service industry;therefore we cannot store our product. This fact has a fairly major effect on the amount of equipment we buy and therefore the amount of capital investment that we make.

Third, we are closely government regulated. We are regulated with regard to the routes we can fly and the rates we may charge. Nonetheless we are highly competitive and the combination of this fact and our close regulation has tended in the past to drive the industry periodically into an over-capacity posture. This puts heavy burdens on the financial officers, and the financial resources of the airlines.

Fifth, we are a high growth industry, so that, if we were normal in all other respects, we would have a fairly high rate of new equipment acquisitions. We are not normal in all other respects, however. We have a rapid technological cycle. Since the airlines first became significant entities in transportation in the early 1930's, there has been a major technological revolution in the equipment we operate on the average of about every seven years. Therefore, we are capital hungry and that is what I am going to be talking about to a very large degree today. Finally, seasonality enters into our economic picture in that we must equip our fleets to satisfy a reasonable percentage of peak demand. In the case of American Airlines, our seasonal peak falls in the summertime on the east-west routes. New York-Los Angeles traffic, for example, may be 50% higher in the month of August than it is on an average day in the month of February.

The "Four Seasons" of Airline Financing

Let me turn now to a historical review of airline financing because I think some historical perspective is necessary to understand how we got to where we are today and how we can, hopefully, finance the requirements of the future. Season I in airline financing I will date as including all years up until the end of 1954. This date was chosen because this was when the manufacturers first approached the airlines to purchase the new jets, the 707's, DC-8's. Now, let's look at the balance sheet just before that happened. (Chart II) We had a fairly comfortable working capital level relative to about half a billion in operating property. Other assets were insignificant and debt was a minor factor, $214 million or 27% of our total capitalization. The bulk of our capitalization, 71%, was stockholders' equity. Outside of a few really minor debt agreements including some RFC financing back in the 1930's, a small amount in the 1940's, and some insignificant insurance company financing in the 1950's, we had financed our growth and our new equipment throughout this time period by stockholder equity: new equity issues, retained earnings and internal cash generation. This period then can be called the equity period and it is the first season of airline financing.

Now let's look at the ratios that come out of the simplified balance sheet that we just saw. (Chart III) First of all the current ratio (the current assets divided by the current liabilities) was about 1.4. That's a healthy ratio. We've learned to live with a lot lower ratio than that since 1954. The debt to equity ratio was 0.4, a very insignificant amount of debt and a very healthy situation. There were no leases, so,even if you include capitalized leases, the ratio is still 0.4. Finally, we were covering our interest charges 13.3 times through internally generated cash flow. Based on these healthy financial ratios, I think you can see why the insurance companies became interested in financing the jet program for the airlines in the period 1955 to 1959. We were healthy, we had a lot of cash flow and we were buying a product which offered true productivity improvement to the airlines. Financing the first jet purchases then was not too difficult a job.

The next chart (Chart IV) shows what aircraft commitments were made by the major U.S. airlines in the 1955 to 1959 time period. These were virtually all 707 and DC-8 aircraft. There were 262 of them committed for in this time period. The total commitment turned out to be $1.5 billion for aircraft and a grand total, adding in ground and other commitments necessary to support this equipment, of $2.2 billion. Comparing that commitment of $2.2 billion to the capitilization base at the beginning of the period of $780 million results in a ratio of commitment to capital base of 2.8. I will be referring to that same ratio as we go along through the various periods of financing. The 2.8 was as high as any ratio that we have had since the second World War. But since we had started with a very strong balance sheet, it was not a very difficult financing problem. How did we do it?

In the period 1955 to 1959, there was $2.2 billion of capital expenditures, as I just mentioned. (Chart V) We also paid out some dividends, about 7% of our total capital usage was dividends, so about $2.3 - $2.4 billion had to be raised. 55% came from internal sources, depreciation plus earnings and 35% came from debt. $841 million of debt was raised in that period on top of the $214 million we had had in the 1954 base year. So we quintrupled our debt in this four year time period and over 90% of it came out of the insurance companies. In addition there was an insignificant amount of lease financing and there was a little bit of equity financing, but less than 8% of the total. I have called this time period Season II, the insurance company period, a time when almost all external financing was senior long-term debt placed with insurance companies.

Q. What forms did these loans take?

A. They took various forms, but generally speaking they were unsecured, senior debt. Guaranteed lease obligations, for example, are senior to these insurance obligations.

Q. The interest rates?

A. The interest rates during this period were delightful by today's standards - in the neighborhood of 4½% or 4¼%. A lot of these original loans have been re-negotiated since and the interest rates have been re-negotiated upwards.

We have reviewed how we sourced our funds in the 1955-1959 time period. Our year-end 1959 balance sheet is shown on Chart VI. Compared to 1954 our working capital had risen to $188 million, not a significant increase. Our operating property, on the other hand, had risen by about a billion dollars to a billion five hundred and sixty two million dollars and our other assets had just about quadrupled. They were $71 million in 1954 and they were $309 million at year end 1959. The balance sheet then, had changed quite drastically. You recall that the stockholder equity was over 70% at the end of 1954; at year-end 1959 it was 43% and debt had risen to 51%. In dollar terms we had increased to almost $1.1 billion from $214 million in debt, and in equity we had gone from $551 million to $880 million. So, for the first time we were beginning to see heavy use of debt financing by the airline industry. Of this total of $1.1 billion, $706 million was in the hands of the insurance companies at the end of 1959, a little better than 2/3 of the entire debt of the industry.

The ratios that result from that balance sheet are shown on Chart VII. The current ratio hasn't changed very much since 1954. The debt-equity ratio, however, had gone from 0.4 to 1.2, so we were then over 50% debt. Inclusion of leases doesn't really change these figures very much because we hadn't turned to leasing at all heavily at that point in time. One key ratio had worsened dramatically. Our times interest coverage had dropped from thirteen fold to three fold and it was just about at this point that the insurance companies began to get a little nervous about loaning more money to the airline industry.

There were additional technological developments in the early 1960's, however, and efficiency required their purchase. The three-engine jet, the 727 came along, the two-engine jets, the BAC's and the DC-9's came along and the industry required additional four-engine jets to retire some of its older piston equipment and to meet growth. So, in this time period we ordered an additional 842 total aircraft (Chart VIII) with a dollar value, including necessary ground facilities, of $4.2 billion. Now, that was a lot of money, but compared to the year-end 1959 capital base, the commitment was small relative to the early jet acquisition program. Our capitalization, debt plus equity, at the end of 1959 had been $2.1 billion. Our 1960-1965 commitments of $4.3 billion result in a ratio to base capitilization of 2.1. That figure compares to the 2.8 ratio in the latter half of the 1950's.

On Chart IX we see the $4.2 billion in capital expenditures plus another $233 million in dividends. This period I have called the third season of airline financing because we were able to finance a very high percentage of our commitments through internal cash flow, from depreciation and from quite healthy profits in the 1963-1965 period. We did have to turn to debt to some degree - $854 million - but it was only 19% of the total sourcing of capital during this time period. There was little insurance money in this period and leasing and equity financing were not a major factor. So the key to this entire period was the ability we had to finance our commitments from internal sources.

Adding the 1960-1965 cash flows to the balance sheet of 1959, you derive the picture shown in Chart X. Working capital and operating property had each about doubled from 1959 and other assets were up about 50% from the prior total. Total debt had risen to $1.9 billion compared from just over one billion at the end of 1959, but had declined as a percentage to 45% of our total capitalization. Leases still played a nominal role in our balance sheet. Stockholder equity had just about doubled rising to $1.6 billion from $880 million at the end of 1959.

We still, however, had more debt than equity as shown in the next slide. (Chart XI) The current ratio was still running along at about the same level, no problem. The debt-equity ratio had actually improved a little bit between 1959 and 1965. If you add the nominal leasing that had been done, we had just about held our own. We did improve our times interest coverage: we got it back to 6.6 from the level of 3.1 that it had hit in 1959. That was the picture at the end of that era as we came into the most difficult financing period that the airlines have had since World War II.

Q. Would you define times interest coverage?

A. It's the internal generation of cash divided by the interest commitment of the carriers.

We had bought 262 aircraft in the 1955-1959 time period (Chart XII); 842 aircraft in the 1960-1965 time period; and in the 1966-1971 time period we committed for 912 aircraft. These were a lot more expensive aircraft, since inflation really started to bite into us in the latter 1960's. We ordered 214 of the old narrow bodied four-engine jets, we ordered 260 more three-engine 727's,with the 727-200's representing a large proportion of this number. We

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also ordered some twin engine jets - 143 of them. The bulk of the dollars, however, went to order 121 747's and 174 of the DC-10 and L-1011 variety. The total commitment for aircraft for the period reached just under ten billion dollars. Including the ground equipment, facilities, etc., the total commitment in this time period was $11.9 billion. Now let's again compare that figure to the capital base that we had entering the period. The capital base at the end of 1965 was $4.2 billion which results in a commitment to capitalization ratio of 2.8. This is the same ratio that we had had in the late 1950's; in between it had been 2.1.

On the face of it then our problem was no more difficult in the late 1960's than it had been back in the late 1950's, but that was not really the case. We didn't have the same balance sheet in 1965, that we had had before we ordered the first jets in 1954. Most financing sources were either drying up, had dried up or had become extremely expensive. We were beginning to get into an inflationary period, interest rates were rising for everyone, but they were rising more rapidly for the kind of credit that the airlines represented than for other kinds of corporations because of our relatively poorer balance sheets and erratic earnings. Insurance companies were not willing to extend further unsecured senior money. (Chart XIII) Prospective equity investors were looking for higher dividend yields because of inflation and, after about 1967, were turned away by declining airline stock prices. So, we came into this period, not with a bigger commitment problem, but with a bigger balance sheet problem, and a much more adverse financing environment than we had had previously. I call this period the fourth season or the "get it where you can" season.

There were three sub-phases to this period. The first phase was use of subordinated convertible debenture financing in order to attract the insurance companies by giving them a sweetener in the form of an equity kicker. The second phase was bank financing and the third phase was lease financing. Those last two phases represent the least desirable types of financing that the airlines can do. We had to turn to them as an industry because other sources were unavailable. They were generally more expensive; nonetheless we had to use them.

Q. Those are sort of the classic money sources. I understand that there are other places like oil companies that have money. How do you get money out of something like that?

A. Out of an oil company? It's quite difficult if you're thinking in terms of direct investment. Airlines normally don't get direct debt financing out of an oil company until they are really in pretty bad shape. Then they may give it to you.

Q. Why shouldn't they care about you being in bad shape?

A. Because they want to collect their money.

Q. Oh, I see.

A. You'll find that carriers really on the ropes may get some oil company financing, but it's just to keep the carrier going and hopefully to collect some back debts. In those cases the oil companies are already so far in, they've got to go little bit more. If you're seeking lease financing by oil companies, you run into real problems with the Internal Revenue Service, when you start to deal with other than financial institutions. To be sure that you have tax credits, you really have to be a financial institution.

Let's take a look now at where the insurance companies stood in the airline financing picture in 1968, the middle of this last time period. (Chart XIV) We've already seen that back in the late 1950's they had financed two-thirds of the original jet acquisitions and accounted for 90% of the direct debt. In the next ten years they represented only 28.5% of the total debt sourcing done by the airlines. Even that financing took a different form, as we will see in just a moment. Seven companies that you're all very familiar with, accounted for the large majority of the airline loans. The Metropolitan has the heaviest position, they have about $600 million in the airlines, the Prudential, $500 million, and just a little bit behind them, the Equitable at $220 million and then Hancock, Aetna, MONY, Connecticut General and a batch of others make up the remainder. That is a very heavy concentration, as Mr. Nader says, but only a handful of insurance companies had the assets in this time period to loan the kinds of monies that the airlines needed and never in my experience have these companies in any way attempted to exert control.

There was then a small expansion in insurance company lending and it came in 1966 and 1967. (Chart XV) As an industry we had trifled with convertible subordinated financing prior to this time period, but I really do characterize it as trifling. There had been a little bit in 1958, a nominal amount in 1961, and one issue in 1964. Just at the end of 1965 the real push on subordinated convertible financing began, with a $53 million issue at 4%, which I believe was ours. Then there was a batch of them in 1966 and 1967. You could pick up the paper practically every day and find that some airline was doing subordinated convertible financing. It was cheap and the insurance companies would take that kind of a piece of paper whereas they wouldn't take senior debt financing.

After 1967, however, airline security prices started to fall out of bed. As a result, convertible financing decreased sharply in 1968. Then we had an aberration in 1969. As you may recall, when Pan Am's stock price got down to a low level and Pan Am's total value in the market place fell slightly below $300 million dollars, International Leisure made an attempt to try and take control of Pan Am. Pan Am shrewdly used that run-up in their stock price to finance. They issued a fairly sizable subordinated convertible debenture issue. TWA rode on Pan Am's coat tails, since their stock price had risen with Pan Am's, and they also did a subordinated issue. Those two issues accounted for the $325 million in 1969. The 1970 financing was Eastern Air Line's. It is the only subordinated convertible debenture that I can recall that carried an 8% coupon rate. It was issued when Eastern's stock was selling at 13, or thereabouts, and the conversion price was set between 15 and 16. It was a very, very expensive kind of financing, but it was all that was available to Eastern at the time. Excluding these aberrations, this phase one of season four ended in the third or fourth quarter of 1967 and subordinated convertible markets became closed for airline financing purposes.

Q. Must airlines have senior lender approval when it's a bond issue?

A. Not if it's a subordinated issue - unless, of course, the airline has reached its limit for such financing contained in its loan covenants.

Q. Does the zero in the 1970 debt represent conversion or does it represent laying off of some airlines?

A. It represents conversions. The conversion price as I mentioned on Eastern was 16 or a little below. Eastern's stock price went right through that level in 1971 and they called. Two of American's issues were convertible at 31 3/4; we called them late last year, and finished the conversion in January. When you get stock prices that permit you to convert these issues, you try and convert them into equity to improve your balance sheet and give you more flexibility.

Q. How do these interest rates compare with insurance interest rates?

A. It depends on what premium is set on the conversion. If it's a 20% premium or a 30% premium above existing market price,it will effect the interest rates that are charged. I would say on balance in this time period a direct senior debt placement would have cost you one-half to a full point higher than these rates.

Q. I think that the VA rate was 3/4 less and a point higher than these.

A. Yes.

Q. Do you do any borrowing from foreign countries?

A. American has none, but some of the international carriers have done some. For a while in 1970 the Swiss market was a pretty good source. You could deal in Eurodollars in a couple of other markets. That was equivalent to bank borrowing, short term borrowing. As an industry we did turn to bank borrowing,but we were able by and large to get our domestic banks to loan at rates that were pretty close to the Eurodollar rate or even below most of the time.

Q. This may not be appropriate now, but if you were unregulated in terms of fare structure would you be better able to cope with your current problem?

A. Yes, I think there would be no question that, if we were unregulated in relation to rate structure, the financial community would feel more secure in lending to us and I suspect the equity investors would also feel more secure. Regulation in certain other areas, however, does give the senior lenders and the equity investors some security. Regulation as a whole is a bit of a mixed bag, but rate regulations, per se, probably does cost us some points.

So the insurance monies were dried up, we had run out of subordinated convertible opportunities essentially at the end of 1967 and we had to turn to the banks. (Chart XVI) The banks had been only a very minor factor up until the end of 1964. Of our total long-term debt at that point, the banks only had $291 million or 17%. At the end of this period, in 1971, we had total debt of $5.2 billion. Of the new debt placed in this time period, the banks took 27½% of it. Bank financing is probably the least attractive kind of financing that an airline can do. Your commitments are invariably long-term commitments. You're looking at purchases of aircraft which you anticipate will have 12 or 14 or 16 year lives. To go to the bank and finance on a five year type of financing makes little sense. In effect, you are commiting to finance that particular debt two or three times during the course of the life of that aircraft. Therefore, whenever possible, you try and do longer term financing. It wasn't possible in this period, so we did turn to the banks quite heavily. At year end 1971, the 12 carriers had $2.1 billion worth of authorized revolving credit at the banks and were using 44% of it, or just over $900 million. Most airlines view such credits first as something you're going to try to refinance as soon as possible, and second, as an insurance policy. It's awfully nice when you're trying to go to sleep at night to know that you have a $300 million revolver down at the bank and you're only using $50 million of it. It means that, if market conditions suddenly go sour or if that lease deal you're trying to work out doesn't go through, you can go down to the bank and use your insurance policy to tide you over until market conditions improve. It's expensive insurance, however, and it's not something you carry just for the fun of it.

Finally, very late in 1969 the airline industry entered phase three of this era: the use of a lease instrument very similar to a railroad equipment trust certificate. (Chart XVII) This was an instrument that TWA invented. In December, 1969 they did a $70 million 747 guaranteed loan certificate financing at a 10% coupon rate. We seized upon this and American Airlines lease financed seven 747's in three separate issues during 1970, representing the majority of this total of $248 million in 1970. We paid interest rates ranging from about 10% on up. I'll never forget our highest rate, it was 11%. Another was at 10 7/8% and I forget what the third issue was. Other carriers issued lease certificates at 11¼% and even a little higher. This was the nadir of the airline financial picture during this time period.

Q. Who picked those up?

A. Most of the ones that American did were sold publicly. It becomes a rather expensive transaction in that you have an equity owner and then you sell the long term bonds to the public at the coupon rates shown on Chart XVII. You then, of course, have to have trustees, etc.

Q. They usually are bonds aren't they?

A. These were bonds. All but the last couple were guaranteed by the corporation. In addition to representing a lien on the aircraft as security for the bond, we had to give a separate corporate guarantee in order to sell the bonds.

Q. You didn't tell us about the highest interest rate I've seen in public bonds?

A. In this kind of financing you are selling 70% to 75% of the value of the aircraft in the form of long-term bonds to the public and 25% to 30% is being placed at very low interest rates with equity investors, usually banks who have unused investment tax credits. When one factors in the very low equity rates with the high bond coupon rates, you typically reduce them 3% to 3½% points in terms of the effective borrowing rates to the airline. The airline, of course, is giving up investment tax credit when it finances this way. I'm not taking account of that.

Q. What was the term?

A. We did ours on an 18 year term, most were done on a 16 year term.

Q. Were these callable bonds?

A. They are not callable, they are actually paid out just like you pay out a lease every six months. You're paying off 1/36th or 1/32nd of the face value of the total bond twice a year.

Chart XVIII is as good a summary of the difficulties that the airlines were in in 1971 as any I can think of. I don't know how many of you are familiar with the New York State Insurance Laws and with similar insurance laws in many other states. This law says that the airline, or any corporation to whom an insurance company makes a loan, must have cash flow equivalent to 1.5 times the fixed interest obligations for the year. Any loans to corporations that fail to meet that test in one of the last two years or on average in the last five years are put into a special pot and the insurance company has to increase its reserve against that particular loan. Normally an insurance company will carry a 1% to 2% reserve against a loan. If you fail this test, however, that will jump to 10% or 20%, depending upon the state. The insurance company just will not loan when they fear that they may have to reserve 10% to 20% against the loan. If they would, the rate would be so high that no airline would be interested in it. American failed this test for the first time in 1970 and was still under in 1971 so we're not eligible at the moment to borrow on an unsecured basis from insurance companies, except under this very high reserve position. Eastern has been under since 1969, Pan Am has been under since, I believe, before 1969, TWA has also been under for three years. United passed in 1969 and then fell out of bed, Braniff has been under throughout the three years, Continental was under for two, they did make it in 1971. Western has been under for the last two years. There are only three carriers today that could go to an insurance company and say I want to borrow some money and the insurance man would smile. They are Delta, National and Northwest. This is an interesting test to watch since it means it is going to be at least a couple of years before we as an industry have real access to the insurance company market.

Q. Have the insurance companies lost anything on their airline loans?

A. They haven't lost anything but when they see figures of this kind their insurance examiners talk to them pretty seriously about how secure is this debt. I went down with Mr. Spater in 1968 and talked to the Chairman of the Board of one of the very large insurance companies and he said we're not going to loan you another cent until you get your current obligation to us down by 33%. That's about $65 million and it's going to be 1980 before we get it that far down on the current repayment schedule.

Q. You defined the fixed charges there as interest and amortization of debt?

A. Yes that's correct. Interest and amortization of the debt and scheduled debt/repayments.

Q. Don, this thing includes rentals?

A. And it does include rentals, yes.

Q. Moreover the ICC has a less onerous test?

A. The ICC has a less onerous test. Under the New York State Insurance Law airlines must include full lease payments whereas the railroads need only include the imputed interest cost portion of lease payments.

Q. Your answer to a question previously asked about oil company money would be that the insurance companies possibly have something better to do with their money?

A. Loan to other people?

Q. Yes.

A. That's what they have been doing to a very large extent. You can sometimes intrigue them with some of the high coupon rates on the guaranteed lease certificates. We did get some insurance companies to participate at 10½% and 11% kinds of rates. Naturally, they like that, because they have the security of the aircraft and they've got the total guarantee of the whole corporation. That's a pretty good piece of paper. It's pretty hard to tempt them, as yet, with less security or with much lower interest rates.

Q. Why wouldn't that same rate attract other investors?

A. It did. For example, a number of pension funds participated in these guaranteed lease certificates from all over the country as did banks and private individuals.

Finally, in the spring of 1971 the airlines got a break. The big investment funds began to believe that 1972 and beyond were going to be very good airline earnings years and airline stocks shot up to double or a little more than double their recession lows. This enabled each of the big five carriers to do equity financing in fairly significant quantities, amounting to increases in shares outstanding ranging from 11% up to 15%. (Chart XIX) You could well see some more such financing. Continental has just completed one in July of 1972, a $27 million issue representing a 10% increase in their shares outstanding. There are other smaller carriers who could follow suit, but I don't think you'll see a lot more of it unless market conditions improve substantially from today's levels.

Q. What's the cost of that?

A. The cost of equity financing? Generally, you have to figure that equity financing in this industry costs you about 15%. It depends, of course, on what you think your cost of capital is and you base your calculations primarily on the expectations of the guy who invests and your historical growth in earnings per share than on anything else. It is expensive, but there comes a point after you've borrowed so much where you have to raise equity to get your balance sheet back in shape.

Q. You show that Continental on the previous chart has been eligible for insurance borrowing. Why did they let them do this instead?

A. Well, I'm not really sure. When they bought their DC-10's they went very heavily into a bank loan. This was in the fall of 1970. They had to get out of the banks, to whom they were further heavily commited, and find some means of lengthening their terms. Continental has a very high debt equity ratio. It may be because of their debt equity ratio that the insurance companies just didn't want to loan to them. They may have had to do something to their equity side to get their balance sheet looking better.

In summarizing then, in the 1967-1971 time period, for the first time since 1956, the industry failed to generate half of its commitments internally. (Chart XX) We only generated 48%. Debt increased by $3.3 billion and as I indicated, it was bank debt and subordinated convertible debt in large part. Leases for the first time became a major factor in the sourcing of funds, accounting for 16% of the total monies raised during that time period. In the latter years of this period half or more of the aircraft being delivered to the carriers were being leased, because that was the most efficient available kind of financing. Equity money, raised mainly in 1970, represented just under 10% of the money sourced. In all, we spent $11.9 billion. Dividends again dropped as a percentage, down to 3.6% of our fund usage, and of course all but a couple of carriers had suspended any dividend payments by the conclusion of this time period.

Looking now at the balance sheet at year-end 1971, (Chart XXI) working capital was $360 million, actually down in dollar terms from where it had been six years earlier. Operating property had quadrupled during the same period and other assets rose about two and half times. Debt had risen sharply to $5.2 billion from $1.9 billion six years earlier and represented 44% of total capitalization. For the first time leases suddenly emerged as a factor at $2.2 billion or 19%. They had only been $200 million six years before. Stockholder equity also rose, to

$3.3 billion from $1.7 billion, but you can see on the next chart the adverse change in the ratio of debt to equity. (Chart XXII)

The current ratio had fallen sharply to 1.18. You can live with this level, but it can't go much lower. The debt-equity ratio which had risen from 0.4 in 1954 to about 1.2 in the 1960's, has now jumped to 1.56 at the end of 1971. Including leases, the ratio was now up to 2.22. Stated another way, 70% of our total capitalization was debt and capitalized leases.

Now let's look at the future and oddly enough, George James forecasted capital requirements don't pose much of a problem in the 1972-1975 period.

Q. Can I interrupt. Your times interest coverage, was it 1.1?

A. Yes.

Q. That 10%, is that all you have to cover dividends and repayment of principle?

A. That's correct. I suspect we just lost another potential investor here.

Q. Your problem is bigger than I can handle.

On the balance sheet chart for the end of 1971 we saw that our total capitalization, excluding leases, was about $9.7 billion. Dr. James has forecasted for the 1971-1975 period that the commitments of the airlines will be about $7 billion. That produces a commitment to capitalization ratio that's totally different from anything we've been looking at. You will recall that these ratios for the previous time periods were: 1954-1959 - 2.8; 1960-1965 - 2.1; 1966-1971 - 2.8. In contrast commitments now are actually less than the capitalization of the airlines going into this 1972-1975 time period resulting in a ratio of only 0.7. There should be relatively no problem in sourcing these funds.

The next chart (Chart XXIII) is an American Airlines sources and uses of funds schedule. It shows you what a typical carrier like ourselves went through in 1971 and what we've been going through in 1972. In 1971, we spent about $250 million for aircraft, another $140 million for facility expenditures, a little bit for debt retirement and about $20 million for other uses, including dividends. Our sources included depreciation at a little over $100 million and deposits with manufacturers,which had been made previously and were applied at the time of delivery of the aircraft,of $45 million. That left us with a short-fall of some $300 million. To bridge this gap we used leasing heavily, principally the equipment trust certificates that I referred to earlier, and we began to use our revolving credit in 1971 for the first time. We also did an $85 million equity issue. So, we were scrambling, we used leasing; we used revolving bank credit; we used equity financing; we used everything we could find to lay our hands on in 1971. And we met this total commitment of about $450 million.

In 1972 American Airlines still has very heavy commitments, about $430 million in all. Some 19 DC-10's are being delivered to us in 1972. That means we have aircraft financing requirements alone of $350 million this year. In the facilities area we appear to be over the hump, as is the industry generally, I think. The big facility expenditures you saw in the 1969-1971 period are a thing of the past, at least for this equipment cycle. For American they should now run somewhere in the neighborhood of $30 million on a continuing basis for several years. Finally, we have debt retirement of about $30 million. On the sources side of the ledger, depreciation will provide about $110 million and deposits another $140 million because we're taking delivery of so many aircraft. This leaves us with a gap to fill which will be met primarily through leasing and, hopefully, some profits. We also, of course, have substantial unused revolving credit. We will use that, of course, to fill the portion of this gap that is not filled by other means.

Now, look what happens to our capital requirements in 1973. No aircraft are on order for 1973 delivery. The same is true for 1974, and at the moment, at least, for 1975. So there are no aircraft commitments to fund. The ground facility expenditures should average only about $30 million. Finally, there are debt retirements of about $30 million which brings us up to a total of about $60 odd million funds required for the year 1973. On the source side, our depreciation will be $125 million and normally we have about $30 million in other odds and ends. We have then about $150 million of sources, plus an opportunity to earn money above that. There should, therefore, be a substantial positive cash flow for the airlines in the 1973-1975 time period. This is the first time that there has been more than one year of a positive cash flow for the airlines in the post-war period. It says we have no new financing problems until 1975.

If you add the anticipated cash sources and uses over the next four years to the industry's 1971 balance sheet, you derive the 1975 balance sheet for the airline industry, shown on Chart XXIV. For this purpose we have assumed working capital will be unchanged. In the area of operating property, we have added the aircraft deliveries forcasted by Dr. James. Other assets have been increased nominally. On the liability side the industry's positive cash flow should reduce debt by $700,000. We have assumed that about 30% of the new deliveries will be leased, so lease commitments go up from $2.2 to $2.7 billion. Deferred credits also go up, leaving stockholder equity to rise by 50%.

This 1975 balance sheet looks a lot healthier than the current one. The debt-equity ratio, excluding capitalized leases, is 0.9. In other words, the industry should have more equity than debt for the first time in a long, long time. Even if you include capitalized leases, the debt equity ratio is only 1.4, which is quite a tolerable level. In deriving this 1975 picture we have assumed that earnings recover steadily in 1972 and beyond, but that they don't recover all the way to the 12% rate of return by any means. We have assumed that the industry will resume paying dividends in 1973, with about a 1/3 payout of earnings after taxes. Finally, we have assumed that those convertible issues which are callable reasonably near their current stock market prices will be called during this time period.

Q. What happens to your times interest ratio now?

A. I didn't calculate it, but we improve markedly from today's levels.

Q. Back up to the 13 level?

A. Oh no. We would be back to a point where we qualify for insurance test purposes. I think it would get back into the 3-5 range.

Q. If all the airlines had a moratorium, no new equipment for five or six years, and if there was a traffic buildup, could you sort of have a guaranteed recovery?

A. We have the cash position for that to happen, but the earnings would be the question mark. We have assumed a fairly good level of earnings in this analysis. Realization of those earnings depends on how we meet our growth. If it is done through high load factor, yes we ought to have the recovery.

Let's turn now to my last slide. (Chart XXV) Until yesterday I thought that

Dr. James was going to forecast commiments of $13 billion in the last half of the decade, but he has come up with a figure of $20 billion. One must put that $20 billion in perspective to understand the challenge that it creates for the airline industry. At the end of 1975, on the balance sheet we just looked at, the capitalization of the airlines should be about $11 billion. The $20 billion commitment versus the $11 billion capitalization results in a ratio of 1.8. Remember we have lived with ratios of 2.8, 2.1 and 2.8 in the past. That should indicate that we ought to be able to live with something less than 2.

Nonetheless, there are problems. First, it is questionable whether the insurance companies will provide a major source of long-term funds. Second, the industry has existing bank credits of about a billion dollars which, I doubt, will be expanded very much. Third, I believe we will lease something like 30% of our new aircraft, but probably not much more than 30% can be leased because of covenant restrictions. Leasing also becomes quite expensive unless we continue to have investment tax credits. Convertible debt is a possibility, but its availability depends upon the stock market price. We will have a flow of $7 billion from depreciation in the 1976-1980 time period, but relative to the forecasted $20 billion commitment this would represent a minor contribution. We have never fallen significantly short of financing about half of our commitments from internal sources, i.e., depreciation plus earnings. In order to maintain that record the industry needs to earn about $3 billion in this five year time period. That is equal to $600 million per year after tax on average. Earnings then are the key to whether or not we can meet this kind of a commitment without ruining ourselves in the process.

Q. Will you repeat that last statement?

A. In the past, I said, we have generated approximately half or more than half of our fixed commitments from internally generated funds. In the latter half of the 1970's we will have $7 billion in depreciation, compared to the $20 billion commitment. So to close the gap, we need another $3 billion to total $10 billion or 50%. That $3 billion has to be earnings. If you divide that by five, you get $600 million per year after tax.

Q. What's the total cash flow?

A. Today, for the industry depreciation is running about $875 million per year. Earnings, according to Mr. Secor Browne, should be in the neighborhood of $250 million this year for the airlines.

BASIC CHARACTERISTICS OF THE AIRLINE INDUSTRY

1. SUSCEPTIBLE TO BUSINESS CYCLE.
2. SERVICE INDUSTRY.
3. CLOSELY GOVERNMENT REGULATED.
   (ROUTES, RATES, SAFETY)
4. HIGHLY COMPETITIVE.
5. HIGH GROWTH.
6. RAPID TECHNOLOGICAL CHANGE.
7. CAPITAL HUNGRY.
8. HIGHLY SEASONAL.

CHART I

CHART II

SEASON I
THE EQUITY PERIOD
UP TO 12/31/54

BALANCE SHEET
MAJOR U. S. AIRLINES
YEAR END 1954

($ millions)

Working Capital	$128	
Operating Property	581	
Other Assets	71	
		% of Capitalization
Debt	$214	27.4%
Deferred Credits	15	1.9
Stockholders' Equity	551	70.7

CHART III

KEY FINANCING RATIOS
MAJOR U. S. AIRLINES

	1954
Current Ratio	1.39
Debt/Equity	.39
Debt/Equity (incl. Leases)	.39
Times Interest Coverage	13.3

CHART IV

AIRCRAFT COMMITMENTS
MAJOR U.S. AIRLINES

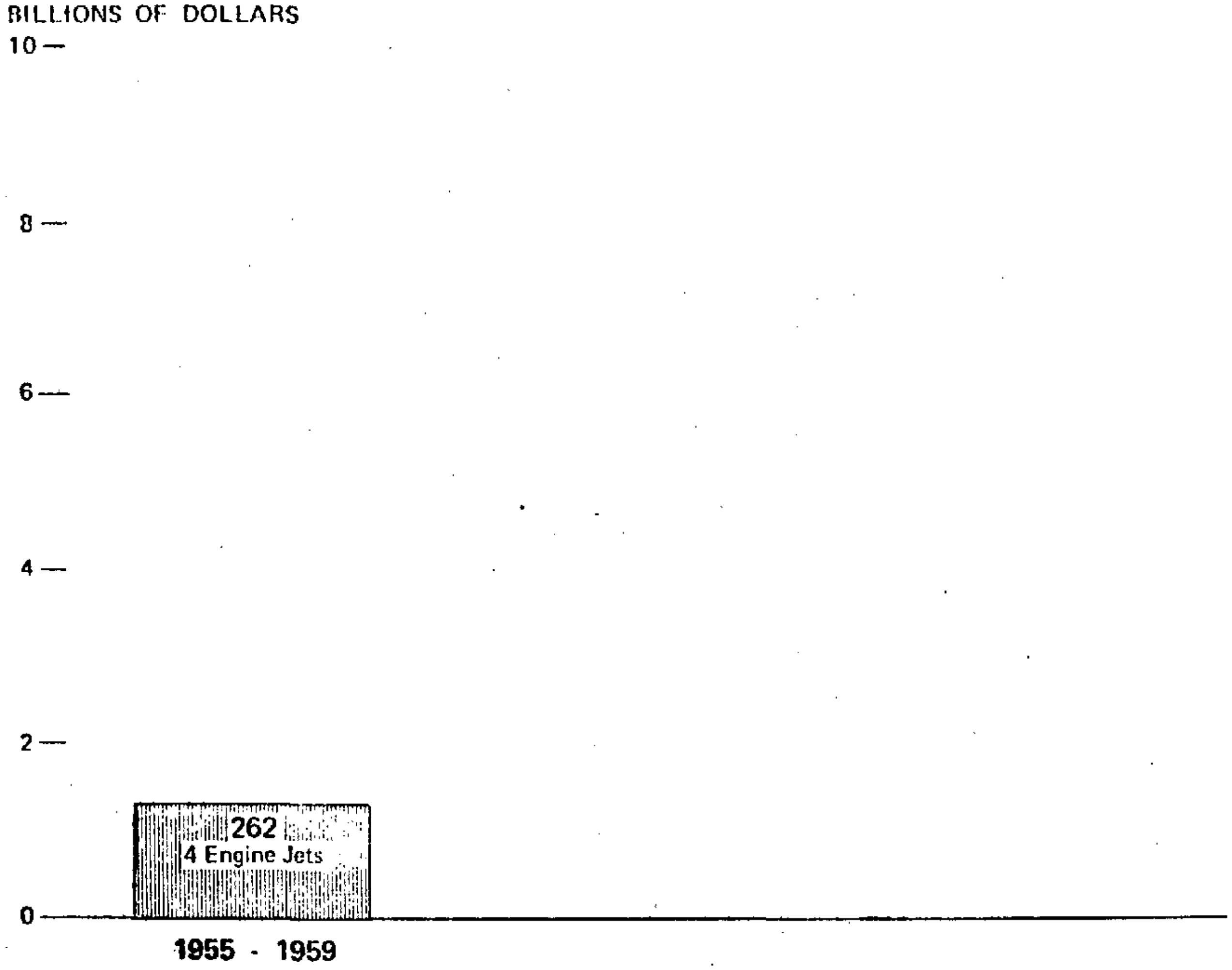

CHART V

SEASON II
THE INSURANCE CO. PERIOD
1955 - 1959

SOURCES & USES OF FUNDS
MAJOR U. S. AIRLINES
1955-1959
($ millions)

Sources		% of Total
Internal	$1305	55.0%
Debt	841	35.4
Leases	42	1.8
Equity	186	7.8
Uses		
Capital Expenditures	$2212	93.2%
Dividends	162	6.8

CHART VI

BALANCE SHEET
MAJOR U. S. AIRLINES
YEAR END 1959
($ millions)

		% of Capitalization
Working Capital	$ 188	
Operating Property	1562	
Other Assets	309	
Debt	$1055	51.2%
Deferred Credits	124	6.0
Stockholders' Equity	880	42.8

KEY FINANCING RATIOS
MAJOR U. S. AIRLINES

	1954	1959
Current Ratio	1.39	1.33
Debt/Equity	.39	1.20
Debt/Equity (incl. Leases)	.39	1.25
Times Interest Coverage	13.3	3.1

AIRCRAFT COMMITMENTS
MAJOR U.S. AIRLINES

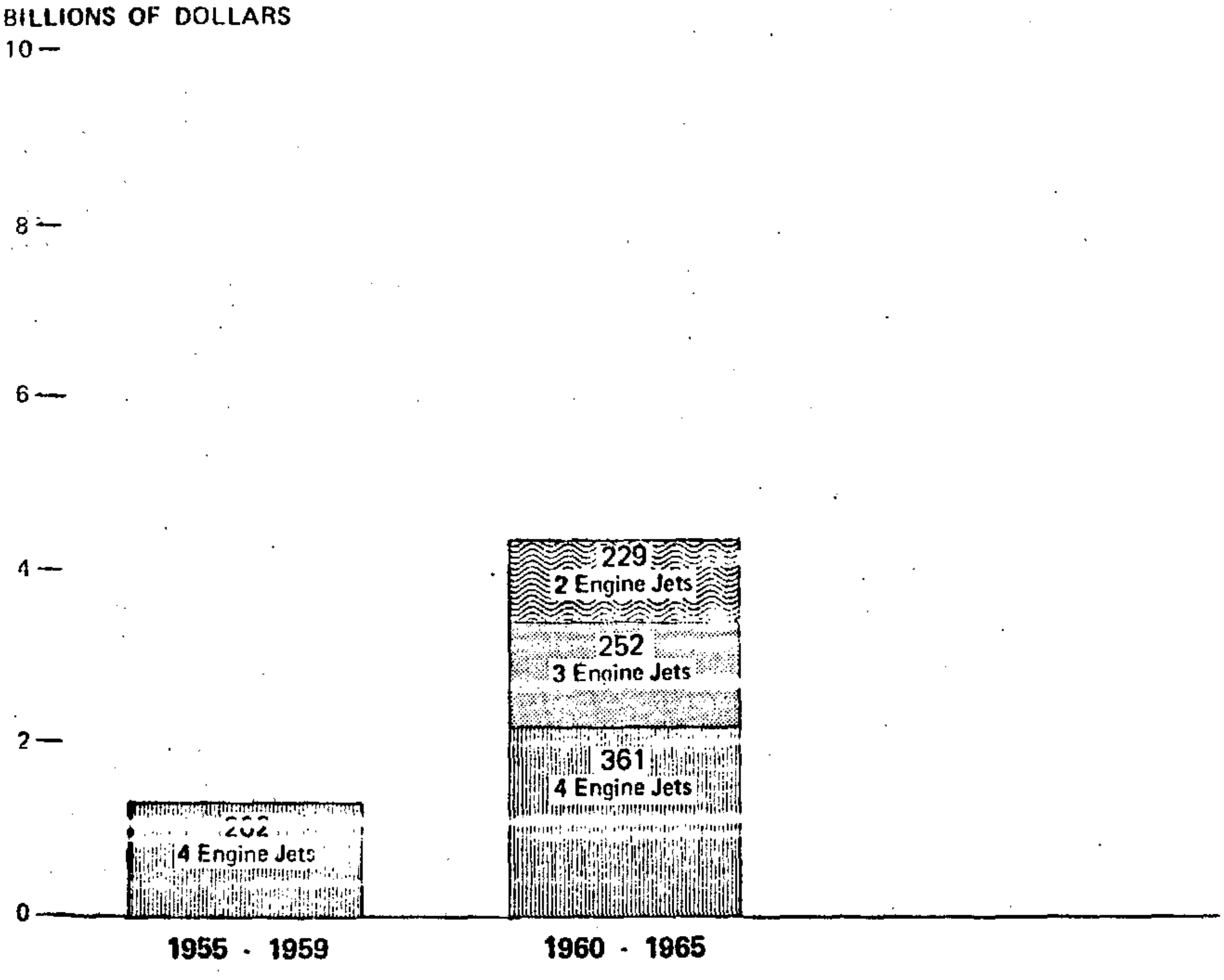

CHART IX

SEASON III
INTERNALLY FINANCED GROWTH

SOURCES & USES OF FUNDS
MAJOR U. S. AIRLINES
1960-1965

($ millions)

Sources		% of Total
Internal	$3174	70.6%
Debt	854	19.0
Leases	175	3.9
Equity	290	6.5
Uses		
Capital Expenditures	$4260	94.8%
Dividends	233	5.2

CHART X

BALANCE SHEET[1]
MAJOR U. S. AIRLINES
YEAR END 1965

($ millions)

Working Capital	$ 378	
Operating Property	3352	
Other Assets	488	
		% of Capitalization
Debt	$1908	45.2%
Leases	218	5.2
Deferred Credits	431	10.2
Stockholders' Equity	1661	39.4

[1] includes capitalized leases for aircraft

KEY FINANCING RATIOS
MAJOR U. S. AIRLINES

	1954	1959	1965
Current Ratio	1.39	1.33	1.39
Debt/Equity	.39	1.20	1.15
Debt/Equity (incl. Leases)	.39	1.25	1.28
Times Interest Coverage	13.3	3.1	6.6

AIRCRAFT COMMITMENTS
MAJOR U.S. AIRLINES

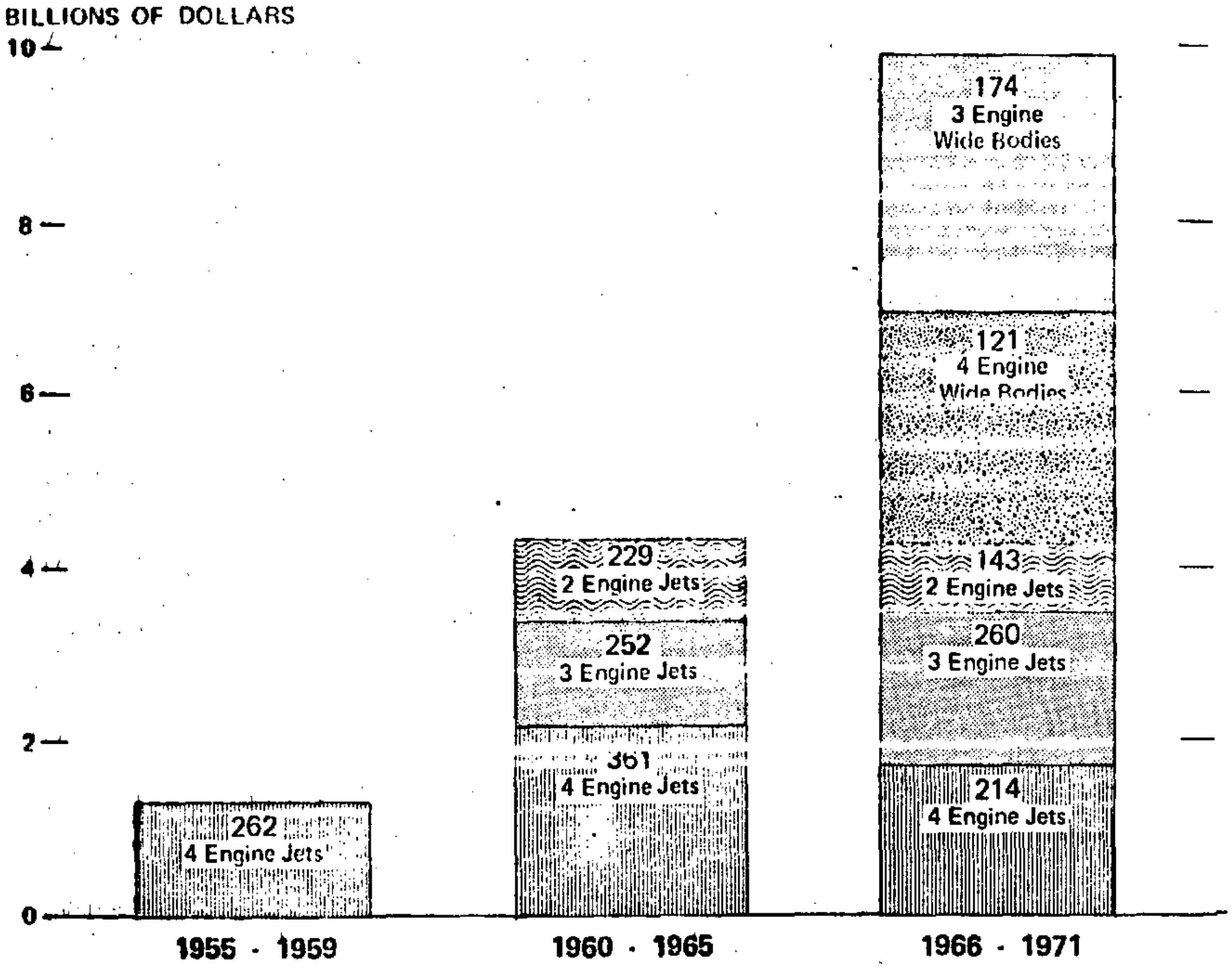

CHART XIII

SEASON IV
GET IT WHERE YOU CAN

THE SECOND HALF OF THE DECADE

MOST FINANCING SOURCES DRIED UP OR BECAME VERY EXPENSIVE

- INTEREST RATES RISING
- INSURANCE COMPANIES NOT WILLING TO INCREASE LENDING
- PROSPECTIVE EQUITY INVESTORS SEEKING HIGHER DIVIDEND YIELDS
- AIRLINE EQUITY MARKET ANTICIPATING DECLINING EARNINGS

BUT CONSIDERABLE EXTERNAL FINANCING WAS NECESSARY TO MEET THE COMMITMENTS FOR NEW AIRCRAFT. MORE EXPENSIVE SOURCES OF FINANCING HAD TO BE TAPPED

a. SUBORDINATED CONVERTIBLE DEBENTURES

b. BANK CREDITS

c. LEASING

CHART XIV

MAJOR U. S. AIRLINES
SOURCE OF LONG TERM DEBT
INSURANCE COMPANIES

($ millions)

Total Long Term Debt at Year End 1959	$1,055
Debt Held by Insurance Companies	706
Insurance Debt as % of Total	66.9%
Total Long Term Debt at Year End 1968	$4,592
Debt Held by Insurance Companies	1,713
Insurance Debt as % of Total	37.3%
% of New Debt Financed By Insurance Companies	28.5%

Representative Companies	% of 1968 Insurance Total
Metropolitan	30.1%
Prudential	21.2
Equitable	12.7
John Hancock	5.3
Aetna	5.0
Mutual Life of New York	3.5
Connecticut General	3.3
Others	18.9

MAJOR U. S. AIRLINES
CONVERTIBLE DEBT FINANCING
PUBLICLY ISSUED

($ millions)

	Amount	Average Interest Rate	% Outstanding At Year End 1971
1959	$ 47	4.9%	8.5%
1961	10	6.0	0
1964	60	4.5	41.7
1965	53	4.0	0
1966	382	5.0	77.5
1967	508	4.3	100.0
1968	80	4.9	100.0
1969	325	5.1	100.0
1970	80	8.0	0

CHART XVI

MAJOR U. S. AIRLINES
SOURCE OF LONG TERM DEBT
BANKS

($ millions)

Total Long Term Debt at Year End 1964	$1,689
Debt Held by Banks	291
Bank Debt as % of Total	17.2%
Total Long Term Debt at Year End 1971	$5,194
Debt Held by Banks	1,256
Bank Debt as % of Total	24.2%
% of New Debt Financed by Banks	27.5%

Revolving Credit Agreements
At Year End 1971

Available Credit Authorized	$2,120
Amount Borrowed	908

MAJOR U. S. AIRLINES
GUARANTEED LOAN CERTIFICATES
($ millions)

	Amount	Average Coupon Interest Rate
1969	$ 70	10.0%
1970	248	11.1
1971	103	10.7

CHART XVIII

MAJOR U. S. AIRLINES
COVERAGE OF FIXED CHARGES

	1969	1970	1971
American	1.55	$\boxed{.68}$	$\boxed{1.02}$
Eastern	$\boxed{.96}$	$\boxed{1.07}$	$\boxed{1.06}$
Pan Am	$\boxed{.38}$	$\boxed{.33}$	$\boxed{.49}$
TWA	$\boxed{1.17}$	$\boxed{.26}$	$\boxed{1.01}$
United	1.88	$\boxed{.58}$	$\boxed{1.01}$
Braniff	$\boxed{1.25}$	$\boxed{.90}$	$\boxed{1.32}$
Continental	$\boxed{1.27}$	$\boxed{1.24}$	1.56
Delta	3.87	3.26	2.97
National	3.09	*	1.77
Northwest	6.51	3.13	*
Western	*	$\boxed{.93}$	$\boxed{1.46}$

☐ does not meet requirement of N. Y. State Insurance Law for coverage by 1.5 times.

* not representative because of strike.

MAJOR U. S. AIRLINES
RECENT EQUITY FINANCING
($ millions)

	Company	Amount	Increase in Shares Outstanding
April 1971	Pan Am	$ 67.0	11.2%
May 1971	United	88.8	13.6
June 1971	American	89.9	15.7
July 1971	TWA	37.9	14.2
May 1972	Eastern	54.3	11.7
July 1972	Continental	27.0	10.6
	TOTAL	$364.9	

CHART XX

SOURCES & USES OF FUNDS
MAJOR U. S. AIRLINES
1966-1971

($ millions)

Sources		% of Total
Internal	$ 5929	47.9%
Debt	3322	26.8
Leases	2001	16.2
Equity	1132	9.1
Uses		
Capital Expenditures	$11934	96.4%
Dividends	450	3.6

CHART XXI

BALANCE SHEET[1/]
MAJOR U. S. AIRLINES
YEAR END 1971
($ millions)

Working Capital	$ 363
Operating Property	10147
Other Assets	1360

		% of Capitalization
Debt	$ 5230	44.1%
Leases	2219	18.7
Deferred Credits	1064	9.0
Stockholders' Equity	3357	28.2

[1/] includes capitalized leases for aircraft

KEY FINANCING RATIOS
MAJOR U. S. AIRLINES

	1954	1959	1965	1971
Current Ratio	1.39	1.33	1.39	1.18
Debt/Equity	.39	1.20	1.15	1.56
Debt/Equity (incl. Leases)	.39	1.25	1.28	2.22
Times Interest Coverage	13.3	3.1	6.6	1.1

SOURCES AND USES OF FUNDS
AMERICAN AIRLINES, INC.
1971 - 1973

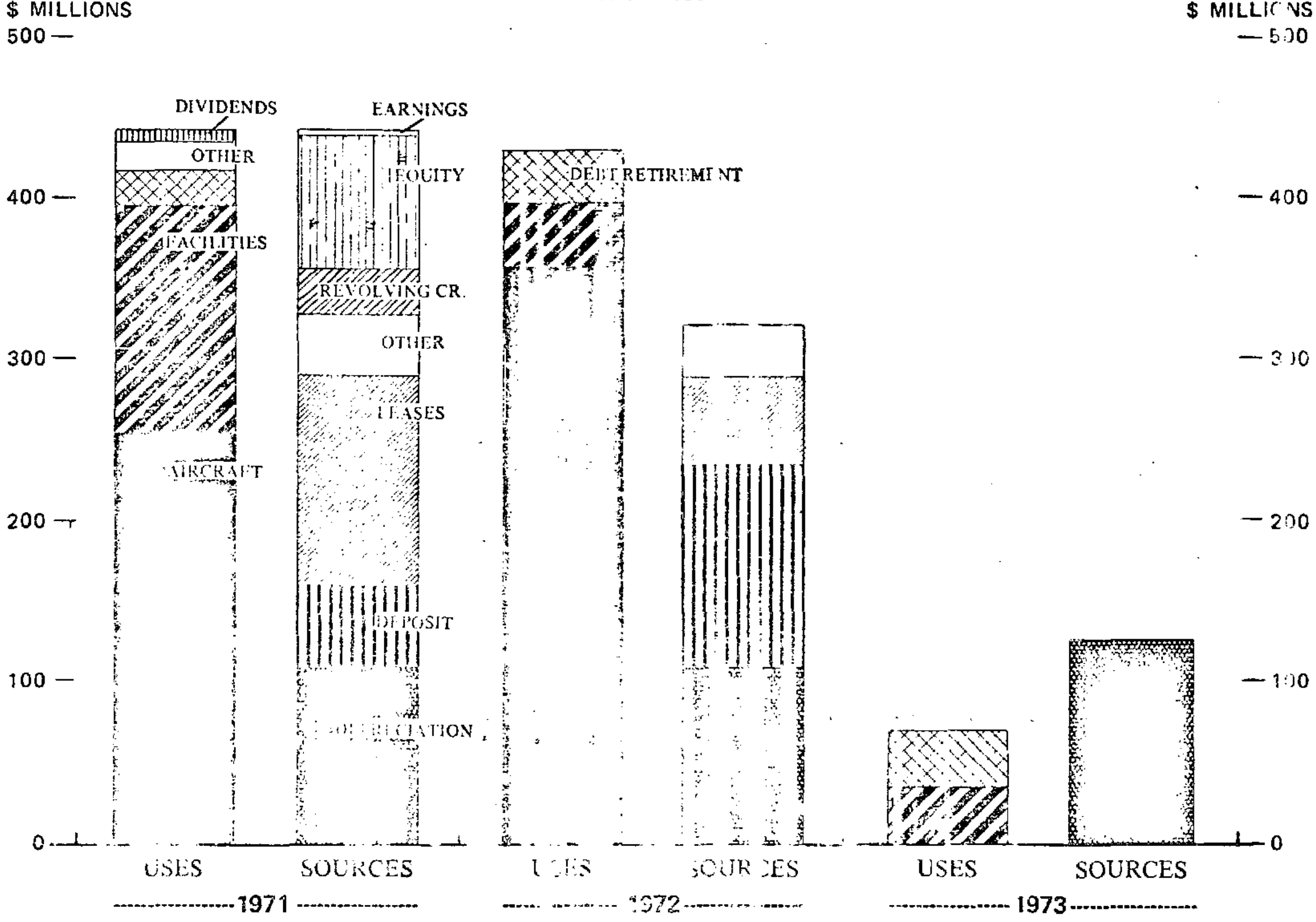

CHART XXIII

CHART XXIV

MAJOR U. S. AIRLINES
COMPARATIVE BALANCE SHEET
ESTIMATED 1975 vs. 1971
($ billions)

	1971	1975
Working Capital	$ .4	$ .4
Operating Property	10.1	11.6
Other Assets	1.4	1.7
Debt	$ 5.2	$ 4.5
Leases	2.2	2.7
Deferred Credits	1.1	1.4
Stockholders' Equity	3.4	5.1
Key Ratios		
Current Ratio	1.18	1.15
Debt/Equity	1.56	.89
Debt/Equity (incl Leases)	2.22	1.41

Basic Assumptions

- Earnings recover, but below 12% return
- Dividends resumed at 1/3 payout
- Convertibles called as equity prices improve
- Capital commitments at $6 billion

CHART XXV

THE SECOND HALF OF THE DECADE
($ billions)

Commitments	
1976 - 1980	$20
Sources of Funds	
Debt	
Insurance Companies	Nominal
Banks-Existing Credit	$1
Leasing	Limited & Expensive
Convertible Debt	Dilution
Depreciation	$7
Earnings	?
Equity	Dependent Upon Earnings
New Alternatives	?

THE ROLE OF THE EXPORT-IMPORT BANK IN DEVELOPING THE EXPORT POTENTIAL OF AIRCRAFT SALES

by Chosei Kuge
Export-Import Bank of the U.S.

July 20, 1972

Abstract

A description of the current patterns, terms, and conditions of Eximbank commercial jet aircraft export financing will be given. As time permits, some discussion of the factors affecting export financing will be noted.

Let me make a few basic observations. Number one, Eximbank is a US Government agency. Number two, its principle objective is to facilitate US exports; you can forget about the "Import" in our name. Number three, we are to supplement and not compete with private sources of financing. Number four, any loan that we make must have a reasonable assurance of repayment; in other words, we are supposed to act as a banker and not as an AID-type agency. To give you an idea of Eximbank's authorized size, we can have total outstanding loans, guarantees and insurance of up to \$20 billion. We have \$1 billion of outstanding capital stock held by the US Treasury Department and \$1.3 billion of reserves. We could borrow from the Treasury Department at any given time up to \$6 billion. As of June 30, 1971 we have total assets of \$5.8 billion. Substract \$2.3 billion net worth from that and our liabilities were about \$3½ billion. In fiscal year 1971 we earned close to \$120 million and paid a dividend to the Treasury Department of \$50 million. The balance of our earnings go into our reserve account.

Question: What kind of a return on investment is that?

Answer: The net income is about a 5% return on net worth.

Let me give you an idea of the amount of financing we have been doing for commercial aircraft. In 1957, we financed four aircraft worth about \$30 million and loaned 16½ million dollars to do that.

Over this period we have been involved in more and more transactions and the dollar volume has been going up. However, the amount of money we actually put up per transaction, on a percentage basis, has gone down. In other words we are utilizing more and more private financing in specific transactions.

On a $10 million transaction, a typical financing pattern would call for a cash payment from the buyer of 10-20%. The buyer raises the cash payment from non-US sources. The other 80-90% of contract price is the financed portion. Eximbank puts up one-half and the other one-half comes from private sources, either in the U.S. or from foreign sources. The repayment term on the financing would be 10 years for a new commercial jet aircraft or anywhere from 5-7 years for used commercial jet aircraft. The amount of cash payment varies somewhat depending on who the buyer is. If you're talking about the major European airlines, cash payment will be 20% or greater. If you're talking about a weaker buyer in Africa, Asia or Latin America, it would probably be closer to the 10% figure.

Question: You require a higher down payment from the Europeans—what's the theory behind that. Usually the better the credit is, the lower the down payment? They are the biggest customers of the US. It seems to me that we should try to figure out some way to encourage greater sales.
Answer: Eximbank has to balance various objectives of the US Government, including the encouragement of greater sales through lower cash payments versus balance of payment improvement through higher cash payments.

We don't require supplier participation any more as a general rule. Supplier participation being Boeing, McDonnell-Douglas, or Lockheed extending credit to the buyer. We used to, and will continue to in a certain number of transactions involving higher risk buyers. Our present interest rate is 6% per annum. We charge a commitment fee on our loans of 1/2 of 1% per annum. If we guarantee the private financing, as we do in many cases, we charge 1/2 of 1% guarantee fee. On loans to strong European buyers, we try to get as much of the private portion from off-shore as we can. In many cases the buyers are able to raise financing equal to 20-25% of total contract price from offshore sources.

Question: When you say 6% interest charge--is that your current rate?

Answer: That's our current rate.

Question: Can you tie that somehow to your own cost of funds?

Answer: Since 1945, Eximbank's lending rate has been consistently higher than its borrowing rate at the U. S. Treasury and has never been lower than the average rate on the total public debt. On a cumulative average, Eximbank's operations have never entailed a subsidy cost.

Question: Wouldn't it be difficult for Pan Am and TWA to compete with foreign airlines against this kind of loan?

Answer: What you've got to take into account is the fact this difference between 6% and whatever Pan Am has to pay for their borrowing is only one element of total cost. There are other national interest reasons why you would want to keep this rate at 6% and try to sell aircraft abroad. One basic reason is if we don't sell these aircraft abroad, our balance of payments and balance of trade are going to deteriorate and weaken the dollar in the world money markets. This could hurt Pan Am and TWA more than any 6% interest rate we charge the foreign airlines. In addition, this 6% only relates to possibly 40% of the transaction. The foreign buyer still has to pay a market rate on the other half of the financing. Also what you are talking about is 10 year Exim financing in contrast to Pan Am and TWA borrowing at 15-20 years.

Question: That could still be a huge difference though. If you're lending money at 6% to KLM and Pan Am has to pay 10% or 11% and the airlines have a huge part of their capital structure on debt, that's going to be a significant factor.

Answer: We have no reason to believe that Pan Am or any other major U. S. carrier is paying interest rates approaching 10% or 11% for their equipment purchases.

We have other programs to help finance U. S. exports, including guaranteeing aircraft leases. Many small aircraft are financed through our FCIA insurance and commercial bank guarantee programs described in our brochure. We have a cooperative financing facility and a discount loan facility through which many of the small to medium size transactions are handled on terms up to say five years. Follow-on spares and other airline equipment are financed through these programs. We also finance U. S. goods and services which go into the airport construction and facilities.

Over the ten years I have been working at the Bank, the programs, methods of financing and outlook of the bank have changed, and I believe that is going to be the case in the future. Thus, if you're interested in how Exim is going to change in the next 10 years in financing U. S. exports, you have to keep in mind such factors as balance of trade and balance of payments. When you see them getting bad, greater efforts will have to be made to encourage and increase U. S. exports. If we don't we are going to have to cut back on other things that we are doing abroad or limit imports. International political and economic developments will also affect U. S. export financing. Eximbank's life is extended every five years. Thus, Congressional support in the following years is essential.

Money market conditions, availability of funds, and interest rates are going to affect what Exim does. Some critics say Exim should not finance jet aircraft exports today because ample funds are available at this time from the U. S. commercial banking sector. They fail to consider that U. S. commercial banks have a liquidity situation, resulting in limited funds from this source on repayment terms exceeding 5-6 years. Today it is very difficult to find commercial financing for new jet commercial aircraft on anything like 7- or 10-year terms. On the other hand, the overseas buyer, as well as Boeing, McDonnell Douglas and Lockheed would like to see Eximbank start supporting terms up to 12 years.

Another factor is that Eximbank is a US Government agency subject to annual review of its operations by the Administration and Congress. Eximbank does not operate on annual appropriations, however, and pays all its expenses out of earnings.

Question: What kind of debt security do you take versus commercial banks?
Answer: In typical transactions, we get notes from the buyer. The commercial bank does exactly the same thing. The notes are usually guaranteed by financial institutions or governments. Mortgages are not required in most instances.

Question: Who has first rights to proceeds from foreclosure when mortgages are taken?
Answer: If the mortgages were required to secure all lenders on a pro-rata bases, then the proceeds would be distributed accordingly.

I should also mention that in a 10 year transaction, Exim is prepared to take the last 5 years maturities and allow a commercial bank to take the earlier maturities. In this way, we are able to meet the commercial bank's requirement for liquidity.

Question: Are these figures typical of all transactions or do you differentiate between aerospace and other products?
Answer: When we're talking in terms of large projects and products, the typical transaction would be a 10% cash payment and 90% financing

of which Eximbank's share would be one-half. As an exception, we have been able to get 20% cash payments from major European carriers for jet aircraft sales because of the competitive advantage of the US aircraft industry in recent years. In other transactions, the typical cash payment is 10%.

Question: Do you know what the Europeans are offering in Latin America?

Answer: Basically, it's 10% cash, 10 year repayment term with a subsidized interest rate. The BAC 111, Caravelle, and A-300B are all offered on those terms.

Question: Are the interest rates comparable?

Answer: The British interest rate is about 6½-7% to the borrower on the total financing. They will change theirs as time goes along. Eximbank charges 6% on one-half the financing, while the commercial banks usually charge the prime rate plus a mark-up on a fluctuating bases. At this time, the rates are probably reasonably competitive.

Question: You said you had a 6% interest rate, plus a ½% guarantee fee and another fee. Could you explain?

Answer: Eximbank charges a ½ of 1% per annum commitment fee on the amount of Eximbank's loan from 30 days after authorization until the loan funds are drawn down. The borrower pays a 6% interest rate on amounts which are drawn down. If Eximbank guarantees the private financing, the Eximbank guarantee fee of ½ of 1% per annum is charged on the private financing from dates of draw down until repayments are made.

Question: Could you comment on Russian YAK-40 financing rates being so low?

Answer: It really doesn't make any difference because the Russians can change the price of their product and the interest rate in any manner they want. Profit isn't their main consideration.

Question: Have European manufacturers offered concessionary terms?

Answer: In some instances in the past, British and French manufacturers have gotten soft loan assistance for their buyers. US AID funds have not been used to finance commercial jet aircraft sales.

I think the extent of non-US content in US commercial jet aircraft will require more and more attention. It's becoming more and more difficult to sell aircraft abroad without some non-US content. Also, the prospects of a major new commercial jet aircraft being manufactured with 100% US companies involved may be very difficult. Other factors requiring consideration are (1) the importance of the non-US market to any new aircraft project, (2) exporting US technology, (3) foreign competition and (4) development of foreign aerospace industries.

Question: When you have multi-national interest and foreign equipment, is the bank precluded from loans on the portion that's foreign?

Answer: As a basic policy, Eximbank finances goods and services of U. S. manufacture and source only. If the amount of foreign content is sizeable, it would be deducted from the contract price and all percentages applied to the net U. S.content.

Question: What effect will the proposed Civil Aviation Financing Plan have? Can that help finance aircraft for foreign airlines?

Answer: Dr. James could answer that question better than I, though it is my understanding that the intent of the legislation is to provide capital to make possible the manufacture of new aircraft and not to provide financing for the ultimate purchaser.

Question: Wouldn't a reduction in cash payments increase sales?

Answer: Possibly, but the question is whether a reduction in the cash payment would increase U. S. exports sufficiently to make an appreciable difference and will increased sales be offset by the reduction in balance of payments from reduced cash payments.

Question: How is the policy of the bank established?

Answer: Basic policy is established by Congress and is set forth in our legislation. To carry out that policy, we have a five-man board of directors appointed by the President with advice and consent of the Senate.

Question: Are you prepared to say that you look upon your activities as a benefit as opposed to whether you exist or whether you didn't exist. In other words, you stimulate sales by existing and if you didn't exist you wouldn't.

Answer: I believe the answer is affirmative. There are many cases where US manufacturers, US commercial bankers, and other financial institutions cannot afford to take the risk that's involved in foreign sales. The only source available in the US to take that risk is the US Government. It is a legitimate objective of the US Government to take such political and economic risks. All of the other countries around the world do the same thing. We're in a buyer's market today.

THE MARKET DEMAND FOR AIR TRANSPORTATION

Nawal Taneja
Flight Transportation Lab
M.I.T.

July 11, 1972

Abstract

Although the presentation will touch upon the areas of market for air transportation, the theoretical foundations of the demand function, the demand models, and model selection and evaluation, the emphasis of the presentation will be on a qualitative description of the factors affecting the demand for air transportation. The presentation will rely heavily on the results of market surveys carried out by the Port of New York Authority, the University of Michigan, and Census of Transportation.

The purpose of this paper is to present a basic analysis of the demand for air transportation. The presentation is divided into five areas: the market for air transportation, the factors affecting the demand for air transportation, the theoretical foundation of the demand function, air travel demand models, and model selection and evaluation.

The Market For Air Transportation

At the global level approximately 383 million passengers were carried on the scheduled domestic and international services of 120 airlines of the ICAO Contracting States during the year 1970. This includes the USSR traffic which accounted for almost 58 million passengers in 1970 and most of which was carried on the domestic routes. Of the total world traffic, 170 million passengers or 44.4 percent was carried by the airlines of the United States. Reliable statistics are not available for total world non-scheduled traffic, a bulk of which is generated in Europe and the United States.

The statistics taken from ICAO in Table 1 show the regional distribution of the total world traffic measured in percentage ton-km. performed on scheduled services. This table shows that almost 86% of the world air traffic was accounted for by North America and Europe (including the USSR).

Table 1

Regional Percentage Distribution of Total Ton-km Performed on Scheduled Airlines of ICAO States

1970

REGION	SERVICES		
	Domestic	International	All
North America[1]	62.9	33.2	51.1
Europe	28.8	44.1	34.9
East and South Asia and the Pacific[2]	5.6	11.2	7.8
South America	1.7	4.2	2.7
Africa	0.7	3.8	1.9
Middle East	0.3	3.5	1.6
Total ICAO World[3]	100	100	100

1. Includes Panama and all countries to the north as well as the Caribbean States and territories.

2. Including New Zealand, Australia and neighboring islands.

3. Including USSR statistics for Aeroflot.

Source: ICAO Bulletin, May 1972

These two areas account for almost 30% of the world's population and almost 80% of the world's economic activity. If we measure economic activity by Gross National Product, then the United States accounts for roughly thirty percent of the total world's GNP and almost 45% of the world's air passenger traffic.

The North Atlantic market represents the largest international air traffic flow in the world, accounting for almost a quarter of the total international passengers. In 1970, approximately ten million passengers traveled on this route with roughly three-quarters of these using scheduled airlines. Roughly a third of the passengers using non-scheduled services were transported by the charter operations of the scheduled carriers.

From the statistics collected by the Civil Aeronautics Board on the passenger traffic carried on United States scheduled air system in 1970, 153 million or a little over 90 percent were carried in the domestic operations. Table 2 shows the percentage distribution of the revenue passenger originations by carrier group. Over 70% of the passengers were carried by the eleven domestic trunk carriers and over 46% were accounted for by the Big Four Carriers. The revenue passenger miles of the United States domestic air system represents less than ten percent of the total for all modes.

Table 2

U.S. Scheduled Air Passenger Traffic & Distribution

Carrier Group	Scheduled Service - 1970 Revenue Passenger Originations	
	Passengers (000)	Percent
Domestic Operations		
Trunks	122,866	72.4%
Local Service	26,472	15.6
Helicopter	573	0.3
Intra-Alaska	351	0.2
Intra-Hawaii	2,643	1.6
Other*	503	0.3
	153,408	90.4%
International and Territorial Operations	16,260	9.6%
Total	169,668	100.0%

* Alaska, Aspen, Tag.

Source: CAB Handbook of Airline Statistics, 1971 Edition, Tables 46 and 47.

Although private automobile accounts for almost 85 percent of intercity passenger traffic in terms of passenger miles, the air carriers are the largest form of common carrier transportation.

For passenger travel on the scheduled domestic air system, the 1970 CAB data shows that 42.8 percent of the passengers traveled a distance less than 499 miles while 99.0 percent of the passengers' trip length was 2749 miles or less. The reader is cautioned that these statistics do not include traffic data for the intra-state carriers. These statistics would change significantly if we were including PSA's traffic on the Los Angeles - San Francisco market, the world's largest passenger market.

The distribution of domestic scheduled air passenger traffic is shown in Table 3 for 1970. The top 100 city-pairs account for 33.4 percent of the total traffic while the top 1000 city-pairs accounts for 72.9 percent of the traffic. According to the CAB data, New York - Boston ranks as number one city-pair with a little over two million passengers in 1970. If we include intra-state operations, then a DOT[1] Study, based on a ten percent sample similiar to the CAB data, indicates that a total of 5.3 million passengers travelled on the Los Angeles - San Francisco route.

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[1] Statistical Compilation of Airline Passenger Markets. Domestic FY 1972. U.S. Department of Transportation. November, 1971. Page 10.

TABLE 3

U.S. Scheduled Domestic Air Passengers

Cumulative Distribution Among City-Pairs

1970

Number of Top City - Pairs In Order of Passengers Rank	Cumulative Percent
1	1.9
10	11.1
50	24.6
100	33.4
200	44.2
500	60.4
1000	72.9
ALL	100.0

Source: CAB's Handbook of Airline Statistics. 1971 Edition

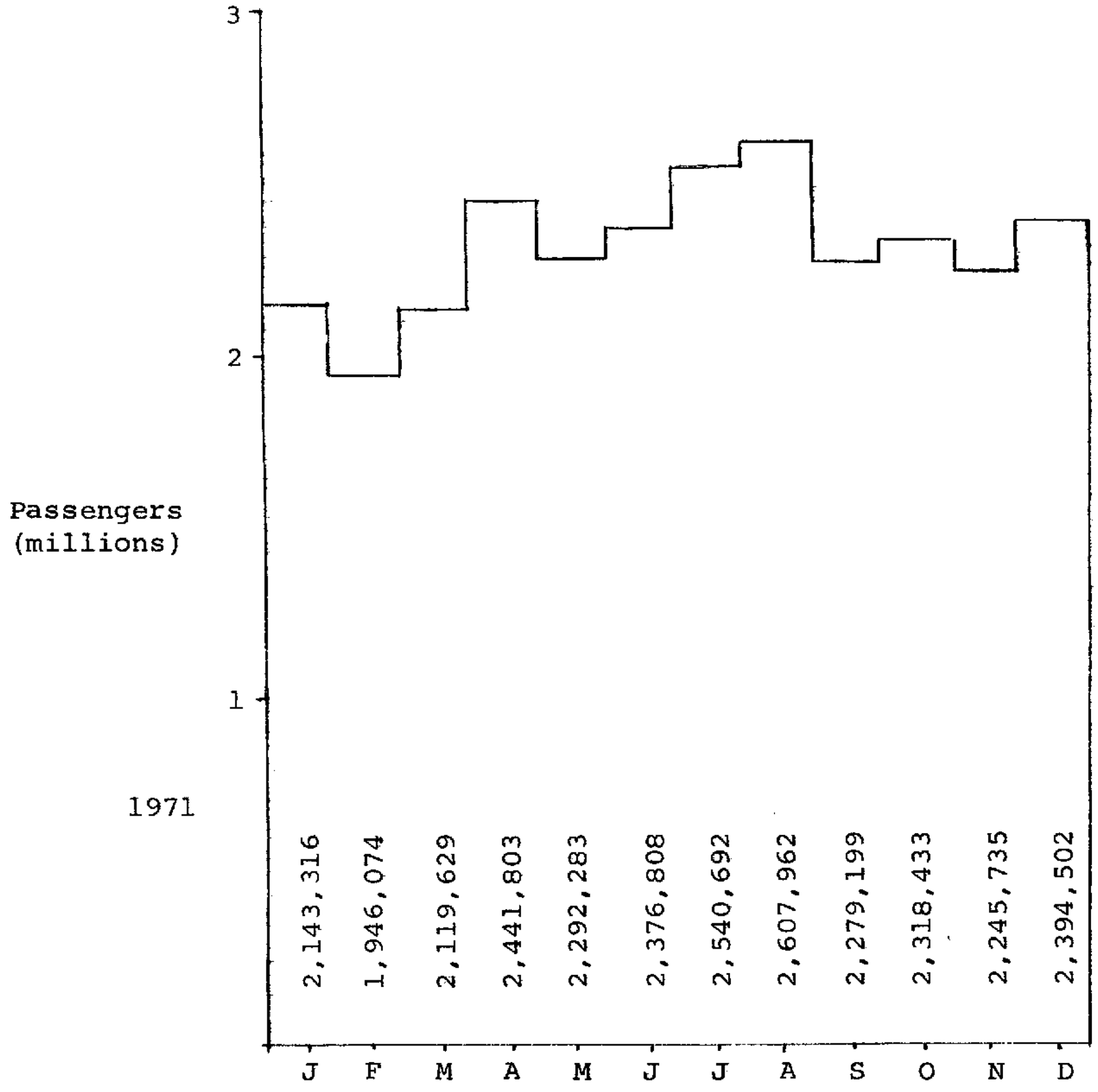
The seasonality of air travel is a very important characteristic. Figures 1 and 2 show the monthly seasonality of the traffic moving through New York. The months of July and August represent peaks for both domestic and overseas travel. The effect of seasonality is more pronounced if we analyze an individual market. Figure 3 shows that on the North Atlantic, the eastbound traffic was almost four and a half times greater in July than in February. Air travel even changes with the day of the week and hour of the day. The peaks in the hourly variation can be explained partially by the preference of the business traveler. The somewhat heavier demand on Thursday and Friday can be partially explained by the preference of the traveler on personal business or pleasure to travel at the end of the week. These demand patterns are seen in Figures 4 and 5.

Part of the seasonality pattern may be artificial. Orginally, excursion or discount fares were introduced by the carriers to shift demand from the peaks to the slack periods. However, the black out periods established to reduce peaking have created their own peaking problems.

Figure 1

Seasonality of Air Travel Demand

U.S. Domestic at New York



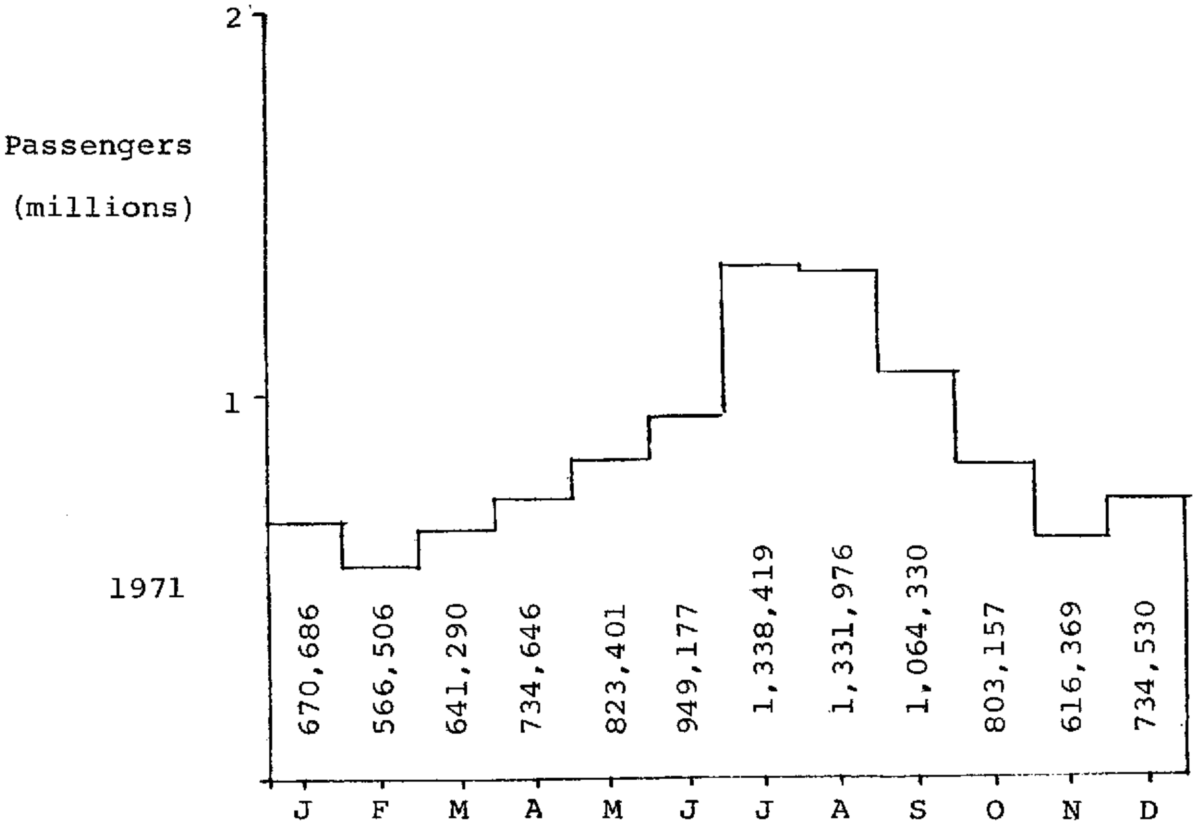
Total Domestic Passenger Revenue Traffic Handled by New York Airports - by Month

Source: PONYA, Monthly Airport Traffic, January-December 1971

Figure 2

Seasonality of Air Travel Demand

U.S. Overseas at New York

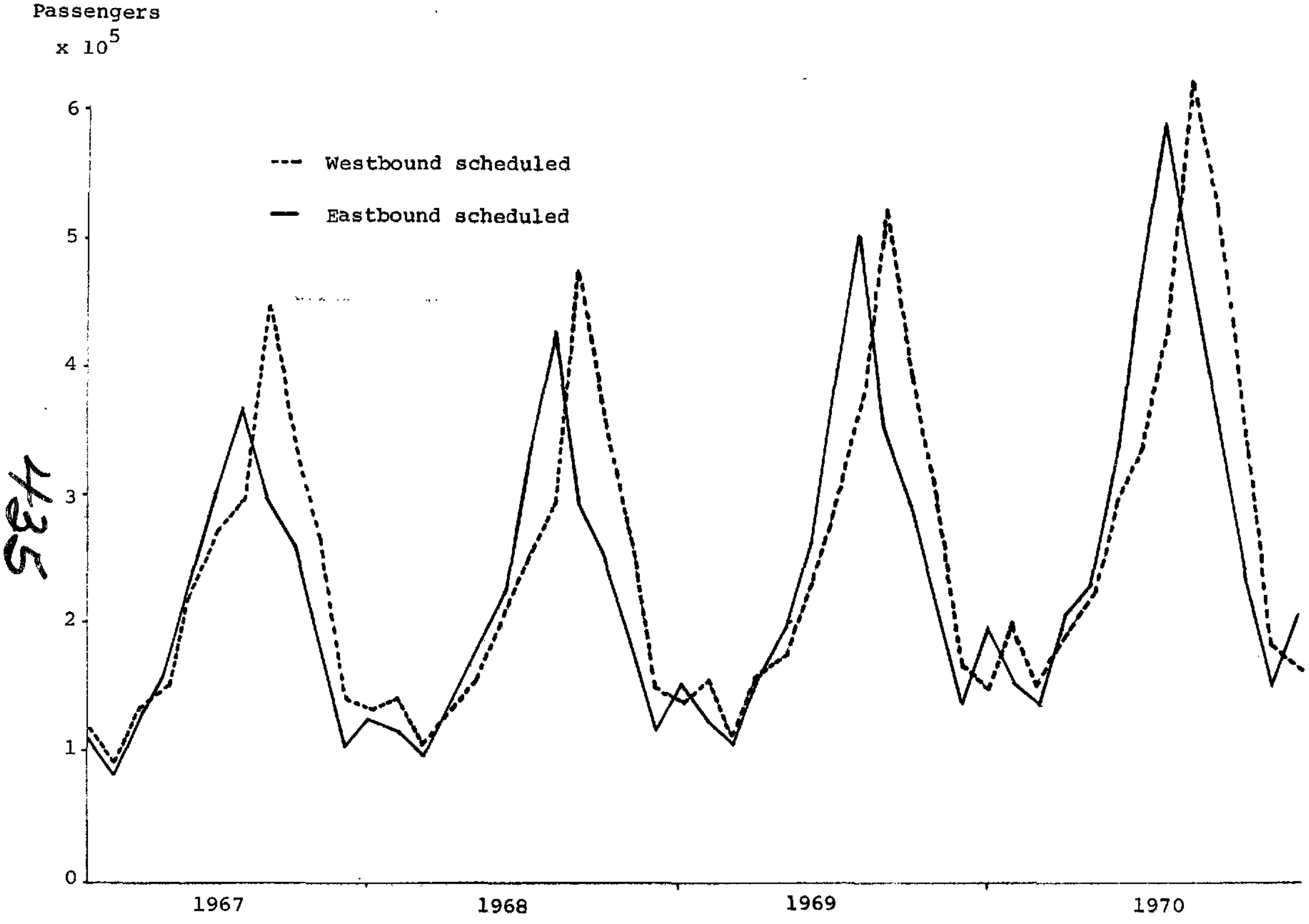


Total Overseas Passenger Revenue Traffic Handled by New York Airports - by Month

Source: PONYA, Monthly Airport Traffic, January-December 1971

Figure 3

Seasonality of the North Atlantic Traffic - by Month

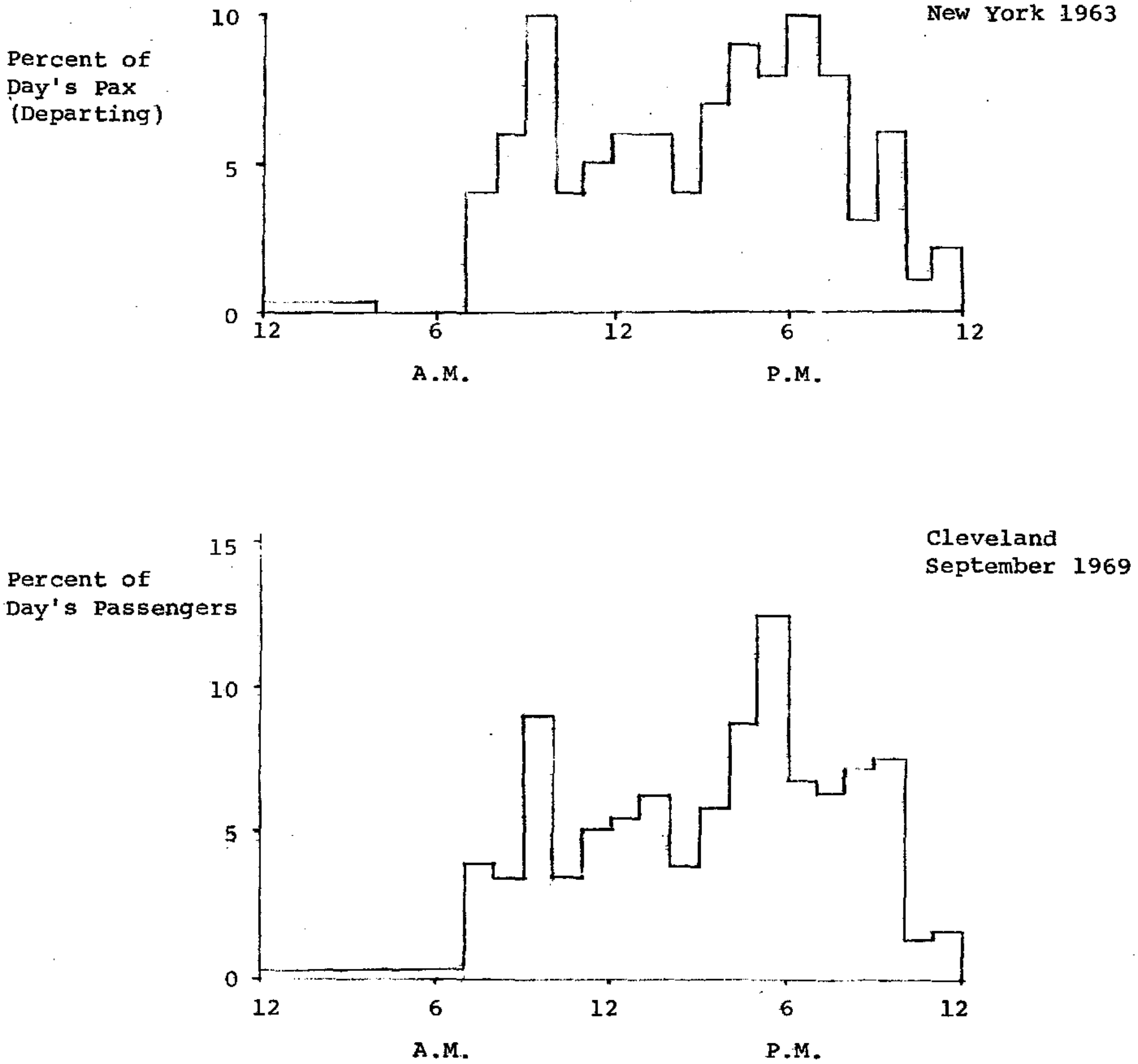


Source: IATA World Air Transport Statistics

Figure 4

Daily Air Travel Demand

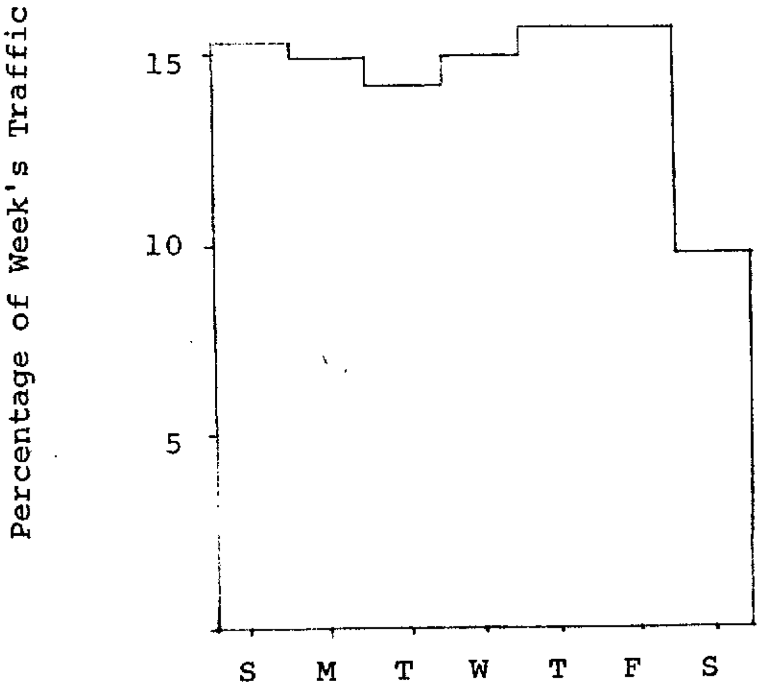
by Hour



Sources: New York's Domestic Air Passenger Market, PONYA May 1965
Cleveland-Hopkins Airport Access Study
Survey Results, Regional Planning Commission, Cleveland, Ohio
June 1970

Figure 5

Weekly Air Travel Demand
by Day



Source: Phase II Survey (September 8-14, 1969)
Cleveland-Hopkins Airport Access Study
Survey Results, June 1970 - Regional
Planning Commission - Cleveland, Ohio

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Factors Influencing The Demand For Air Travel

Factors affecting the air travel demand can be grouped into two broad categories: market related and trip related. The market related variables, also called the socio-economic variables, are those inherent to the general economic, geographic, social and political environment. This group can be further divided into characteristics related to the traveler (income, age, occupation, etc.) and demographic characteristics (population, industrial activity, tourism, etc.). The trip related variables, on the other hand, are those inherent to the transport mode, that is cost, travel time, comfort, safety and convenience. The demand for air travel is influenced by a complex interaction of one or more of these variables. This section contains a qualitative description of some of these factors.

The demand for air travel can be analyzed in two parts: personal travel and business travel. Table 4 shows the distribution of air travel by purpose of trip. In 1967, based on the survey carried out by the Census of Transportation, personal and business travel each accounted for about 50 percent of the air travel market.

Table 4

Percentage Distribution of Air Travel by Purpose of Trip (1967)

	person-trips	person-miles
business	45.8	40.8
conventions	5.5	6.5
visits to friends & relatives	23.9	26.0
outdoor recreation	2.4	2.5
entertainment	3.4	3.6
sightseeing	7.6	7.6
other pleasure	2.2	2.3
personal & family	9.1	10.7
	100%	100%

Source: 1967 Census of Transportation

Market Related Factors

Income: Air travel is strongly determined by income, personal income in the case of personal travel and national income in the case of business travel. The ability to pay however, has to be accompanied by the willingness or the desire to spend. The demand for air travel is unlikely to change, if for example, an increase in income is accompanied by an exact increase in savings. Table 5, taken from Port of New York Authority's survey data for 1967 shows that 94 percent of the passengers surveyed had an annual family income higher than $5000. The data implies that the higher the income, the higher the percentage of travel. A similar survey carried out by the University of Michigan in 1962 showed that in a sample of 5093 respondents, 28 percent of the respondents had family income less than $4000 and accounted for 6 percent of the airtrips, while 17 percent of the respondents with family income of $10,000 and above accounted for 60 percent of the air travel.

There are at least three forms of per capita income that can be used to explain the demand for air travel: national income is equal to domestic product at factor cost plus net factor income from abroad; disposable income is defined as personal income less taxes; discretionary income is that portion of disposable income in excess of the amount necessary to maintain a defined or historical standard of living.

Table 5

Average Family Income of New York's Domestic Air Passenger Market

Family Income	Percent of the Survey Population 1956	1963	1967
Under $5,000	12%	6%	6%
$5,000 - $9,999	32	19	16
$10,000 - $14,999	21	25	21
$15,000 - $19,999	10	16	17
$20,000 and over	25	34	40
(Median)	$11,400	$15,000	$17,000

Source: Port of New York Authority Reference 2.

This last type of income may be saved or spent with no immediate impairment of living standards. Thus, it would appear that discretionary income would be a better and more consistent predictor of air travel growth than either disposable or national income. However, most studies employ disposable income for the following reasons:

1. unavailability of consistent data for discretionary income.
2. difficulty of quantification of discretionary income.
3. subjective definitions as to the size of discretionary income.

Although data on disposable income per capita for the United States is readily available, similar and consistent data for other countries is not available. For international travel, one can use the data on national income which is published by the United Nations in consistent form for many countries including the United States.

Various studies have shown that a factor which is even more important than the level of personal income is the distribution of family income. Some analysts prefer to use the distribution of family income above a certain base level to explain the demand for air travel. Asher[3] uses a base of $7,500 for international travel; in other words, the traveler's annual income is greater than or equal to $7,500 and the greater the income (above $7,500) the greater the chances of his taking the trip. The use of such a districution should be viewed with caution since:

1. The base level is a subjective measure and analysts differ in their views of its numerical value. Furthermore, the level would vary by geographic region.
2. The data is very sketchy on the distribution of income in the United States and almost non-existent for some of the foreign countries.
3. The variation in the income distribution is fairly difficult to forecast accurately.

It has been shown previously that the level of income is an explanatory variable which partially explains the pleasure demand for air travel. While higher income families are more likely to travel, it is not income alone that influences them to travel. Now, we will introduce other variables related to income which also influence the pleasure travel demand. Given the relationship between income and the demand for air travel, the relationship between occupation, education, social status, etc., is fairly easy to predict. Travelers in the higher status occupations are usually educated to a higher level, belong to a higher social class and earn a higher income.

Table 6 shows the relationship between occupation and air travel. In 1967, the survey of the pleasure air travelers in New York shows that 19 percent were in the professional and technical category.

Table 6

Occupation By Broad Purpose of Trip

New York's Domestic Air Passenger Market

1967

Occupation	Personal			
	Visiting Friends or Relatives	Sightseeing or Visiting Resort	Other	Total
Technical, Professional	21	20	10	19
Manager, Official	14	17	6	12
Salesman	3	4	1	3
Secretary, Clerk	11	12	3	9
Mechanic, Craftsman, Factory Worker	4	4	2	3
Armed Forces	2	1	24	7
Housewife	22	23	19	21
Student	17	12	32	20
Retired	5	5	2	4
Other	1	2	1	2

Source: Port of New York Authority. Reference 2.

Further, the 1967 Travel Survey shows that for 56 percent of the trips taken, the occupation of the household head was either professional or managerial. The category of factory workers and service workers accounted for only 3% of the sample population.

The level of education attained has a high correlation with income, occupation, social status, human wants, buying habits and attitudes. The educated generally travel more. Even when income is held constant, the better educated population tends to outspend the lesser educated for all goods and services. In addition, the better educated respond strongly to innovations. Therefore, the amount of education is increasingly important in estimating the demand for certain products.

Higher education inspires an interest in and a desire to see other places, and thus affects demand for air travel. Today, there is a phenomenon which is not so much a pressure against heavy spending as a pressure to spend money as educated men are supposed to spend it. This is shown in the National Travel Survey by the fact that in 1967, 66 percent of the air travelers had some college education and 94 percent had high school training. The vital role education plays in the air travel demand is substantiated by many other surveys

For example, in a 1955 survey of United States Tourists in Europe, 57% were found to be college and university graduates. Life magazine, in a survey in 1960, found that 72 percent of the respondents sampled had some college education (19 October 1960).

Knowledge of the social class with which a comsumer affiliates and/or to which he aspires also provides an indication of the likelihood of his traveling. The middle class considers non-business air travel prestigious and a middle class person normally aspires to develop purchasing habits and attitudes similar to those of persons with higher social status.

This phenomenon also takes place within the same social class. For example, having relatives, friends or business associates who traveled and enjoyed their trips appears to be an important determinant of a person's decision to travel. As a result of social pressures such as status-seeking and a desire to conform, the travel decision of the individual may be a reflection of his friends' and associates' spending preferences.[4]

While rising incomes account for part of the increase in the demand for air travel, changes in taste also account for part of the growth. For example, a reduction in income may not be accompanied by a proportionate reduction in travel and visa versa. Tastes change with time and the availability of other goods and services will continually influence the demand for air travel.

It appears that business travel is not sensitive to personal income. Business reasons are not self-selected, and although highly paid senior management executives travel more than middle and lower level staff, income of the business traveler seldom seems to directly influence the frequency or, in some cases, the class of travel.

Business travel in general appears to depend, among other things, on the state of the economy. In individual city-pairs, the demand for business travel will depend on the type and extent of the business activity in each city. On the other hand, the demand for international travel may depend on the level of exports, imports, investment abroad, balance of payments, etc.

Since the economy is correlated to the demand for business travel, it stands to reason that during recessions, the amount of business travel diminishes. Conversely, during an expansion of the economy, business travel increases. During recessions when corporate profits are down and costs are rising, one of the means of reducing corporate costs is to curtail business travel. It can be seen from this that a relationship exists between the fluctuations in the economy and the travel trend. However, this relationship is very general, since fluctuations in the economy do not exactly coincide with fluctuations in traffic. The reason for this is twofold. First, there is never just one factor at play. Every year's traffic is influenced by many factors simultaneously.

Secondly, there is a time lag between the movement in the economy and the influence on traffic. To attempt to predict this time lag accurately would require very sophisticated techniques and numerous statistical data. It has been suggested that a variable time lag should be considered. The variation implied here is twofold. First, the time lag should be different for the pleasure and business markets. Secondly, it should reflect the economy at any given time as being in the state of expansion, recession or normality. Due to the sophistication involved, accuracy is usually sacrificed for simplicity and fixed lags are used.

Population: Although it stands to reason that other things being equal, the demand for air travel would increase in some proportion to the population growth, its influence is seen more clearly from the analysis of geographic concentrations of populations and its distribution by age, income and occupation. The influence of occupation and income has already been shown. Many surveys have shown that the average age of the traveler is declining. Table 7 shows that between 1960 and 1969, the percentage of the United States population in the age group 15-29 years increased from 19.5 percent to 23.4 percent.

Table 7

Population by Age: 1960 and 1969

(Total resident population, excluding Armed Forces abroad)

AGE (in years)	Percent Distribution	
	1960 (Apr. 1)	1969 (July 1)*
Total	100.0	100.0
Under 5	11.3	8.9
5-9	10.4	10.3
10-14	9.4	10.2
15-19	7.4	9.1
20-24	6.0	7.8
25-29	6.1	6.5
30-34	6.7	5.6
35-44	13.4	11.5
45-54	11.4	11.5
55-64	8.7	9.0
65-74	6.1	5.9
75-84	2.6	3.1
85 and over	0.5	0.6

* Preliminary

Source: Statistical Abstracts of the U.S. 1970

The influence of varying growth in different sectors of the population has different effects on the demand for air travel. For example, as pointed out by Wheatcroft[5] in his paper on the elasticity of demand for the North Atlantic, the influence of the population growth on the demand for air travel, should include an allowance for the growth of the European immigrant population. This section of the United States population has grown almost twice as fast as the rest of the population. He has also pointed out another demographic factor which has influenced the traffic over the North Atlantic; the tendency of the United States population to shift towards the West Coast and the influence of immigration. Data taken from the United States Abstracts shows that from 1790-1960 the centre of gravity of the United States population moved from a point 23 miles east of Baltimore, Maryland to a point 4 miles east of Salem, Marion County, Illinois, a distance of roughly 700 miles westwards. Besse and Demas[6], in their study reported that from 1940-1960 the centre of gravity of the United States population moved 160 km westwards. This might be regarded as an adverse influence for European travel, since it would imply that an increasing porportion of the United States population lives nearer other competitive areas of pleasure travel (Hawaii and the Orient).

Trips Related Factors

Fares: The Marshallian law of demand is applicable to air travel: consumers will buy more at lower prices and less at higher prices, if other things do not change.

Both personal and business air travel demand is dependent upon total trip cost and varies inversely with the trip cost as compared with other prices. Table 8 shows the historical trend of domestic and international fares and its relationship to consumer prices. The fares are represented by yield which is defined as revenue per revenue passenger mile. To compute yield, the accounting procedure is to divide the total passenger revenue for a given time in a given market by the total revenue passenger miles in that time period. Only revenue passengers are counted. The product of one passenger traveling one mile constitutes a revenue passenger mile.

Table 8 shows while consumer prices have increased sharply since 1965, the domestic and international yields have declined. It should be pointed out that a decline in yield does not always imply a change in fare levels. A change in the traffic mix and/or change in the average stage length may cause a change in the average yield. A change in the fare can also be the result of a change in the tax levied on air transportation.

Table 8

Domestic and International Yields for Scheduled Operations, Compared with Consumer Price Index

1967 = 100

Year	Domestic Fare (cents)	Foreign Fare (cents)	Domestic Fare Index	Foreign Fare Index	Consumer Price Index
1957	5.25	6.49	95.5	129.3	84.3
1958	5.58	6.46	101.5	128.7	86.6
1959	5.80	6.31	105.5	125.7	87.3
1960	6.01	6.39	109.3	127.3	88.7
1961	6.18	6.08	112.4	121.1	89.6
1962	6.35	5.87	115.5	116.9	90.6
1963	6.07	5.82	110.4	115.9	91.7
1964	6.01	5.44	109.3	108.4	92.9
1965	5.94	5.26	108.0	104.8	94.5
1966	5.69	5.13	103.5	102.2	97.2
1967	5.50	5.02	100.0	100.0	100.0
1968	5.45	4.96	99.1	98.8	104.2
1969	5.70	4.95	103.6	98.6	109.8
1970	5.80	5.02	105.5	100.0	116.3

Source: CAB Report - July 1971

"Productivity and Employment Costs in System Operations of the Trunk Airlines and Pan American, from 1957 through 1970"

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While the transportation cost is a significant determinent of the demand for air travel, the total trip cost appears to be a more important explanatory variable, especially in the case of international travel. Table 9 shows the historical trend of the total average cost of a transatlantic trip. The declining trend since 1960 is due to the decline in fares and the decline in average expenditures while traveling in Europe. The downward trend in expenditures abroad is explained partially by the growing number of United States citizens with limited funds who are now traveling and partially by the fact that air travelers have been staying shorter periods in Europe and spending less. The average stay declined from about 66 days in 1950 to 45 days in 1963. Data presented in a recent Boeing publication indicates that in 1969 the average stay had further declined to 28 days.

Table 10 compares the major components of the cost of a ten day trip in Europe and a large city in the United States for the years 1958 and 1970. In both cases, the air fare represents a smaller part of the total cost in 1970 compared to 1958. This was accompanied by an increase in the ground costs. This table also shows that in the case of the European trip, almost half of the total cost represents the air fare, while for the domestic trip, the hotel bill accounts for half of the total cost.

Table 9

Average Cost of a North Atlantic Trip

Year	Transportation Cost	Expenses While in Europe and Mediterranean	Total Cost
1951	$ 610	$ 759	$ 1369
1952	630	767	1397
1953	641	812	1453
1954	628	858	1467
1955	640	889	1529
1956	660	867	1527
1957	666	867	1533
1958	655	876	1531
1959	650	850	1500
1960	660	840	1500
1961	630	760	1390
1962	595	705	1300
1963	550	605	1200
1964	520	650	1170
1965	510	610	1120
1966	487	583	1071
1967	460	562	1022
1968	455	510	965

Source: Ref. 4 and the Annual Reports on Foreign Travel published in the Survey of Current Business, U.S. Department of Commerce.

Table 10

Components of Cost of Travel

Component	Distribution of Expenses for a 10-Day Trip In Europe 1958	 1970	 In a Large City in U.S. 1958	 1970
Air Fare	75.8%	48.7%	31.6%	18.7%
Meals	12.0	25.3	26.2	32.2
Hotels	12.2	26.0	42.2	49.1
Total	100%	100%	100%	100%

Source: Air Transport 1971. ATA, Washington, D.C.

The cause of declining fares when the price of almost everything else has been going up is the continuous reduction in the unit operating costs (both direct and indirect) for the scheduled airlines due to the higher productivity of the successive generations of civil aircraft. The jet aircraft has considerably higher productivity being both bigger and faster than the piston-engined aircraft. Although the new aircraft also have higher operating costs per hour than their predecessors, the gain in productivity per hour was greater than their increase in costs per hour. Therefore, the net effect of their introduction was to produce a fall in the average unit operating costs.

The reduction in the normal air fares has been important in attracting new and repeat travelers. They have made it more attractive for consumers who had never traveled before and others to take more frequent trips. There have also been many special areas, adapted to certain categories of users. The big fare reductions brought about by the introduction of a new class are probably those which strike the public most, but it would be a mistake to underestimate the influence of special fares, which have certainly generated a constant and very substantial increase in traffic. Examples of such fares are:

- Excursion fares, which presupposes a given length of stay, sometimes with departures only on certain days of the week. Often they are limited to certain times of the year which are staggered according to the point of origin of the passengers

- Out-of-season fares, which also tend to lessen the seasonal nature of traffic while permitting certain categories of passengers to go on a trip at a lower price.
- Family fares
- Group fares granted automatically to parties comprising more than a certain number of members.

In addition to the introduction of special fares, Charter has played a very important role in the development of air travel, especially in the international market. Historically, charter operations were started by scheduled airlines using spare (unproductive) equipment at off-peak periods. However, advanced equipment, with higher productivity (increased capacity and speed) and lower unit operating costs brought about by high load factors have made charter operations profitable.

In recent years, charter traffic across the North Atlantic has been growing very rapidly relative to the traffic on scheduled carriers. The supplemental airlines have increased their share of traffic very significantly from less than 2 percent of the total transatlantic passenger traffic in 1963 to over 15 percent in 1969. Charter sales have increased as the price spread between charters and scheduled services has increased. This gap in fares (estimated over $160 average in 1968) from California to Europe has been largely responsible for the growth of supplemental charters in the market.

Supplemental charter traffic refers to the carriers offering charter service only. In the early sixties, several carriers were authorized to supplement the scheduled carriers by concentrating on charters for bona fide groups. However, authorization was not for these carriers to sell individually ticketed, point-to-point, transportation to the general public. It appears that the main reason for the tremendous growth in supplemental carriers traffic is simply that these carriers have misinterpreted their authorization and have carried traffic other than bona fide groups.

Charters, although a small percentage of the total transatlantic market, are very important in several key markets. They account for one-third of the transatlantic traffic originating in California, and almost 85% of these charters are on supplemental carriers. The price spread between charters and scheduled service depends on the length of travel, the ratio of ferry mileage* to live mileage and the load factors. In 1968, for example, this spread was about $70 for New York-London roundtrip and about $160 for Los Angeles-London roundtrip.

The impact of lower fares depends among other things on the purpose of the trip. The pleasure traveler who uses charter services, does so to save money and is, therefore, willing to put up with a certain amount of inconvenience.

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* Ferry mileage refers to the aircraft flying without revenue load. One reason for the negligible supplemental charter activity on the North Atlantic during off-season is due to the high ferry to live mileage ratio.

Many surveys have shown (TWA on-board surveys, PONYA) that the two categories most attracted to charter travel are ethnic and religious groups and educational and youth organizations. Ethnic groups are often attracted to a particular destination with which they feel they have emotional ties, often a desire to visit the homeland. Their travel is generally for the purpose of visiting friends or relatives. Price in this case plays a very important role. The cost of the stay after arriving at their destination is small. Similarly, students are usually limited by cash, have a specific destination and the cost of their stay is small relative to the cost of transportation. Charters, therefore, are attracted to these groups because they can generate full plane-loads through established organizations.

Charters are also attracted to professional and cultural organizations. These include organizations from the upper income sections of the community, for example, the medical, legal, cultural organizations such as symphony and art societies and political organizations. Charitable organizations are also included in this group.

<u>Trip Time</u>: The decision to go by air is mainly a function of trip time. Speed is the primary competitive advantage of air travel over other modes, for the air journey has become both shorter and more reliable with speed improvements in newer aircraft.

Over the years the cruise speed of each generation of new aircraft have increased from about 110 miles per hour for the Ford Tri-Motor to almost 600 miles per hour for the Boeing 747 introduced in service in 1970. The increases in non-stop range of aircraft have also led to shorter point-to-point travel times through the elimination of intermediate stops. A longer-range capability was not necessarily combined with higher cruising speed in newer aircraft.

Reduction in trip time, basically due to the higher speeds of aircraft, has affected both the business traveler as well as the pleasure traveler. Higher speeds have meant that the businessman can reach his destination in less time. Higher speeds also mean that the pleasure traveler can visit more distant places in a given time.

The total demand for air travel (pleasure and business) varies inversely with the time required to complete a given trip. The value placed upon travel time for both pleasure and business purposes would presumbly be related to some measure of the traveler's earning rate. One such measure is the wage rate. There are, of course, many reasons why the value of time spent in travel might be larger or smaller than the traveler's wage rate. To the extent that the business traveler works during part of the flight or the pleasure traveler reads or watches a movie, travel does not take time away from other activities that have value.

In addition, traveling might be sufficiently relaxing, exciting, or prestigious to the extent that travelers would pay for these pleasures by placing a lower rate on their value of time. Conversely, those for whom travel is boring, fatiguing or frightening would value travel time at rates higher than otherwise. Thus, although it is reasonable to expect that the higher the traveler's earnings, the higher the value he would place upon his time, the exact value he places upon his time actually be either greater than or less than his earning rate.[3]

Comfort, Safety, Convenience: It is extremely difficult, if not impossible, to determine the exact effect of comfort, safety and convenience on the volume of traffic. The difficulty lies in the fact that these variables are difficult to quantify and that their relative numerical value is rather subjective. Nevertheless, they do affect travel demand even if the contribution may be small. It has been suggested that changes in these variables such as comfort and convenience tend to occur more or less evenly over time. It is assumed that while each of these variables may be quite difficult to measure empirically, the net effect of all these factors may be approximated by a time trend function.

Comfort: Improvements in the quality of air travel tends to be of greater importance as a competitive factor rather than in creating new travel. Comfort is related to the comfort in the aircraft as well as comfort at the aiport. With respect to comfort in the aircraft, there have been gradual product improvements related to the air trip. The newer aircraft have gradually improved the quality of the air service. Major innovations which have led to greater comfort are the pressurized cabins and the reduction in cabin noise and vibration. Other factors contributing to inflight comfort have been a significant improvement in the quality of food service, items such as special meals, vast quantities and variety of reading material, inflight stereo, multi-channel music and movies. The level of inflight comfort has also been increased due to lower values of seating density, the classical example being the B-747. The distance between seats and their individual width vary with the type of service which the passenger buys.

The comfort level at the airport has also been steadily improving. Modern facilities at the airports, easy and comfortable access to the aircraft (covered ramps, mobile lounges) have increased the level of comfort.

Access times to and egress times from the airports have generally increased around some larger cities. This is partly due to the movement of airports to locations more distant from the city centers but mostly due to the increasing traffic congestion on the roads.

Safety: It is true that a certain percentage of the traveling public will always be diverted to other modes for safety reasons. For this group, fear plays a large role in keeping them away from the airlines. This remains true even though the relative improvement in the safety of airline service, according to the measures usually presented, has been greater than for major surface transport media as shown by Table 11. Of course, the absolute number of passenger deaths due to aircraft accidents has been growing but the number of passengers has been increasing more rapidly. Table 11 also shows the comparative transport safety record of the United States carriers compared to other countries. It is interesting to note that the record of the United States scheduled domestic, international and territorial airlines is significantly better compared to all scheduled airlines of the ICAO Contracting States.

The attitude of the traveler towards safety is somewhat related to his experience as an air traveler. This was substantiated by the results by a Michigan University survey on the feelings about air safety. The question asked was, "Do you feel that air travel is safer now (1962) than it was 10 years ago?" The results show that 74 percent of the experienced air travelers felt that air travel was safer now, compared to 58 percent of the inexperienced travelers. Fourteen percent of the inexperienced travelers indicated that air safety had in fact deteriorated.

Table 11

Comparative Transport Safety Record

Passenger Fatality Rate per 100 Million Passenger Miles

	United States			Scheduled Airlines	
	Motor Buses	Rail Roads	Autos	U.S.	All ICAO Members
1960	0.11	0.16	2.2	0.76	1.29
1961	0.15	0.10	2.2	0.30	1.11
1962	0.11	0.14	2.2	0.26	0.97
1963	0.26	0.07	2.3	0.23	0.78
1964	0.15	0.05	2.4	0.26	0.58
1965	0.16	0.07	2.4	0.31	0.56
1966	0.23	0.16	2.5	0.07	0.70
1967	0.18	0.09	2.4	0.22	0.40
1968	0.24	0.10	2.4	0.27	0.47
1969	0.22	0.07	2.3[E]	0.11	0.43
1970	N.A.	0.09[P]	2.2[E]	0.001	0.27[*]

E = Estimated P = Preliminary * = Includes USSR

Source: ATA's U.S. Air Transport 1971 and ICAO's Monthly Bulletin, May 1972.

Convenience: Factors contributing to greater conveniences have been excess capacity, an increased number of flights in any given market, increasing number of origins and destinations, more direct flights, city-centre baggage check-in locations etc. Excess capacity implies that the passengers are not forced to plan their trips well in advance. This is especially important to the business traveler whose plans cannot be confirmed too far ahead of his departure.

Increased frequency reduces the waiting time at the terminals and provides greater flexibility in making connections. A greater number of origins and destinations also implies a reduction in connecting time and, hence, a reduction in the total trip time. Direct flights also have the same effect. For example, the success of non-stop flights from the United States West Coast to Europe have shown the convenience of direct flights. Where a traffic market does not justify direct flights, the carriers have offered through- plane service. For example, Cleveland-New York-London, Los Angeles-London-Paris and Detroit-Boston-London are specific instances of through-plane service. In these cases, stop-over times are lower than connecting times and passengers are assured of being on the plane and not missing a connection.

City-centre check-in locations save the passenger carrying his baggage to the airport and thus avoid lengthy check-in queues at the airport. It also reduces his pre-flight check-in time at the origin. The net effect of all these factors is to increase passenger convenience and to reduce the total trip time.

Theoretical Foundation of the Demand Function

Although it is not esstential, it is useful for the analyst to have some idea of the theoretical background to the formulation of the demand function. In this section an attempt is made to outline in descriptive form some of the basic concepts relating to the theory of demand. Demand is treated as consisting of two parts: the demand for business air travel and that for pleasure air travel. The foundations of the two components are different. The demand for pleasure travel is derived from microeconomic theory, the utility theory to be more precise. The demand for business air travel has not been formalized as yet. However, its foundations lie in the macroeconomic as well as microeconomic theory.

The Demand Function For Pleasure Travel

The theoretical demand function for pleasure travel can be derived from an analysis of the traditional cardinal or ordinal consumer utility theory. An individual's utility can be thought of as satisfaction received from consuming different goods and services. The term cardinal utility refers to the explicit measurement of utility on an absolute scale. In contrast, the ordinal utility theory assumes that an individual is only capable of stating which of the two groups of goods and services he prefers, if either.

The important concept in arbitrarily assigning an absoluate scale to the utility measurement is not the absolute size of the utility derived from each commodity, but rather its size relative to all other commodities.

The cardinal utility function relates an individual's total utility to his consumption of a set of goods and services. If we know the prices of each of these commodities as well as the available income of the consumer, then the utility is maximum when the marginal utility per dollar is the same for all commodities in the set. This results in maximum utility because if the marginal utility per dollar was less from consuming service A than from service B, then the individual could increase his total satisfaction, just by rearranging his purchases without spending additional money. This can be shown mathematically. Assume that x_1 denotes the quantity of the i^{th} commodity consumed in a given time period, then the utility function can be written as

$$U = F(X_1, X_2, --- X_i, ---X_n) \qquad (1)$$

where U relates the total utility of the individual to his consumption of a set of n different goods and services such as food, housing, transportation, etc.

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If we assume that P_i represents the price of the i^{th} commodity and Y denotes the consumer's income, then the total utility of the consumer is limited by his budget constraint

$$Y = X_1P_1 + X_2P_2 + --- + X_1P_1 + --- + X_nP_n \tag{2}$$

The utility can be maximized through the use of the Lagrangian multiplier method.

$$L = F(x_1, x_2, \cdots x_i -- x_n) + \lambda \left(Y - \sum_{i=1}^{n} X_i P_i \right) \tag{3}$$

The satisfaction of first order conditions will maximize the consumer's utility. The second order conditions or the sign of the bordered Hessian determinant will determine whether the utility is maximum or minimum.

$$\frac{\partial L}{\partial X_i} = \frac{\partial U_i}{\partial X_i} - \lambda P_i = 0 \tag{4}$$

and

$$\frac{\partial L}{\partial \lambda} = Y - \sum_{i=1}^{n} X_i P_i \tag{5}$$

$$\therefore \frac{\left(\partial U_1/\partial X_1\right)}{P_1} = \frac{\left(\partial U_2/\partial X_2\right)}{P_2} = \cdots \frac{\left(\partial U_n/\partial X_n\right)}{P_n} \tag{6}$$

Equation 6 expresses that the marginal utility per dollar of each of the n goods and services is equal. This equation states that for a given marginal utility, the lower the price the higher is the marginal utility per dollar. Thus, as the price of a good increases, the marginal utility per dollar decreases and it pays the consumer to decrease the quantity he buys. The reverse of this argument also holds and this confirms the concept of the downward sloping demand curve.

The solution to Equations 4 and 5 will also provide the consumer's demand function for each of the n available commodities. For example, the consumer's demand function for the i^{th} commodity, say air travel, can be obtained by solving for X_i. In general, the demand function for the i^{th} commodity will be of the following form:

$$X_i = X_i \left(P_1, P_2, ---, P_i, ---P_n, Y\right) \qquad (7)$$

If we hold the consumer's income constant and the prices of all other commodities remain unchanged, then the quantity of the i^{th} commodity consumed by an individual will depend on the price of the i^{th} commodity.

Although the exact shape of the demand function for the i^{th} commodity depends on the parameters and functional nature of the consumer's utility function, we will assume that the Marshallian law of demand is applicable to air travel: consumers will buy more at lower prices and less at higher prices, all other things being equal.

The Demand Function for Business Travel

There is no formal derivation for the demand function for business travel. However, we can point out the areas of economic theory which can contribute to the formulation of the theory. It is logical to assume that the air travel demand for business trips is related to the economy in general and specifically to the level of investment by the business concerns, the interest rates available, some measure of stock prices, etc. At the same time, it is logical to assume that the air travel demand for business trips is related to the firm's output of products and services. We are, therefore, assuming that an individual firm will treat the business travel by its employees as another input factor to the production activity. In this case, we are hypothesizing that the demand for business air trips can be derived from the demand for the output of all major industries producing goods and services.

Air Travel Demand Models

A market demand model explains the demand of all consumers for a particular good or service. This model can be used to explain the behavior of consumers in a particular market, all markets, a particular class of travel, all classes of travel, the market share of a particular mode, the market share of a particular carrier, or some combination of these. The models used to estimate the demand for air travel can be broadly classified into four categories: aggregate, gravity, modal split and inter and intra modal market share. This section contains a brief description of the models and the basic theoretical assumptions. The problems involved with the statistical specification and the empirical significance of the models is dealt with in the next section.

The Aggregate Models

The most simplistic models used for explaining the demand for air travel are single-equation aggregate market demand models. The aggregate model assumes that the service, air travel, is a homogeneous unit such as revenue passenger miles or revenue ton miles, etc. The index revenue passenger miles is determined by summing over all routes the product of number of passengers and the distance flown by each.

These models usually relate the total demand for air travel, to a selected number of demographic characteristic of the traveler and the market and the trip related factors, that is, factors describing the level of service offered.

There are normally four sets of "independent" variable in the model: some measure of average price of air travel, a measure of price of other commodities such as an alternative travel mode, a measure of the traveler's family income and some form of a time trend to account for factors which have not been included explicity in the model.

The aggregate model assumes that the volume of passenger traffic is related to the same parameters in all markets. This implies that the travel demand in the New York-Bermuda market can be characterized by the same parameters as in the New York-Chicago market. This assumption is weak, since the first is a pleasure market and the latter is mostly a business market. This being the case, although price paid by the traveler may be important in both cases, the impact of price is different in the two cases.

Normally, the single equation aggregate demand models do not contain a supply parameter. This is justified on the grounds that the airlines usually operate with considerably less than full capacity and it is unnecessary to include a supply variable.

Secondly, monopolistic routes are almost nonexistent and insufficient capacity is unlikely due to the market forces. The standard criticisms of excluding the supply factor are, first, that there may be some routes with very high load factors and secondly, that an increase in supply may increase demand.

The price variable is usually taken to be the average yield, that is, average revenue per revenue passenger mile for a given period. In theory, only one price should exist for a homogeneous commodity at any given time in a competitive market. However, in the case of air travel we have different prices. The average yield is a weighted average revenue and as such is subject to change even if the level of fare does not change. A change in the composition of the passenger mix or average length of haul can change the numerical value of yield. Similar arguements can be put forward for the use of an average per capita income.

The demand for air travel cannot be explained by price and income alone. It is generally recognized that some measure of value of time should be included in the model. The increases in aircraft speed relative to other competitive modes of transportation have been a very significant factor in the growth of the air travel. On the other hand, advanced technology has required greater amounts of investments which in turn, have affected the cost and in turn, the price of air travel.

Although there are many reasons for choosing aggregate market-demand models, the most important one is the lack of adequate published data. It is true that a first class revenue passenger mile cannot be added to the one generated by the economy class passenger or that average yield is inadequate, since no one pays the average fare. However, since data does not exist by class of service (other than first class vs. economy), purpose of trip, true origin-destination, by type of fare, etc., the analyst is forced to investigate the demand for air travel on an aggregate basis. The second major problem related to the data is the inability to quantify subjective data such as changes in personal taste. In general, the mathematical formulation of the aggregate demand model can be expressed as:

$$T_{ij}(t) = K \cdot F_{air}^{\alpha}(t \pm \epsilon_1) \cdot F_{competition}^{\beta}(t \pm \epsilon_2) \cdot Y^{\gamma}(t \pm \epsilon_3) \cdot S^{\delta}(t) \cdot g(t)$$

where:

T_{ij} (t) = traffic between origin i and destination j during time period (t)

K = constant

F_{air} = some average price for air travel

$F_{competition}$ = some average price for a competitive mode of transportation.

Y = some measure of the traveler's family income.

S = representative aircraft speeds.

g(t) = time function

ϵ = lag or lead for the variable

This is a multiplicative type of extrinsic model. An extrinsic model is one where, although time can enter the relationship as a predictor variable, it cannot be the sole predictor variable. The left hand side of the demand function contains a small number of variables which are presumably more important, and the net effect of the excluded variables is represented by a stochastic variable, a time trend. This variable accounts for all forces which should be included explicity in the behavioral demand function but are unquantifiable or subjective. Variation of these forces is, therefore, allowed through the use of a time trend function. The basic assumption is that the effect of the stochastic variable is similar to that observed in the past and, furthermore, on the long-term basis, time function will satisfactorily account for many of the secondary variables. The selection of the predictor variables is limited due to the availbility of data and the difficulty of quantification.

The exponents in the model represent partial elasticities, one elasticity coefficient for each factor which may be regarded as an average elasticity over the range of the data. The implicit assumption here is that the partial elasticities are constant. This aggregate form of the demand model contains one term to represent inter-mode cross-elasticity. It does not, however, contain intra-mode cross-elasticities. This is to say that first class traffic is not separated from the economy or excursion traffic and business travel demand is not separated from the pleasure travel demand. These limitations of the aggregate model exist due to the substantial limitations of the data available to reflect the price upon which the traveler makes his decision and the lack of techniques to secure homogeneity so that the price and income effects may be isolated.

The model also includes the flexibility to incorporate the delays with which the socio-economic factors exert their influence on the volume of traffic. For example, the family income in year t may effect the demand for air travel in year t, (t-1), or (t+1).

The Gravity Models

The gravity model for the demand for air travel is based on the gravitational law of physics. The model expresses the relationship between the demand for air travel between two cities as a function of the population of the two cities and the distance between them. The general form of the model can be expressed as:

$$T_{ij}(t) = K \cdot \frac{P_i^{\alpha}(t)\ P_j^{\beta}(t)}{d_{ij}^{\gamma}}$$

where:

$T_{ij}(t)$ = traffic between city i and city j during some time period t.

K = constant

P_i = population of city i.

P_j = population of city j.

d_{ij} = the distance between city i and city j.

The general form of the model does not assume that the population of each city should have equal travel inducing effects, or that the exponent of the distance factor has a numerical value of 2. The basic limitations of this model are:

1. it is difficult to define precisely the population of a city;
2. the model assumes that the population of a city lives at a "node" of a city;
3. city characteristics, such as average income, type of city, etc., are excluded from the model;
4. it is assumed that the same factors characterize the demand for all city-pairs.

It is possible to generalize the gravity model further by including factors such as average income, community of interest, availability of alternate modes of transportation, etc. By definition, then, gravity models are cross-sectional in nature, that is, they are generally used to analyze the demand for air travel between different city-pairs.

The variable "community interest" is an interesting one to analyze. Brown and Watkins[7] represent "community of interest" by the number of international air passengers travelling on the same route. Although it is difficult to prove the significance of these two factors in explaining the community of interest, they appear to provide a reasonable "fit" to the empirical data.

Modal Split Models

A modal split model determines the functional relationship between the share of traffic attracted to a particular mode over a route. The most common form of the modal split model assumes that total trip time and total cost are the two most significant factors which the travelling public will use in determining their choice of a mode of travel.

The mathematical formulation of one form of a modal split model is given in Figure 6. The total trip time includes the times for access, egress, passenger processing and waiting for the next line haul service.

Figure 6

Modal Split Model

$$MS_{ijm} = \frac{C_{ijm}^{\alpha} \cdot T_{ijm}^{\beta}}{\sum_{m=1,m} C_{ijm}^{\alpha} \cdot T_{ijm}^{\beta}}$$

WHERE MS_{ijm} = SHARE OF TRAFFIC BETWEEN i AND j TRAVELLING ON MODE m

C_{ijm} = TOTAL TRIP COST = ACCESS + EGRESS + TRIP FARE

T_{ijm} = TOTAL TRIP TIME

= $T_a + T_p + T_w + T_b + T_e$

T_a, T_e = TIME FOR ACCESS, EGRESS

T_p = TIME TO PROCESS PASSENGER AT STATION

T_w = TIME TO WAIT FOR NEXT SERVICE = $\frac{TD/2}{f_{ijm}}$

T_b = BLOCK TIME ON MODE m

TD = DAILY HOURS OF OPERATION FOR MODE m

f_{ijm} = DAILY FREQUENCY OF SERVICE FOR MODE m

α = TRIP COST ELASTICITY

β = TRIP TIME ELASTICITY

Source: Concept Studies For Future Intercity Air Transportation Systems. MIT - FTL, 1970

These factors are taken to account for the "convenience" aspect of the system. The model does not contain factors on comfort safety and reliability. In this figure, the time to wait for next service, T_w depends on daily frequency. The total trip cost, again, consists of trip fare and the cost of access and egress.

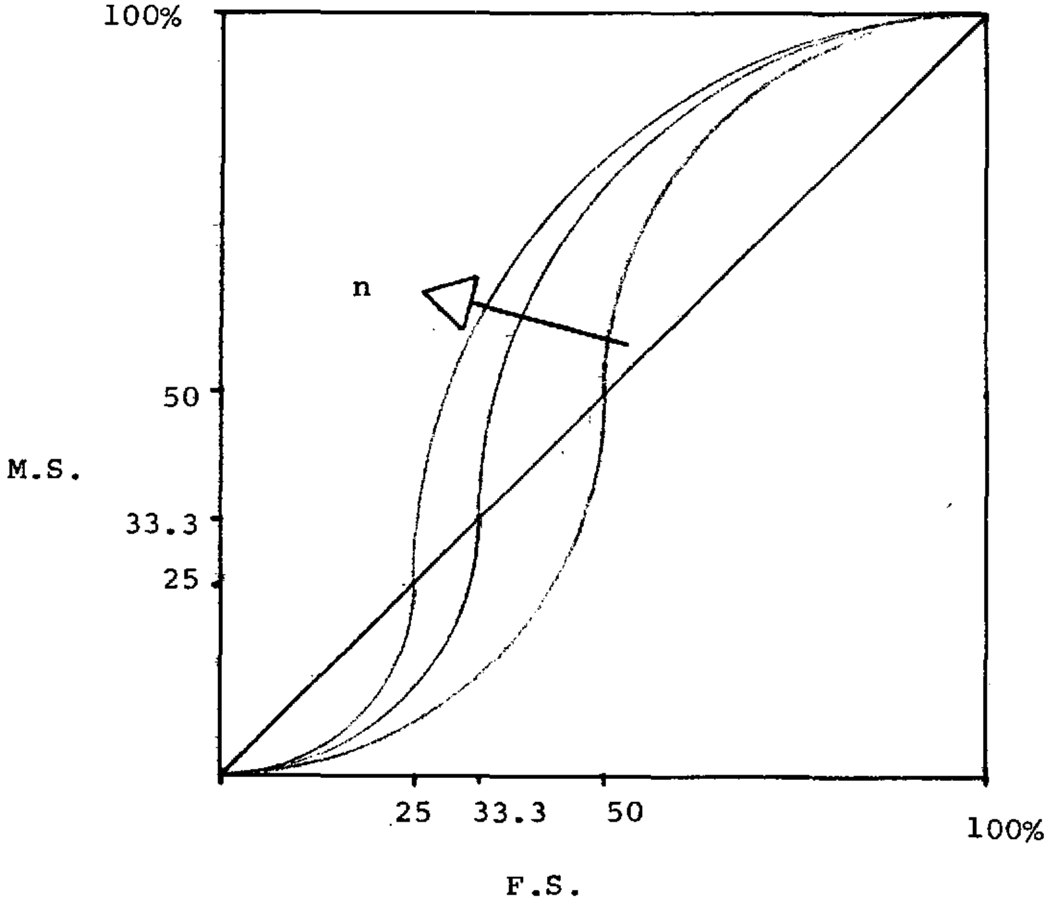
Market Share Models

A market share model shows the realtionship between the share of the passenger traffic for an airline in a given competitive market and the factors which describe the quality of service offered in the market by the carrier. Since, for a typical United States airline market, service factors such as fares and the type of aircraft are similar for all competitors in the market, the market share becomes a function of factors such as frequency of service, departure and arrival times, the image of the carrier, etc.

Research in the area of market share estimation in the airline industry has indicated that the most significant explanatory variable of market share is frequency share. More precisely, the empirical evidence shows that market share is an S-shaped curve and its location is a function of the number of carriers in the market. This concept is illustrated in Figure 7.

Figure 7

Market Share - Frequency Share Relationship



Source: N. K. Taneja, Airline Competition Analysis
MIT, Flight Transportation Laboratory, 1968

Various studies have indicated that the effects of multi-stop service and preference for various types of aircraft can best be accounted for by assigning weighted values to the daily frequency. Although these numbers have been highly criticized for their numerical and relative value, it should be pointed out that the values of these weighting factors are not extremely critical since services on competitive markets are normally very similar.

Another significant variable in the estimation of market share is the image factor which is usually built on such factors as inflight service, on-time performance, advertising, attitude of personnel, etc.

Model Selection and Evaluation

The selection of a particular model depends on the purpose of investigation, the validity, the simplicity, the accuracy, the cost of operation and maintenance and perhaps personal preference of the forecaster. The criteria for model selection and evaluation becomes significantly complex when there are a number of conflicting factors to consider. Nevertheless, it is necessary for the analyst to sort through the many factors and select a model. The following are a number of factors which can be used as guidelines for model selection and evaluation. It is not claimed that this list is complete or even that the criteria listed are more important than the ones left out.

To begin with, it is necessary for the analyst to be clear of the purpose of the investigation. For example, if the main object of the investigation is to estimate the true numerical value of demand elasticities upon which to base pricing and marketing strategies, then the unbiased estimation of the particular demand elasticity should be the criteria for model selection and evaluation. On the other hand, if the main object of the study is to forecast the demand for air travel, then the criterion for the selection of the model should be based on the forecasting ability of the model or the accuracy of the forecast.

The model selected should produce the smallest standard error of estimate and standard error of the demand coefficients. Similarly, if the purpose of the model is to produce a long-term forcast, then the choice of a cross-sectional model may not be the best one since the parameters in a cross-sectional model are estimated from a sample of observations at a given point in time.

Having narrowed the choice to a particular category of models, the next criterion should pivot on the validity of the model. The validity factor should be investigated in four parts: the theoretical foundations of the model, the underlying assumptions, the statistical validation, and the empirical calibration data in the case of econometric models. Again, these factors are only guidelines to investigate the validity of the model. The analyst can, however, perform very sophicticated and in-depth analysis of each factor. Once again, the effort put in evaluation should not be out of proportion to the development and use of the model per se.

All models should be based on some fundamental theory, may it be economics, engineering or otherwise. For instance, the demand for air travel can be based on economic theory. The analyst can go one step further and relate for example, the demand for pleasure travel to consumer's utility theory, or business travel to the theory of the firm. In other cases, the analyst can, for example, relate the gravity model to the gravitational law of physics. Unless some background theory can be put forward, it would be difficult to justify a model which, for example, predicts the air travel in the United States based on the amount of tea consumed in England.

Equally important in selecting a model, are the basic assumptions incorporated in the model. One can not justify using an aggregate demand model with constant price elasticity for forcasting the demand on a highly price elastic route. In another case, for example, the analyst can not use a model calculated using subsonic aircraft data, to forecast the potential on the supersonic aircraft. In each case, it is crucial to investigate the fundamental assumptions on which the model is based. The analyst who favors trend analysis is assuming that in the future the impact of factors influencing the market demand to air transportation will be similar to that observed in the past. Even an analyst who does not believe in forecasting, has a model and a set of assumptions For not forecasting, he is implicitly assuming a state of status quo.

The next area of investigation refers to the statistical validation of models which are known as analytic, regression or econometric.

These models may be subject to statistical problems[*] such as multicollinearity, autocorrelation, heteroscedasticity identification, etc. In each case, if a statistical problem exists, the chances are that the estimated parameters would be biased and the predictive ability of the model is subject to errors. The existence of more than one type of statistical problems complicates the matter further and evaluation of the model becomes even more difficult. The analyst, however, does have a set of statistics to help him determine the existence and in some cases, the extent of the problem. In the case of an econometric model, the analyst is usually provided with statistics[*] such as standard error of coefficient, multiple correlation coefficient, the F-statistic, the Durbin Watson or Von Neuman ratio, the Chow test, etc. A combination of one or more of these statistics and tests can be used to determine the statistical validity of an econometric model.

Closely related to the above is the general validity of the calibration data. In selecting and evaluating a particular model, one must investigate the calibration data which is used to estimate the demand parameters. Again, the data can be analyzed for adequacy, consistency and reliability. Putting it in another way, one must

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[*] For a description of these statistical problems, the reader is referred to standard texts such as Johnston and Wonnacott. References 8 and 9.

examine the data to see if the sample size was adequate, each data point was measured by the same rules and that the data is relatively free of significant errors.

The next set of selection criteria are somewhat interrelated. Simplicity is tied to the ease and cost of operation and maintenance on the one hand, and cost, accuracy and personal preference on the other hand. An historical trend analysis may be simple, cheap and easy to perform, but how accurate is it to forecast the demand for travel in a time period which may have supersonic aircraft, subsonic mass transportation or hypersonic aircraft or none of these? On the other hand, and equally important one has to weigh the marginal predictive accuracy against marginal cost of formulating a sophisticated model. Furthermore, a sophisticated model may not be necessarily more accurate than a simple one and yet for the sophisticated model, the collection and manipulation of the input data may be very expensive.

References

1. Statistical Compilation of Airline Passenger Markets. Domestic FY 1972. U.S. Department of Transportation. November, 1971.

2. Port of New York Authority Surveys. Aviation Department, Aviation Economics Division. Various Years.

3. Asher, N.J., et al
"Demand Analysis for Air Travel by Supersonic Transport." Volumes I and II. Institute for Defense Analysis. December, 1966.

4. Triandafyllides
"Forecast of the 1975 Demand for North Atlantic Travel." Ph.D. Thesis - Washington University, 1964.

5. Wheatcroft, S.
"Elasticity of Demand for the North Atlantic Travel", IATA July, 1964.

6. Besse, G. and Demas, G.
"Conjuncture of Air Transport." ITA International Symposium, November 1966.

7. Brown, S.L., Watkins, W.S., "The Demand for Air Travel: A Regression Study of Time Series and Cross-Sectional Data in the U.S. Domestic Market. Civil Aeronautics Board, Washington D.C. 1968.

8. Johnston, J.
"Econometric Methods," McGraw-Hill, New York, 1972.

9. Wonnacott, R.J. and Wonnacott, T.H. "Econometrics" John Wiley & Sons, Inc., 1970.

[illegible]

A key ingredient in the analysis, planning, implementation and operation of any successful transportation system requires accurate and realistic forecasts of traffic volume expected to use the system. Although the planning process involves much more than a forecast of the future traffic statistics, these statistics provide an essential quantative dimension for the planning process. Forecasts of expected traffic are therefore an essential prerequisite to both long and short-range planning.

This paper outlines the basic techniques of forecasting the air passenger traffic. The differences between the various forecasting methods exist, in part, due to the degree of formalization of the forecasting procedure. Each technique has its special use and the selection of an appropriate technique depends on a number of factors such as particular application, available data, projection period and desired accuracy.

Forecasts can be classified according to the time period they cover. "Short-term" forecasts are normally used for planning current policy, evaluating current developments, and in general are concerned with the day-to-day operations. The time framework can range from one month to a year. "Budget" forecasts normally refer to a fiscal year and are used for establishing basic operating requirements such as determining cashflow and adjusting station employee requirements in line with seasonal movements in traffic.

"Long-term" forecasts normally cover a period of three to fifteen years. They are generally used for fleet planning, market and route planning, etc. Time frame for the forecast will influence the selection of the technique. For example, a long-range forecast of the market potential of a given route requires a different forecasting technique than a forecast of the system traffic for producing next year's financial budget.

One of the most crucial trade-offs in the selection of a forecasting technique is of accuracy versus cost. Although greater accuracy can be obtained at higher costs, there is usually an optimal point beyond which diminishing returns take over. In this context, the cost of the forecast is used in the general sense. It includes such components as time required to forecast, use of computer facilities, the additional cost of acquiring more suitable data, the cost of error in the forecast, etc.

Techniques for forecasting air passenger traffic can be broadly classified into four categories: judgmental, time-series analysis, market analysis and analytical. The judgmental or subjective method relies on the analyst to make an educated guess of the travel demand for the forecast period based on his experience of the past volume of traffic and his intuition of the future.

Although the analyst does not use any specific travel demand model, he intuitively takes into account the factors which influence the demand for air travel and weighs these factors according to his judgment. This method is especially useful in cases where the data sample is small or nonexistent as may be the case requiring traffic forecast on a new market or a forecast of the market acceptance of a new type of aircraft. Although the judgmental method has the advantage of low cost and ease of operation, it is limited to short-term forecasting. This approach has little merit in long-term forecasting since it is natural, although perhaps, unintentional, for the analyst to place greater weight to more recent developments.

The judgmental forecast can be produced by a single analyst or by a committee as with the delphi technique. In the delphi method, a group of experts is consulted through a set of carefully designed sequential questionaires. The answers to one set of questionaires are used to design the next set and all members in the group have access to each other's information.

The time-series analysis method assumes that the air passenger traffic will follow its established pattern of growth. This means that the future travel demand is a time function of the past experience. The time-series analysis, therefore, assumes very little causation. The method can be useful for broad long-term projections especially in cases where there is very little knowledge on the cause for growth. On the other hand, the method has little merit for forecasting detailed long-term patterns. Since the assumption of the future being direct function of the past is more likely to be true in the case of short-term, the trend method can be very useful for producing detailed forecasts on the short-term basis.

The application of time-series analysis varies from the simple extrapolation of historical trends to the use of complex mathematical growth curves, such as the Logistic and Gompertz curves. These are known as intrinsic models, that is, time is taken to be the only predictor variable, reflecting the interplay of economic, industry, and governemnt activities. The difficulty lies in determining accurately the appropriate trend curve. We can use empirical and theoretical considerations to narrow the selection of the growth curve. For example, the very long-term forecast of the air passenger traffic in the United States may be estimated by an asymptotic trend, such as a Gompertz curve, since there are good reasons to place an upper limit on the level of traffic.

The simple extrapolation involves a projection of past observed trend through visual inspection. Although such a method will suffice for certain applications,direct extrapolation, in general, is not considered a satisfactory method of forecasting especially for cases involving turning points. The method merely indicates that parameters exist which have influenced the demand in the past at a rate which is a function of time. It is, therefore, difficult to project the demand based on time alone unless one knows these time-based parameters and the extent of their influence. It is also difficult to forecast the time at which these influences may cease to operate or their effects will change. For example, it is well-known that the sea traffic on the North Atlantic has been declining steadily. A direct mechanical extrapolation of this trend will produce a total disappearance of the sea traffic on this route after a certain time. A reasonable forecast, on the other hand, would set a minimum on the passenger market patronizing the water mode.

For annual budget forecast, the analyst is usually interested in forecasting monthly traffic which can fluctuate due to trend, cyclical and seasonal factors. In addition, the seasonal traffic pattern may contain random noises. The long-term trend is usually the result of steady and continuous increases in population and technical improvement. The cyclical fluctuations are generally the result of movements in the economy or business cycles and do not usually conform to a set pattern. The seasonal effects occur at a given time in the year and are usually the result of season or custom. The random noise is the irregular or the residual part of the pattern. The time-series forecasting model attempts to project the value of the first three components of the series and sum the results to get the forecast value of the traffic. It is usually impossible to forecast the random noise component.

Various time-series statistical models are available to analyze and forecast values of a fluctuating pattern. Smoothing techniques are the most common means of investigating time-series components. These techniques attempt to cancel out the random effects by using "averages." The normal smoothing schemes are the moving average type and the exponential smoothing. The former scheme calculates averages over a fixed base time period while the latter scheme calculates an average using all past values of the series. The weight given to the individual value of the series is determined by the smoothing constant.

The accuracy of this method depends on the behavior of the traffic pattern. A well behaved pattern with small random variation will be relatively easy to forecast compared to one containing a significant random pattern. Normally the historical raw time-series data is adjusted and massaged to eliminate known distortions caused by ad hoc factors such as strikes, introduction of new aircraft, bad weather and extra ordinary large scale promotion. A forecast of the time-series model can then be used on the clean data to produce a forecast of the seasonal traffic pattern. The experienced analyst would then apply to the predetermined forccast intuitive factors such as expected changes in competitor's traffic, introduction of excursion fares, and movements in economy to obtain a more realistic traffic forecast for budget purposes.

The market analysis method relates the travel patterns of a given segment of the population to its demographic and economic characteristics. The Port Authority of New York and New Jersey has investigated the use of this method based on a series of national household surveys conducted over a period of fifteen years. The results of these surveys indicate a strong relationship between the travel pattern of a group of people and such characteristics as income and occupation. A forecast of the air traffic activity is obtained from a forecast of the demographic and economic characteristics of each of the population segments.

The air travel market is usually divided into a large number of "cells" each defined by a cross-classification of socio-economic characteristics such as age, education, occupation, and income for personal travel and industry, occupation and income for business travel. Once the cells have been established, a relationship is investigated between air trips and these characteristics. This relationship is then applied to a forecast of the segment of population expected to fall under similar cells to obtain the projected number of air passengers for all cells. Projections of population and its distribution with respect to age, labor force, income groups, etc., can usually be obtained through sources such as United States Census Bureau and United States Department of Labor.

There are three critical assumptions regarding the validity of this method. First, an assumption has to be made regarding the stability of the relationship between travel patterns and the socio-economic characteristics. Secondly, a realistic assumption is needed on the projected growth of the traffic group within an individual cell. Third, the model should take into account future expected changes in the socio-economic structure of the population and segments of the population which are not included in the surveys.

Market analysis can be an extremely useful tool in identifying those segments of the population which generated most of the air activity and those which are good future potentials. The weakness of the method is that it does not take into account service characteristics such as fare and trip time. The market analysis method, for example, will not be able to relate the changes in the demand for air travel to changes in the average fare level or introduction of new fares introduced to attract a certain market.

The market surveys can be taken from actual travelers or from households with potential travelers. In the later case, consumers are asked about their travel intentions and the responses are subject to many "errors". The most common of these is due to misinterpretation and lack of ability to quantify subjective responses. The common limitations of these surveys are that the respondent may not be the ultimate decision-maker or that he may be unable to state accurately his travel plans. In any case the plans can change due to family circumstances and general economic conditions.

The analytical method attempts to relate the variation in the movement of logically relevant economic variables such as income, demographic variables such as population, and service variables such as fare and trip time. This method explores and analyzes parameters which have affected the historical travel demand pattern and those parameters which may influence the future travel demand. An analytical demand model shows through one or more equations, an economic relationship between demand and a number of predictor variables which can be classified as exogeneous or endogenous. The endogenous variables are determined within the model itself while the exogenous variables are predetermined. It should be noted that although time can enter the relationship as a predictor variable, it cannot be the sole predictor variable. It must also be emphasized, however, that statistical correlation does not always imply cause and effect. In many cases the relationship is empirical or logical at best.

There are basically four steps in building an analytical model: specification, data analysis and collection, calibration, and evaluation. The specification stage involves the formulation of a set of testable hypotheses showing the relationship of volume of air passenger traffic with economic and transport-related variables. It refers to the task of formulating a set of precise mathematical equations. The selection of the variables is based on the considerations of empirical data, economic theory, statistical techniques and computational advantages. Since the relationship cannot be an identity, it is usual to include an error or residual term.

The next step involves the analysis and collection of past data on both the dependent and the independent variables. This is a very critical step since the unavailability of certain types of data can force the analyst to an alternate model specification. The data analysis is usually performed with respect to sample size, reliability, consistency and availability of projected values. The data collection involves not only the gathering of statistics but the adjustment of the data for ad hoc influences such as strikes.

In the third stage of the model development, the parameters of the regression equation are estimated from the past data on both kinds of variables. The calibration of the model is carried out by deriving the appropriate functional relationship through experimentation with the past data and the use of regression techniques.

For a base period, various functional relationships are empirically manipulated. The object is to find the relationship which gives the least variance between the derived demand and the actual demand.

The final step is an evaluation of the model in terms of its effectiveness to explain the volume of traffic. This step may lead to an alternative specification of the model and hence, repetition of the first three steps. In general, model evaluation can be performed in two steps. First, it is necessary to justify the model on theoretical grounds. For example, a travel demand model with positive price elasticity should be questioned on logical ground. The second stage of evaluation is based on statistical validity. The four most common indicators of statistical validity are degrees of freedom, the coefficient of determination, standard error of the regression coefficient, and the standard error of estimates. For greater details on the significance of these tests, a standard text on econometrics can be consulted.

There are three fundamental assumptions underlying the analytical approach. First, it is assumed that most of the variation in the dependent variable can be explained by using a few selected independent variables. This assumption is necessary due to the availability of limited data. Furthermore, in many cases it is difficult if not impossible to quantify all the variables even though we recognize that these variables have influenced the volume of traffic in the past and will continue to do so in the future.

The second assumption is that it is easier and/or more accurate to forecast the independent variables than the dependent variable. Normally the data for the projected values of the independent variables can be obtained directly from external sources, giving the analyst two advantages. First of all, certain external specialists in various branches of the government, private industry, and/or academic institutions are probably better equipped to produce the projections. Secondly, it is important that the assumptions regarding the projections of economic activity should be consistent. The third assumption is that the functional relationship will remain valid throughout the period for which the forecast is required.

Like any other method, the use of analytic technique has its own problems. Again without going into depth, the two most common problems associated with this method are multicollinearity and autocorrelation. The former is caused by the existance of relationships among some of the independent variables. The term autocorrelation is normally used to describe the lag correlation of a particular time-series with itself. This problem can cause the model to systematically "overshoot" or "undershoot" the pattern.

In the past, most forecasts have relied heavily on the use of time-series analysis. In cases where attempts were made to formulate more sophisticated demand models, the scope was limited due to unavailability of statistical data such as volume of traffic by purpose of trip, discretionary personal income and lack of the ability to measure certain factors, such as taste and the effect of advertising. Current research is devoted to developing models which are analytic, multivariate, behavioral, dynamic and probabilistic.

The analytic formulation offers the advantage of statistical tests of several groups of alternative hypotheses relevant to the demand for air travel. The multivariate characteristic allows the model to contain more than one independent variable. The behavioral model of demand relates the consumer behavior to observable decision-making processes. This approach focuses on rational consumer behavior under insufficient knowledge. The dynamic nature of the model will eliminate the assumption that the demand coefficients, for example, income and price elasticity, should remain constant over time. In the real-world and on "a priori" grounds, it is expected that the long-run partial coefficients of the explanatory variables in the market demand function will vary with time. The probabilistic characteristic allows the analyst to treat the demand for air travel as a random variable and obtain an approximation for its probability distribution together with an estimate of the expected value and variance. This method is particularly useful when the demand is a random process due to lack of data or insufficient knowledge about the variables which affect air travel.

The model can be expressed as a system of simultaneous equations, thereby lifting the constraint that all of the explanatory variables will be exogenous with virtually zero feedback. For example, there is a feedback relationship between the type of aircraft available and demand. The demand for air travel should be denoted as an explicit function of a small number of systematic variables which are presumably more important and can be quantified fairly easily. The net effect of the secondary variables can be represented by a stochastic variable. This variable can account for all forces which should be included explicitly in the behavioral demand model but are either unquantifiable or subjective. On theoretical grounds, some of the predictor variables may assume a lead-lag structure. The model can also incorporate dummy variables which will relay, for example, the existence or non-existence of SST, sonic boom, etc. In the final analysis, the sophistication and complexity of the model will depend largely on the availability and the degree of quantification of the data.

BIBLIOGRAPHY

1. Menhenhall, William and Reinmuth, James, "Statistics for Management and Economics," Duxbury Press, 1971.

2. Clelland, deCani, Brown, Murray, Bursk, "Basic Statistics with Business Applications," John Wiley and Sons, 1966.

3. Wonnacott, R., and Wonnacott, T., "Econometrics," John Wiley and Sons, 1970.

4. "Air Travel Forecasting" Market Analysis Method Domestic Air Passenger Market, 1965-1975. The Eno Foundation for Highway Traffic Control Saugatuck, Connecticut, 1957.

5. Brown, R.G., "Smoothing, Forecasting and Prediction of Discrete Time Series," Prentice Hall, 1963.

6. Augustinus, A.G., "Air Traffic Forecasting At The Port Authority of New York and New Jersey," PANYNJ, July, 1972.

7. Chisholm and Whitaker, "Forecasting Methods," Richard D. Irwin, Inc., 1971.

8. Parker and Segura, "How to Get a Better Forecast," Harvard Business Review, March-April, 1971.

9. Chambers, Mullick and Smith, "How to Choose the Right Forecasting Technique," Harvard Business Review, July-August, 1971.

AVIATION FORECASTING IN ICAO

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Introduction to ICAO

ICAO, the International Civil Aviation Organization, is a specialized agency of the United Nations which came into existence as a result of the 1944 "Chicago Convention". The aims and objectives of ICAO as outlined in the Convention are "to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport..."

ICAO has a sovereign body, the Assembly, and a governing body, the Council. The Assembly normally meets every three years to review the entire work of the Organization in the technical, economic, legal and technical assistance fields and to plan the work programmme for the ensuing three year period. There are presently 124 Contracting States and each State has one vote in the Assembly.

The Council is a permanent body responsible to the Assembly and is currently made up of twenty-seven Contracting States elected for a three-year term. The Council provides the continuing direction for the Organization and is aided in its work by various Committees it has established and by the Air Navigation Commission.

A number of international organizations participate in the work of the Organization through their role as observers at many of the meetings of the ICAO bodies. These organizations include the International Air Transport Association (IATA) which is an organization of international airlines, and the International Federation of Airline Pilots Associations (IFALPA) among others.

The work programme of the Organization is carried out by a Secretariat of some 500 headquartered in Montreal and some 125 secretariat in the six Regional Offices in Bangkok, Cairo, Dakar, Lima, Mexico and Paris.

Air Navigation

I think it is fair to say that the main thrust of the work of ICAO has been in the field which we term "air navigation". In this field ICAO deals with the technical standards and practices for all aspects of international civil aviation operations - in the operation of aircraft, aircraft airworthiness and the numerous facilities and services required in their support such as airports, telecommunications, navigational aids, meteorology, air traffic services, search and rescue, aeronautical information services and aeronautical charts.

Recommendations for Standards and Recommended Practices of international air navigation are made by the Air Navigation Commission and are adopted by the ICAO Council as annexes to the Convention on International Civil Aviation.

The work of ICAO in air navigation also involves the detailed planning of facilities and services and the formulation of procedures to support increases in traffic density, new air routes and the introduction of new types of aircraft. This planning function is facilitated by regional air navigation meetings which are held periodically in each of the nine regions of ICAO. The Air Navigation Plans which result from these meetings are reviewed by the Air Navigation Commission and presented to the Council for approval.

Technical Assistance

ICAO has participated in the multinational effort to assist technologically developing nations of the world primarily through its role as the Executing Agency for aviation projects of the United Nations Development Programme (UNDP). The degree of ICAO's participation is determined by the individual requests submitted by the Governments of developing countries, which are responsible for deciding what portion of the total assistance made available to them by the UNDP should be used for civil aviation.

ICAO's work in the field of technical assistance covers a number of different activities. One of the most important activities is to supply aviation experts to developing countries to carry out the aviation component of their country programme. Our work in technical assistance also includes operating training courses for civil aviation personnel, such as the Civil Aviation Safety Centre in Beruit which provides training in air navigation and in air transport economics. ICAO currently has a roster of some 165 experts engaged in technical assistance around the world. While much of the aid provided by ICAO has been of an advisory nature, some projects have called for assistance of an operational nature, involving the actual discharge of executive functions within the departments of civil aviation. To give you an idea of the scope of our activities in this field, current ICAO projects include among others: development of STOL operations for a domestic airline, initial operation of air navigation and aeronautical meteorological services at a new airport, design of an air terminal complex, and establishment of remote communications switching centres.

Legal

The Legal Committee of ICAO advises the Assembly and Council on the interpretation of the Chicago Convention; it studies and makes recommendations on other questions of public international law brought to it by the Assembly or the Council; and it also considers problems of private law affecting international civil aviation.

Although the Legal Committee has a number of items on its general work programme, an item of major concern currently is the problem of unlawful interference with civil aviation - including the subject of hijacking. As early as 1963 the Aviation Community adopted the Tokyo Convention on offenses and certain other acts committed on board aircraft. This Convention contains some limited but nevertheless useful provisions on unlawful seizure of aircraft. However, due to the sharp increase in the number of incidents of unlawful seizure of aircraft in later years, a detailed convention concerning unlawful seizure was developed at the Hague Conference of 1970. This Convention is concerned with acts performed by a person on board an aircraft and while it does not contain specific penalties, it does contain an undertaking by each Contracting State to make the offence of unlawful seizure of aircraft punishable by severe penalties. The States however, were unwilling to make provision for automatic extradition of the suspected hijacker.

In Montreal in September 1971 States adopted the Convention for the Suppression of Unlawful Acts Against the Safety of Civil Aviation. The Montreal Convention is intended to supplement the Tokyo and Hague Conventions and is aimed at suppressing such acts as sabotage, armed attacks, or any act which could endanger the safety of an aircraft or damage or destroy an aircraft.

Work in ICAO on these problems is continuing. For example, on the 19th of June the Council directed that a special sub-committee be established to look into the question of multilateral action to eliminate havens for hijackers.

Air Transport

ICAO's work in air transport covers a wide range of subjects including: facilitation, the joint financing of air navigation services, airport economics and the economics of en route navigational facilities, air transport statistics and air transport studies.

Our work in facilitation is aimed at simplifying the entry and departure of international civil aviation traffic. Broadly speaking, the facilitation programme aims at 1) eliminating all unessential documentary requirements, 2) simplifying and standardizing the remaining forms, 3) providing certain minimum facilities at international airports and 4) simplifying handling and clearance procedures at airports.

Although each State normally provides air navigation facilities and services in its own territory there are cases where States cannot afford to provide these services (which are frequently very costly) or where these services must be provided in regions of undetermined sovereignty and on the high seas. These are cases where the joint financing of facilities becomes necessary and there are currently several agreements in effect, administered by ICAO, which provide for this.

ICAO periodically reviews the financial situation of airports and has issued studies on significant individual items of airport finance - such as landing charges and non-aeronautical revenues. ICAO also publishes annually a manual of airport and route facilities charges levied by States. The organization has also become involved with on route facility costing and charging and has attempted to establish guidelines in this area.

Our work in statistics is probably best known to those outside the organization through those blue and grey Digests of Statistics we publish. These digests cover data on traffic, traffic flows, finances and fleet and personnel of the airlines, and also airport traffic and the civil aircraft on register in different countries. Recently, we have expanded our programme to begin collecting statistics on non-scheduled operations.

Over the years our air transport studies have covered a wide variety of subjects. This range includes studies on international air mail and those on the development of passenger and freight transport in various regions such as Africa, Latin America, the Middle East, Europe and, most recently, South and East Asia and the Pacific. We have also published studies on cooperative efforts in air transport and periodic reviews of the economic situation of air transport. Recent work in this area includes the publishing of a manual on air traffic forecasting which I will describe in some detail a little later on, and an examination of the feasibility of undertaking studies on fares and rates in international air transport. Our future programme of air transport studies includes the continuation of the series of regional studies on the development of international air passenger and air freight transport, and the preparation every three years of a new Review of the Economic Situation of Air Transport.

Most of the substantive work described above is carried out by the Secretariat of the Air Transport Bureau at Headquarters. However, by the end of the year we will have an Air Transport Officer stationed in each of the six Regional Offices I listed earlier. The main functions of these officers is to lend general air transport assistance to States in each region and to serve as a liaison between civil aviation administrations and ICAO Headquarters in Montreal.

In a further effort to give assistance to Member States in air transport we have arranged a number of small, informal workshop meetings on such subjects as statistics and airport economics in an effort to bring civil aviation personnel into direct contact with the specialized staff at Headquarters.

ICAO has also lent assistance in the creation of regional civil aviation bodies - notably the European Civil Aviation Conference (ECAC) and the African Civil Aviation Commission (AFCAC). These organizations, which are independent of ICAO but work closely with it, consider the problems of international air transport from the point of view of their respective regions.

Brief Description of ICAO Forecasting Activities

Now that you have a general idea of the work we do, I would like to give you a brief description of our forecasting activities to date in the fields of air navigation, technical assistance and air transport.

In preparing for the regional air navigation meetings which I mentioned earlier, the Secretariat normally prepares a five year forecast showing the frequency of service over each of the routes in the given region. These short term forecasts are derived from information provided both by States and by the carriers on their anticipated future operations. Two forecasting groups - the EUM Traffic Forecasting Group and the NAT Systems Planning Group - have been created by some of the States in the European and North Atlantic regions, respectively, to prepare long-term forecasts of the peak traffic demands. These forecasts are then used in establishing the long-term systems requirements for air navigation facilities and services in the region.

In the technical assistance area the forecasting work being done is really an integral part of the work of the technical assistance experts. What frequently happens is the developing country requests a technical assistance expert, usually an aerodrome engineer, to give them some guidance on planning for their future airport facilities. Of course, one of the necessary prerequisites for this type of planning is the preparation of a traffic forecast for the airport in question so that the requirements for such items as passenger and cargo handling facilities, runway length etc., can be developed. Although we do have air transport economists among our technical assistance staff, there is such a great demand for their services relative to the number we do have, that it is frequently the aerodrome engineer who must prepare the forecast. This coupled with the factor that the data are frequently faulty, incomplete or even non-existent and that the time in which the work must be completed is frequently very short, makes this work extremely difficult. There does not seem to be any simple solution to these problems in the short-run, at least.

Prior to producing our Manual on Air Traffic Forecasting (which I will describe in a moment) the bulk of the forecasting work of the Air Transport Bureau was done in conjunction with our other studies, some of which I mentioned earlier. An exception to this was the circular we prepared in 1966 on traffic forecasts for the North Atlantic covering the period to 1975. This study, which included forecasts for passengers, cargo and mail, was based on trend analysis modified by some explicit assumptions we made regarding relevant economic parameters such as price elasticity, fare changes and the timing of the introduction of new aircraft types.

Our studies of passenger, cargo and mail development in the different regions normally contain a discussion of the forecasts made by others for the given region. For example, in our latest study of the East and South Asia and Pacific region, we discuss four recent forecasts made for the area by Boeing, McDonnell Douglas, the Economist Intelligence Unit and by Curtis Greensted Associates. In addition, we present some information supplied by the States in the region estimating the probable growth of airport and airline traffic through 1980.

Our triennial reviews of the economic situation of air transport have presented our <u>own</u> work in forecasting the future volume of passenger, freight and mail traffic. These forecasts are based on trend projections coupled with explicit assumptions regarding the development of key economic variables; a procedure we used in our North Atlantic forecasts.

From this you can see that we are certainly not newcomers to the field of air transport forecasting. On the other hand, I think we would be the first to admit that, in the past, we have concentrated on extremely simple forecasting techniques.

Currently, as a result of a recent Assembly resolution, we are beginning to strengthen our forecasting capabilities. An initial step in this direction is the recent publication of our Manual on Air Traffic Forecasting which I would now like to describe for you in some detail.

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The ICAO Manual on Air Traffic Forecasting

The Assembly of ICAO, at its sixteenth session held in Buenos Aires in 1968, set up two requirements for the Organization's work in forecasting - one was the preparation of medium-and long-term forecasts of future trends and developments in civil aviation, both on a global and on a regional basis, and the second was the development of material on current forecasting methods to be used in the Organization's own forecasting work and to be disseminated to member States for guidance in their own forecasting.

As a partial fulfilment of the second requirement the Secretariat developed a Manual on Air Traffic Forecasting, which was published and distributed to member States in the spring of this year.

The manual is primarily addressed to directors of civil aviation as well as to others in civil aviation administrations and to planners of airports and route facilities. The purpose of the manual is to provide a survey of the techniques currently in use in medium-and long-term forecasting and to give practical guidance on the application of these techniques. Discussion of theoretical problems or of methods which are not readily and quantitatively applicable has been avoided to the greatest possible extent.

Our objective at this stage is certainly not to advance the state of the act but rather to make more effective use of what has already been developed and our manual is the initial step in this process.

The manual is divided into two basic parts - the first part deals with forecasting by trend projection, the second part with methods of traffic forecasting based on studies of the factors governing traffic development. The second part includes a chapter on the technique of formulating mathematical relationships between the traffic variable and the underlying factors which we have called "Econometric Forecasting". Other techniques included in the second part of the document are based on specific studies of individual sectors of the air transport market or on studies of plans and expectations of the parties engaged in the air traffic activity.

Trend Projection

In the material dealing with forecasting by trend projection the various types of trend curves such as the linear, exponential, modified exponential, Gompertz and Logistic are described both mathematically and geometrically and the methods of fitting trend curves to observed data are described. One appendix describes and illustrates a simple method of fitting a Gompertz and a modified exponential curve to observed data. The least squares method for curve fitting is demonstrated in another appendix using, as an example, the passenger traffic development at Geneva airport. While the method and rationale for calculating both regression coefficients and the coefficient of determination are described in the appendix, readers are referred to standard statistics textbooks for a more complete discussion of significance tests and confidence intervals. It was felt that a discussion of probability theory which, of course, is necessary for an understanding of these two topics, went beyond the scope of the manual.

Econometric forecasting

The bulk of the material in the manual deals with what we call the econometric technique in forecasting. In addition to describing the different models which have been developed in this area, practical guidance is given regarding the problems of applying this technique.

Whether applied to passenger air transport, freight transport, general aviation or other aspects of civil aviation, the conduct of an econometric forecast comprises, in principle, four phases: first, there is the identification of the underlying factors (independent variables) to be taken into account in forecasting the air traffic activity (dependent variable); second, the determination of the type of functional relationship existing between the dependent and independent variables; third, there is the empirical testing of the relationship between the dependent and independent variables, including the evaluation of coefficients and exponents; and fourth, the forecasting of the values for the independent variables and the subsequent derivation of the traffic forecast.

In an attempt to provide a summary of the independent variables most frequently used in econometric forecasts, we developed a table which showed, for each type of influence on traffic (eg. size and spending ability of the market), the different variables used to represent that influence (eg. population,disposable personal income). The list was not intended to be exhaustive but rather to indicate the range of variables that can be used.

In determining the type of functional relationship between the dependent traffic variable and the independent variables, emphasis is placed on judgment and experimentation,taking into account the experience gained from earlier forecasting work. In order to give the reader an idea of the range of models already in use in forecasting, we present a dozen different models under four headings: non-directional passenger forecasts (i.e. those dealing with the overall volume of traffic generated at a certain place or in a certain region), directional passenger forecasts (i.e. those concerned with traffic on specified routes or between specified regions), a model for non-directional air freight forecasts, and a model for forecasting general aviation activity. While we have nearly 400 documents on forecasting in our files, it should be stressed that the list of models included in the study is far from exhaustive - some of the comments we have already received on this study amply demonstrate this point.

Six different models for forecasting non-directional passenger traffic are presented. The first model, developed by the Air Transport Association in 1969, was used to forecast domestic passenger traffic in the United States. It is a very simple model - it makes passenger revenue a multiplicative function of Personal Consumption Expenditure in the United States. Testing the model on U.S. data gave an elasticity of passenger revenue to Personal Consumption Expenditure of about 2.0.

The second model was developed by the Institut du Transport Aérien (ITA) in 1971 for predicting future growth rates for a country or a region or between countries or regions. The model was intended to be used for three to five year forecasts. This model relates the traffic in a given year to the traffic in the initial year in a multiplicative fashion through a series of three coefficients. The first coefficient reflects the changing propensity of the market to travel due to exogenous factors; the second reflects changes in the air transport services available; and the third reflects the changing penetration of air transport into the overall travel market. Although the future values of these coefficients are left more or less to a subjective judgment, ITA gives some guidance as to how they might be calculated. The first coefficient - representing the influence of exogenous factors - is presented as a function of the growth rate of a general economic indicator (such as Gross Domestic Product) and of the growth in the proportion of consumption devoted to travel. The second coefficient - representing the availability of air services - is presented as a function of the change in air fares during the forecast period and the relevant price elasticity which, for the domestic traffic cases studied, was found to be between -0.6 to -1.7. The third coefficient - representing the penetration of air transport - could be estimated by estimating the total potential travel market and through a subjective evaluation both of the development of surface/air competition and of political factors.

The third model for forecasting passenger traffic volume was prepared by Bo Bjorkman for the European Civil Aviation Conference (ECAC) in 1970. This model makes the dependent variable, passenger-kilometres a multiplicative function of disposable income, disposable income per capita, and yield (average revenue per passenger kilometre). Using data on European air travel Bjorkman obtains a price elasticity of -1.5 and an income elasticity of 0.6. This model was also tested against U.S. domestic and international air travel from 1962 to 1968 and gave elasticities of similar magnitude to those for European travel.

The fourth model, intended for forecasts of long-term developments of long-distance international air travel demand in the United States, Europe and elsewhere was presented by the National Planning Association (NPA) in 1971. This model makes the dependent variable, total air passenger miles, a multiplicative function of discretionary income and an index of the cost of air travel which is defined by the level of fares plus the value of elapsed air travel time. The NPA tried alternative models, which included time and a variable reflecting the business cycle, but these models were found no better than the simpler model they adopted.

The values for income elasticity were developed from cross-sectional data (i.e., studies of the frequency of air travel in different income groups at a certain time). The income elasticities were found to be between 1.2 and 1.6.

To determine the price (cost) elasticities, the value of time was equated to a typical hourly wage rate for air passenger. The resulting price (cost) elasticities were between -0.8 and -1.8.

The fifth model was developed by Sam Brown and Wayne Wathins of the CAB in 1968. In this model the dependent variable, the change in annual passenger miles per capita, is a multiplicative function of the change in the average fare per mile, the change in disposable personal income per capita and a residual term representing time. This model differs from the others in that it relates the change in traffic to the changes in the independent variables while the other models related traffic levels to the levels of the independent variable. One result of this difference is the fact that the intercept value in this model represents a time influence on travel while this is not so for the other models.

The coefficients developed by applying the model to U.S.data for the 1946-1966 period imply that if fares and income had been constant in constant money value, the traffic would have increased by something less than 5 per cent per year. The coefficient on the time variable was negative, implying that this "automatic" growth rate tends to decrease over time.

The final non-directional passenger forecast model was developed in 1968 by Wallace and Moore of the Boeing Company. The dependent variable in this model is an unusual one - revenue passenger miles per unit of Gross National Product - and its percentage change is given as a function of the percentage change in the quality of service plus the percentage change in fare multiplied by the fare elasticity. A notable feature of this model is, of course, the use of a quality of service variable in the formulation. The quality of service is defined as a weighted index of a number of items - among them are the number of seat departures, schedule reliability ("on time"), flight time, cabin noise and ride comfort. In total there are nine quality items.

There is a peculiarity regarding the price elasticity in this model since it is given a different value for price increases than for price decreases. For price increases the elasticity was given as -1.0 while for price decreases the value was -2.0. The measure of "quality" in this model was developed through judgment and specifically related to U.S. traffic. For this reason, and because data on a number of quality elements might be difficult to obtain, we felt the application of the model precisely as it was presented might prove difficult.

The section on directional models of passenger traffic starts off with a somewhat detailed description of the classic gravity model where the number of travellers between two points is positively related to the product of the populations in the two cities and inversely related to the distance between the cities. It is pointed out that while the basic gravity model is not really applicable to medium-or long-term forecasting, modified versions of this model have found rather widespread use. Since the variety of modifications to this model have been so great it was only possible to give a general indication of the range of these modifications.

A model for forecasting air travel between pairs of countries which is based on the gravity model, as well as on the non-directional model developed by Bjorkman previously described, was presented by the European Civil Aviation Conference in 1970. This model includes as independent variables: the populations of the two countries, the Gross National Products, a typical fare for air travel between the two countries and the price elasticity of demand. Coefficients for this model were developed using data on intra-European traffic. It was found that the value for price elasticity which best explained the distribution of traffic at a certain point in time among different European States was 2.0, whereas a representative value for predicting the development of traffic over time for one pair of States was 1.6. Regarding the applicability of the model, it was found that this model, which does not take into account competition from surface transport, tends to over-estimate the traffic on short distance routes.

A method for forecasting the total travel by public transport between two cities, as well as the air transport share ,was developed by Eric Culley and presented by the Canadian Transport Commission in 1970. This method was intended for application in Canada but it can be applied wherever there is significant competition between surface and air transport. The method takes into account the time and cost involved in using the various modes as well as their frequency of service. It also includes the populations of the cities involved and the different income levels of the cities. Finally the model takes account of the linguistic similarities of the two cities.

Use of this model involves two separate estimating procedures. One is to estimate the total traffic between the two cities regardless of the mode used and the other to estimate how the total traffic is to be split among the various modes (bus, rail and air in this model).

The modal split model estimates the share of each mode on the basis of what the author calls their "level of service". For a given mode, the level of service is a multiplicative function of a constant (which differs for each mode with the lowest value for bus and the highest for air), the average trip time, the average trip cost, and the daily frequency.

The model for estimating the total traffic between two cities regardless of mode includes seven independent variables: the product of the populations of the two cities, an index of linguistic community of the cities, the percentage of families above $12,000 income, highway driving time between the cities; both average trip time and average trip cost by public transport (weighted according to the modal split), the perceived total trip cost by automobile (approximately 1.5 cents per mile per person) and finally, the level of service (as defined in the model split) for the entire public transport system. Since the exponents were developed for transport in eastern Canada it is likely they would have to be adjusted for application elsewhere.

Another model, intended for use on routes with effective surface competition, was presented by Abraham, Baumgart and Blanchet in 1969. This model, which originally was applied to French domestic traffic, is more micro-economic in character than the other models presented in the sense that it deals with the market on a route as a spectrum of users, each of whom behaves in accordance with his economic status.

The basic assumption is that the traveller's time can be assigned a value which is directly related to his income and that the traveller will choose that mode which minimizes the "generalized" cost of the trip where cost is defined as the fare plus this value of time in transit. The model further assumes that the frequency of travel is directly proportional to the individual's income (raised to a certain power) and inversely proportional to this "generalized cost" to the 2nd power.

A further factor determining the number of travellers on a route is the product of the populations raised to a certain power. Finally the model assumes that the income distribution, and therefore the value of time distribution, in a developed country like France can be approximated by Praeto's law.

As I stated earlier, we presented only one model for forecasting freight traffic. This is due to the fact that there have been relatively few econometric models developed for forecasting freight perhaps because the factors governing both the demand and supply for air freight capacity are so complex. However a model for predicting the development of domestic air freight in the United States was developed by Irving Saginor and David Richards of the CAB which is similar to the other CAB model we presented in that it relates changes in traffic to changes in the independent variables. This model makes the change in annual freight-ton-miles a multiplicative function of the change in the rate per ton-mile and the change in the gross national product. The results of the application of this model to the 1946-1969 air freight experience in the United States imply that if freight rates and GNP had remained constant over the period the volume of air freight would still have grown by about 6.7 per cent per year under the influence of factors not accounted for in the model.

We presented one example of the use of the econometric approach to the problem of forecasting the number of general aviation operations in a district. This approach was developed by Baxter and Howrey in 1967 and consisted in testing different combinations of five independent variables against the dependent variable-the number of general aviation operations. The independent variables tested were: the population of the district, the per capita income of this population, the number of airports in the district, an index of the quality of those airports and the proportion of the employment in the district being in agriculture.

Different models were tested by cross sectional analysis of the general aviation activities in 485 countries in Eastern United States. In general, the multiplicative rather than additive function proved superior. Generally, models including all the independent variables mentioned except agricultural employment were found to explain the differences between general aviation operations in the countries reasonably well.

We point out in the manual that this model could also be used for forecasting the effect of building a new airport in a district or for medium-or long-term forecasts of general aviation at existing airports if time series data is used.

After presenting these forecasting models we discuss the application and testing of econometric models and the forecasting of independent variables. It is pointed out that every forecasting problem is to a certain extent, unique, and that a good deal of care and judgment should be exercised before attempting to apply these results to a different set of circumstances.

Once the model has been selected and the independent variables are defined, it is necessary of course to evaluate the constants and coefficients in the model. Although the forecaster is not entirely in the dark since he can develop some expectations regarding the range of values of these coefficients based on the examples given, the uniqueness of each forecasting situation requires a new estimation of these values. We point out that since the relationship between the dependent and independent variables can frequently be expressed by a linear equation (eg. a multiplicative relationship which is linear in its logarithms) the coefficients can be developed through multiple regression. An appendix explains the concepts behind multiple regression and gives a step-by-step demonstration of the calculations involved. Because of its complexity, tests of significance are described in very brief terms and the reader is referred to standard statistics textbooks for further elaboration.

In discussing the testing of models we covered a number of problem areas including the importance of sample size, time series vs. cross-sectional analysis and the problems created by omitted variables and misspecification. We try to caution the reader against placing too great a faith in the accuracy of any model and point out that, in fact, there is just no adequate substitute for good judgment.

The final section of our manual describes two approaches to forecasting which do not involve the formulation and testing of mathematical models.

The Port of New York Authority in 1957 carried out an air traffic forecast of U.S. domestic traffic which was based on a detailed market study. This approach was chosen because of the availability of abundant information on the characteristics of air travellers. For the purpose of the forecast, all air travel was divided into personal and business travel. To analyse personal travel, the entire population was divided into 160 different groups, each characterized by a certain combination of age, occupation, income and education. To analyse business travel the total labor force was similarily divided into 130 groups, each characterized by a certain combination of occupation, income and type of industry.

All the 290 groups were so chosen that the travel habits with respect to personal travel or business travel according to travel surveys were uniform within each group. Travel surveys had further shown how the travel habits tended to develop within each group and on this basis, as well as on the basis of forecasts of future numbers of people in each group, the forecast for the total volume of air travel could be derived for the period 1957 to 1975. The actual traffic development up to 1970 confirmed that the forecast was fairly accurate.

An example of a market analysis approach to air freight forecasting was outlined in an ICAO study of air freight in the Europe-Mediterranean region issued in 1970. It was shown there that in North Atlantic trade, the share of a commodity group carried by air was fairly closely related to the average value per unit weight. Above a certain average value per unit weight, the use of air transportation increased rapidly. Using available information on the distribution of all trade with respect to value per unit weight, and assuming that the values above which air transportation tends to be competitive will decrease if the air transport rates also decrease, it was possible to estimate the potential future demand for air freight capacity. In the ICAO study, the analysis was not aimed at actually preparing a forecast but rather at verifying that other forecasts were plausible. However, the approach may serve as an example of a possible avenue for air freight forecasting through market studies.

A second approach to forecasting discussed in the manual is that based on the opinions or plans of qualified experts in the field.

ICAO uses this approach for forecasting the future requirements for the air navigational facilities and services of international civil aviation. ICAO periodically collects information from States and operators on their anticipated future operations, consolidates this information, and forecasts the future level of activity at different airports.

The International Air Transport Association also uses a similar approach in providing a forecast service for airport authorities to assist them, at their request, in developing master plans for their airport development. In preparing these forecasts, IATA circulates a number of questionnaires to member airlines serving the airport requesting information on their future services and their requirements for airport facilities and services.

This information is consolidated by IATA and used to establish forecasts of essential aspects of airport activity required for airport master planning.

Future Forecasting Work in ICAO

As the forecasting work of the Organization in the past has been fragmentary and limited, it is the firm intention of the Organization to make a much more solid and consistent contribution in this field in the years to come.

In accordance with the directives given to us by the Assembly, the future activities in civil aviation forecasting will serve three objectives:

1) a more extensive and improved treatment of forecasting aspects in studies carried out by the Organization;

2) as a service to our Member States, a systematic collection and dissemination of material on aviation forecasting;

3) a contribution to the science of forecasting by organizing meetings where forecasting experts can exchange views on methods and techniques.

The first of these objectives will be met primarily by involving our forecasting officer in most of the economic and other studies being carried out as part of the regular ICAO work programme and particularly in our studies of the development of international air transport in various regions of the world. A special effort will also be made to take a close look at the overall prospects for international air transport in connection with the general Reviews prepared every three years for the Assembly.

The second objective will be met partly by periodically updating and improving the Manual I already described to you. In addition to this, we are also envisaging a great increase in ad hoc requests for guidance material which can be used for forecasting work by national administrations in our Member Countries.

The third objective we will try to meet by organizing about once every year informal meetings where a limited number of people active in aviation forecasting will get an opportunity to discuss matters of principle and techniques in forecasting work. The Organization has had experience with such informal international meetings in other fields and we hope that this type of meeting will also prove fruitful in fostering a better and wider application of good and sensible forecasting techniques.

You will see from this that our ambitions for the future are quite high compared with what we have accomplished in the past. We do, however, realize that our resources are very modest and that our muscle may not be quite compatible with our ambition, but we will do our best.

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July 14, 1972

ROB RANSONE:

"American Airlines' Propeller STOL Transport Economic Risk Analysis"

When American Airlines evaluated STOL Transports, we received 13 proposals for our state-of-the-art-technology Propelled STOL Transport (PST) that could be available by 1975. We evaluated these, cut the list back to 3 airplanes on which we did a detailed risk analysis. It is this risk analysis I'm going to talk about today. The studies that have been made by various people on market demand and modal split did not provide the information that American needed, because they started off with assumtions that people would pay a certain fare premium for STOL, and then calculated the size of the market. American had no doubts whatever that there was a large market. Their question was, "Would passengers pay a STOL premium fare?" The real question was completely opposite from the data that was provided. Furthermore we wanted to look at specific rather than hypothetical areas and hypothetical airplanes, because we were afraid that you would end up with hypothetical people and hypothetical profits that way. We felt that

STOL was necessary in the New York area because the demand was for the city center operation rather than for an RTOL operation at the suburban airports. Furthermore we had reason to believe that you could put a city center STOLport in Manhattan, although not in Chelsea. The Chelsea reaction was not because it was a city center STOLport, but because it was a residential STOLport. There is an area at Hunters Point, on the East River (Queens) that is not a residential area and could be expected to have no community reaction against a STOLport. We looked at the market share: I'll explain later how we got this. Where we had numbers with a fair amount of confidence, we used those numbers. Where there was uncertainty we used a probability analysis. For instance, we determined a most likely value for the O&D market, a pessimistic value and an optimistic value. In the analysis 80% of the data came from the most likely level, 10% from the pessimistic and 10% from the optimistic. We looked at the spares cost in a similar probablistic fashion. Other uncertain economic factors were the size of the O&D market, the direct operating cost, and the indirect operating costs. Values of which we were confident or were fixed values were fare levels, the available seat miles offered, the aircraft cost, the aircraft resale value, the investment tax credit rate and the interest rate. We assumed 50% equity, and financing for 50% at a 10% interest rate. These were fully allocated costs. We developed the internal rate of return on investment. We used internal rate of return because we felt it was more representative of the actual profit and loss of the operation. The usual measure, return on investment, has to assume a certain depreciation rate of the aircraft, but internal rate of return is a function of discounted cash flow. It tells you whether you are making profits this year or next year and is therefore of more interest. We ran 3 airplanes (the Canadair CL-246, the McDonell 188 and the DeHavilland DHC-7) through the computer 100 times each, on a Monte Carlo risk analysis. Monte Carlo is a type of gambling procedure where the computer with random access selects values that you give it. It can select these values with certain probabilities. In this case it was directed to select 80% of the O&D share out of the most likely value and 10% out of each of the pessimistic and optimistic. You never know whether it is going to pick a number from the top here and the bottom there or something else, but in the long run you end up with a probability distribution which shows that the probability of making a certain expected internal rate of return is predictable. The 10% bound indicated that 90% of the cases were above this value and therefore there was a 90% probability of making this level of internal rate of return, or better. We plotted a mean and the 10th and 90th percentile. This was plotted versus fare premium over CTOL, and number of seats offered.

Now, I will discuss some of the input functions. There was a typical mission profile. You start the engine in Washington. There was a fixed climb and maneuver to get on the flight path below 1500 feet, then climb and cruise, a 5 minute hold at 5000 feet which was a delay factor built in, and then landing at New York. There was a 10 minute time in New York, no refueling, just change passengers, and takeoff, and climb. And return to Washinton, five minutes hold and either descend and land or divert. There was a half hour spent on the ground here to service the airplane for the round trip. The total non-cruise allowances were 10 minutes regardless of where you flew. The initial assumption was that there would be two STOLports in Manhattan, one downtown STOLport and one in the suburbs. Immediately it was discovered that since no one really wanted to go to the suburbs the airplanes would be empty, and therefore the STOL airplane would have to deadhead over to the suburban STOLport. Even if it is a 10 minute flight over there, if you have a 10 minute system time, it becomes a 20 minute flight to the other STOLport. If the time from Washington to New York was roughly 40 minutes of flying plus 10 minutes system time, or a 50 minute total flight, and if we add the other 20 minutes deadhead, the total is 70 minutes of cost time but only 40 minutes of revenue time. This is right back where we started now with the 70 minute block time scale for B-727s between New York and Washington. Thus we assumed that there would only be one city center STOLport in New York and one in Washington. The range is 180 nautical miles between New York and Washington. We set up a schedule with these airplanes by chasing tail members back and forth between New York and Washington. We assumed that there would be no market sensitivity due to the frequency because the frequencies were from every half hour, every 20 minutes, every 15 minutes and every 10 minutes; and because of this very high frequency no one really cared whether they missed one airplane or not.

We calculated realistic block speeds, realistic winds and temperatures for takeoff and landing performance. The ground distance each way was 180 nautical miles. We used the highest speed cruise because fuel cost was of no consequence; time was more valuable. The 85% probability winds for the winter and for the summer were known. Because of the effect of winds on cruise performance you do not subtract 24 knots if you are going downwind, you can only subtract a certain portion of it. There's a Boeing analysis that we used for this. We ended up with equivalent air distances. These then are reflected in the times. For the DHC-7, the block time was 70 minutes (and this includes the 10 minute system time) from New York to Washington and 59 minutes from Washington to New York. We used the winter winds because this is conservative, providing the greater cycle time. If you look at the actual times, then the DHC-7 would depart from the Washington STOLport and it would arrive in New York City 59 minutes later. It has to stay on the ground a minimum of 10 minutes. It ended up staying on the ground 11 minutes here which was fine. Now, if it had arrived at 61 minutes instead of 59 minutes, it would have had to stay on the ground a whole cycle and could not have left at 70 minutes, for example; it would have to wait over. Similarly, it ended back at Washington after 140 minutes elapsed time, 30 minutes later it could leave at 170 minutes. If this happened to turn out to be 9 o'clock for example, it could leave at 9:30 and it would be the 9:30 flight. If it happened to arrive at 9:05, it could not leave at 9:30, it would have to leave at 10 o'clock, so there was wasted time. This shows the effect that just a small difference in cruise speed can have on the value of an airplane in its productive time and utilization. This is quite important.

Looking at the market, we tried to determine where the market was coming from. We did not assume any market generation or any market stimulation. We figured that from New Jersey, roughly 25% of the people would fly from Newark, perhaps 25% of the people would keep going to LaGuardia. No one was going to go out to Kennedy to fly to Washington; but 50% would probably go to the STOLport in Manhattan. From Manhattan we figured no one would go to Newark, 10% to La Guardia, none to Kennedy, but 90% would go to the STOLport in Manhattan and so on across. Remember, 90% is the probable value. Looking at the optimistic value everyone in Manhattan would go to the STOLport, and pessimistically only 2/3 would go. We did a similar thing for the Washington area and when we got through, we added these things up. Furthermore, based on the market data, more people fly from New York down to Washington then go from Washington up to New York. Perhaps, this is because in Washington we say if you want to talk to us, come in and see us. At any rate, we figured 2/3 of the people were originating from Manhattan and only 1/3 from Washington, and so this means that we ended up with about 60% of the people who wanted to fly using the STOLports, optimistically 70% and pessimistically only 43%.

The Pan Am fare sensitivity assumption input into the CAB Norhteast corridor VTOL investigation says that STOL will capture 83% of the market at a CTOL fare but only 45% of the market at a CTOL fare plus a $7.00 premium. We did not necessarily agree with this but we did not have anything better to use, so we used it. If you extrapolate historical market data you will find that in 1975, supposedly 4 million people will be flying between New York and Washington. American was a little more conservative than that. They said instead of using this 9% growth rate we will use a 4% growth rate. We predicted 2.8 million. Now, at the 83% penetration that would move the probable STOL to 2.3 million at a CTOL fare. Using the data from above about who would actually go to the STOLports for the mean dropped it down to 60%. We have the optimistic case and the pessimistic case also.

Market assessment is a pretty slippery thing to get hold of, but using the fare sensitivity then we could determine the size of the market vs. the people who pay the fare. There is another factor here which we did not put in. That was the inelasticity because of convenience. People may pay a $2, $4 or $6 premium to save some time. We ignored this to be conservative. Also, this is just the air fare which does not take into consideration any savings which the traveller might have from higher cab fares going to airports further away.

Looking at the costs, we used the CAB in 1970 dollars. We did not look at 1975 dollars because we felt that if you start looking at 1975, you have to figure out not only the inflation and the cost but also the increased air fares themselves and then what is the dollar worth then to the traveler. We felt that if it could be made profitable in 1970, then it would be similarily profitable in 1975.

We did not use American Airlines' usual overhead burden. We set this up as either a subsidiary airline or a separate airline entirely. The STOL costs had no bearing on the American Airlines costs other than just as a point of departure. The pilots' salaries are conservative in that they are the levels of the BAC-111 pilots, which would be high for a DHC-7. We felt that if the source of the pilots was American Airlines, the pilot would have to make at least as much salary as he was making already. On direct maintenance, we did not accept the numbers of the manufacturer. Instead, our maintenance people looked at the airplane, system by system, and compared it to the Electra on which we had operational data and determined the relative complexity. This then gave them a basis on which they could esitmate the direct maintenance and maintenance labor overhead.

On depreciation, we did not use the CAB rate but estimated how long we could use the airplane and what would they be worth when we sold it. We felt that if these airplanes were available in 1975, they would have a useful life of only 5 years, because we would have to sell them as soon as the jet STOL's came in, for competitive reasons. We felt that the DHC-7 would have a very high resale value based on the Twin Otter experience and with discussions with 3rd level operators and so, we felt that a 5 year depreciation to 50% was reasonable for that airplane. That approximated the CAB allowance for a 4 engine turbo prop of 12 years to 5%. On the other aircraft, however, because they are more complex, the 3rd levels could not be counted on to buy them. The market there would be in South American countries where they need an aircraft that has high performance for operation in the mountains and we felt that a million and a half was all these people could afford. Those aircraft were the McDonell 188, and the Canadair CL-246. They were depreciated in 5 years to 1½ million dollars, which was a

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variable rate depending on their initial cost, but was roughly double the CAB rate.

Now this was not what you normally see for DOC, this was cash DOC because this is cash flow accounting. The depreciation is added later so the total of $353/ block hour is not the total DOC. You have to add the depreciation, which varies from 130 to 137 dollars/block hour for the DHC-7, depending on its utilization. Utilization varied because we were flying on different frequencies. You could add the cash DOC and depreciation for a total DOC of roughly $500/ hour.

Looking at the indirect operating costs, this is an annual cost, not per hour. There are certain things that are a function of just getting started. The stewardess training for example, and the advertising and publicity. Our marketing people felt that it took quite a bit of advertising to let anybody know you are around, so there was a big initial effort. For the recurring cost, some things were fixed, some things were a function of the round trips per day and the number of passengers per aircraft. We came up then with an indirect operating cost in dollars per year in a formula to which we added a 10% contingency factor. These factors were all figured out based on the specific type of operation that was being considered. For example, with the food, there were savings because we were only loading one end. The type of service provided was not meal service but rather liquor, which would be sold, and soft drinks and coffee; very austere service. Furthermore, a savings was realized because there was no baggage checking. If you provide baggage checking for one then you must have someone there to handle all of the baggage and you then have the whole system. There would be room on the airplane for someone to put his bag, but no baggage checking. Landing fees were based on an analysis of STOLports which we had made and felt that a 65¢ per passenger was reasonable.

What did all of this come up to be? Looking at the internal rate of return as a function of the annual seats and the flight frequency, it looked like Figure 10. The numbers in parentheses are the load factors. We restricted load factors to greater than 45% and less than 80%, 80% is a little high, but the American Airlines' Jet Express average load factor between New York and Washington is 70%. We felt that since this was running back and forth, and since we had the option with this high frequency of cutting out a flight, or a round trip at off peak times, we could maintain a higher load factor. 80% was the cutoff point. The value of the internal rate of return (IRR) that you see is a little bit higher than you see normally for return on investment (ROI). ROI is not directly relatable and not really convertible. If you have a 10 to 12% ROI you might say that that is roughly equivalent to maybe 24 or 26% IRR, but you have to be cautious because it is not really the same thing. Note that the size of the market varies and that we have airplanes of different sizes in here competing in a way. This method of analysis was able to handle this. Figure 11 is the internal rate of return vs. the fare premium. There is a 10th percentile line probability of making at least this return on the investment. The large spread was caused by the fact that there was considerable variation in the pessimistic and optimistic values that were put into the analysis. The little numbers in parentheses are the load factors, 44% up to 74%. This shows that even with the conservative costs, the DHC-7 had a 90% probability of breaking even at a CTOL fare. This is quite interesting. If you charge a little fare premium then you can make more but it starts dropping off at a higher level. The question comes up of course then, what happens if you cut fares; does IRR continue to increase? This would of course be interesting. Figure 11 shows the data for the DHC-7. The CL-246 was above this and the McDonell 188 was below this. This was mainly caused by the input costs for the airplanes.

Now this is where the economic analysis stops but that is not where the decision process stops, because other factors enter into it. The McDonnell 188 and CL-246 could not go into production on the basis of this one market. These airplanes will not be available because there is not enough justification. The DHC-7 is likely to go into production and therefore could be available, but this is not the size of airplane nor the image that American Airlines wanted to get involved in. If you put on a very conservative hat and look at the return on investments and the money that is already obligated for DC10s and the B-747s, it just does not make sense to buy a prop airplane. Therefore, the decision was made to terminate further study of the propeller STOL transport and concentrate on maintaining the option for jet STOL operation when it is available in the '80's. If I were a regional carrier, or someone who can offer this type of airplane, I think that the airplane would work and be very good. At American Airlines it did not work for us and so I recommended against.

The next step would be to look at a jet STOL transport and run through this same type of analysis. The prop airplanes were small, they were too small for the market. The jet STOL would be a much better size.

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STOL RISK ANALYSIS

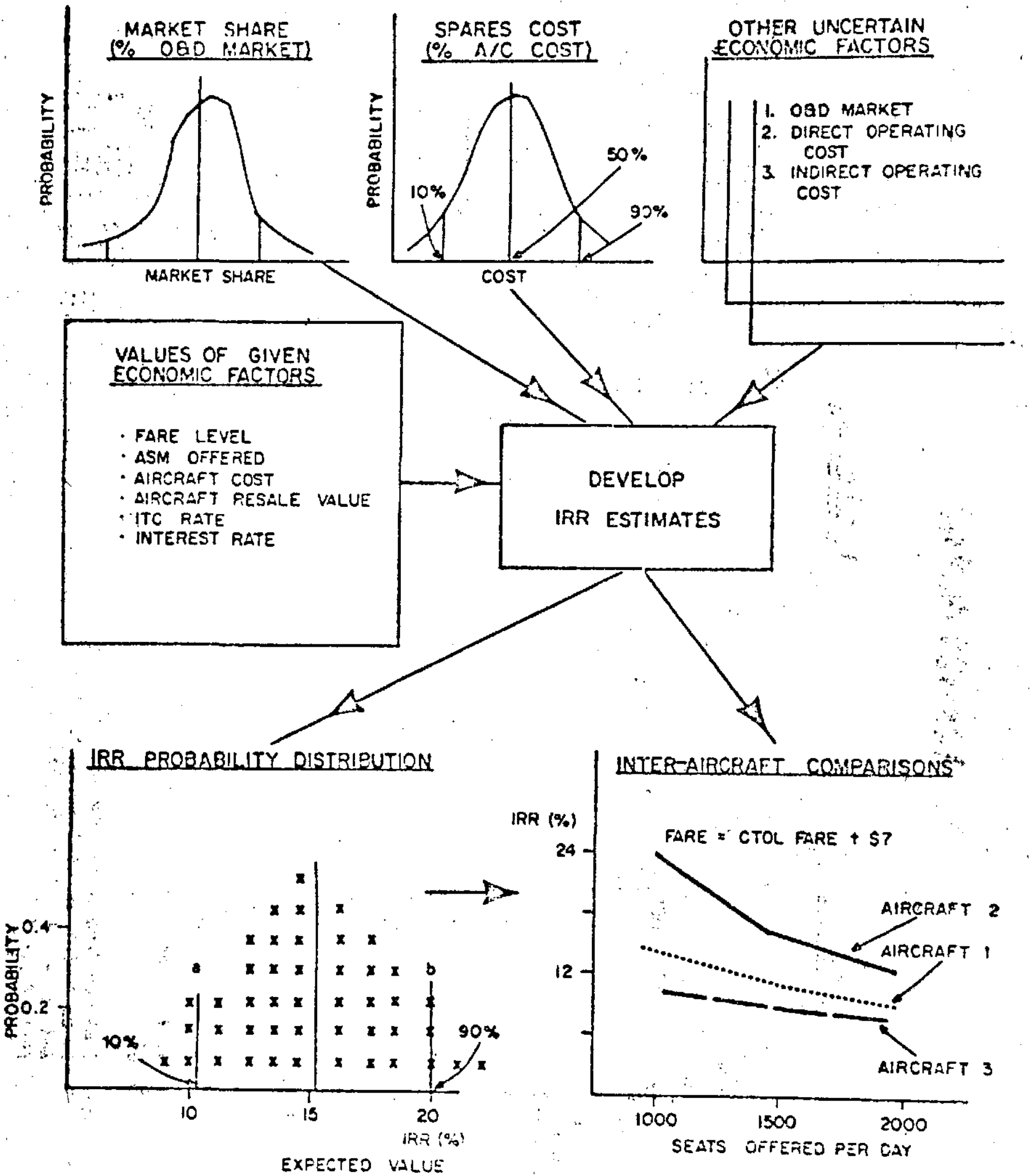

Figure 1

MISSION PROFILE

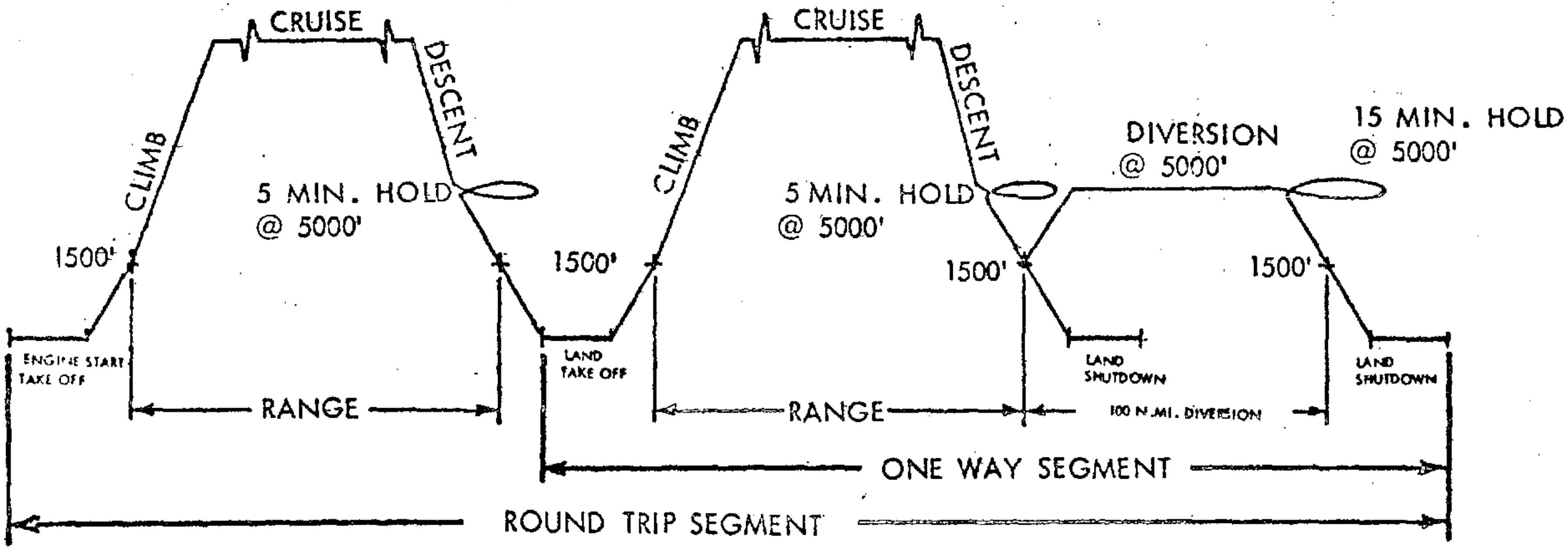

Figure 2

Allowances:

1 minute - Takeoff
5 minutes - Ground delay
1 minute - Climb maneuvering @ 1500'
2 minutes - Approach man. land & taxi in
10 minutes

Note: 5 minute congestion hold at 5000' is used to figure fuel reserves only, and it is not used to compute block fuel or block time.

Missions:

I. Round Trip Segment (unrefueled)
   (a) Range = 180 n.mi. (DCA-NYC-DCA)
   (b) Range = 50 n.mi.

II. One Way Segment
   (c) Range = 50 n.mi.
   (d) Range = 100 n.mi.
   (e) Range = 200 n.mi.
   (f) Range = 300 n.mi.

EQUIVALENT AIR DISTANCES

	DHC-7
Ground distance (DCA-NYC) each way - n.mi.	180
High speed cruise true airspeed - knots	235
85% January winds (NYC-DCA) - knots	-44
(DCA-NYC) - knots	+6
85% Summer winds (NYC-DCA) - knots	-24
(DCA-NYC) - knots	-1
Equivalent Air Distances:	
Winter NYC-DCA	221
DCA-NYC	176
Summer NYC-DCA	200
DCA-NYC	181

Figure 3

PST BLOCK TIMES

		DHC-7
Winter	NYC-DCA - minutes	70
	DCA-NYC - minutes	59
Summer	NYC-DCA - minutes	65
	DCA-NYC - minutes	60

Figure 4

PST SCHEDULE TIMES
(Accumulative Minutes)

	DHC-7
Depart DCA	0
Arrive NYC	59
Depart NYC	70
Arrive DCA	140
Depart DCA	170
(repetitive cycles)	(etc.)

Figure 5

1975 PST MARKET SHARE @ CTOL FARE

DCA-NYC-DCA

		From: New Jersey	Manhattan	New York & Conn.	Long Island	TOTAL
NEW YORK	EWR	25%	0	0	0	6%
	LGA	25%	10%	34%	50%	30%
	JFK	0	0	0	0	0
	STOL (Probable)	50%	90%	66%	50%	64%
	STOL (Optimistic)	60%	100%	75%	60%	74%
	STOL (Pessimistic)	30%	66%	50%	35%	45%

		From: Virginia	Washington	TOTAL
WASHINGTON	DCA	90%	10%	50%
	STOL (Probable)	10%	90%	50%
	STOL (Optimistic)	20%	100%	60%
	STOL (Pessimistic)	0	80%	40%

Figure 6

<u>Assume About 2/3 of Total O&D From NYC:</u>

Probable 1/3 (64 + 64 + 50) = 59 say: 60%

Optimistic 1/3 (74 + 74 + 60) = 69.3 say: 70%

Pessimistic 1/3 (45 + 45 + 40) = 43.3 say: 43%

PST MARKET PREDICTION
NYC-DC O&D
1975

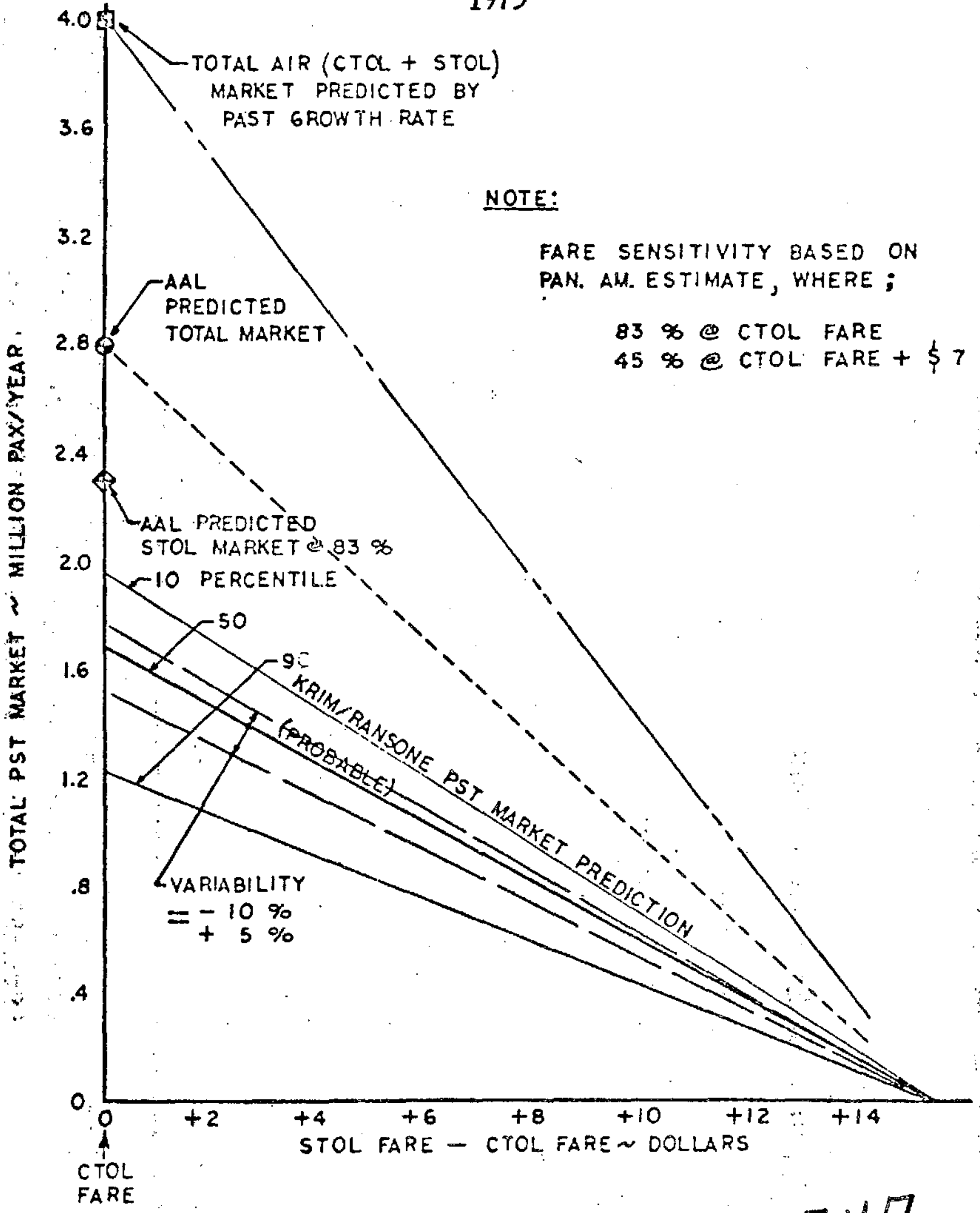

Figure 7

PST DIRECT OPERATING COST
(1970 $ @ 200 n. mi. Stage Length)

	DHC-7
5100 - Flying Operations	
2 pilots	82
Fuel & Oil	33
Insurance (@ $7.70 per $ mil flyaway cost)	17
5200 - Direct Maintenance (60% labor)	106
5300 - Maintenance Burden (1.8 x maint. labor)	115
7000 - Depreciation and Amortization	— — —
Total Cash DOC - $/block hour	353

<u>Note</u>: Depreciation was added separately during the risk analysis since it was a function of aircraft utilization. It varied from $130/B.H. to $137/B.H. for the DHC-7

Figure 8

PST INDIRECT OPERATING COST

(Annual Cost in 1970 $)

Item	One time	Recurring (add 10% contingency)		
		Fixed	$f\left(\frac{\text{R.T.}}{\text{day}}\right)$	$f\left(\frac{\text{R.T.}}{\text{day}}\right)\left(\frac{\text{Pax}}{\text{aircraft}}\right)$
5500 -				
Stewardesses			6,730	
Stew. Training	$2{,}460\left(\frac{\text{R.T.}}{\text{day}}\right)$			
Stew. Uniforms			409	
Pax Food				206.50
Pax Supplies				111.30
6100 -				
Aircraft Servicing		29,750	3,660	
Landing Fees				429.00
Facilities Costs				169.00
6200 -				
Traffic Handling		5,040		184.50
6300 -				
Servicing Admin.		62,000		
6500 -				
Res. & Sales				67.40
6600 -				
Adv. & Publicity	350,000			
6800 -				
G&A (Public Liability)		35,000		
Total IOC - $/year	$350,000 + $\$2{,}460\left(\frac{\text{R.T.}}{\text{day}}\right)$	$131,790	$\$10{,}799\left(\frac{\text{R.T.}}{\text{day}}\right)$	$\$1167.70\left(\frac{\text{R.T.}}{\text{day}}\right)\left(\frac{\text{Pax}}{\text{aircraft}}\right)$

Figure 9

DHC-7 VARIATION IN IRR AND ITS RISK WITH CHANGES IN CAPACITY OFFERED AT TWO LEVELS OF FARE PREMIUM AND MARKET SIZE

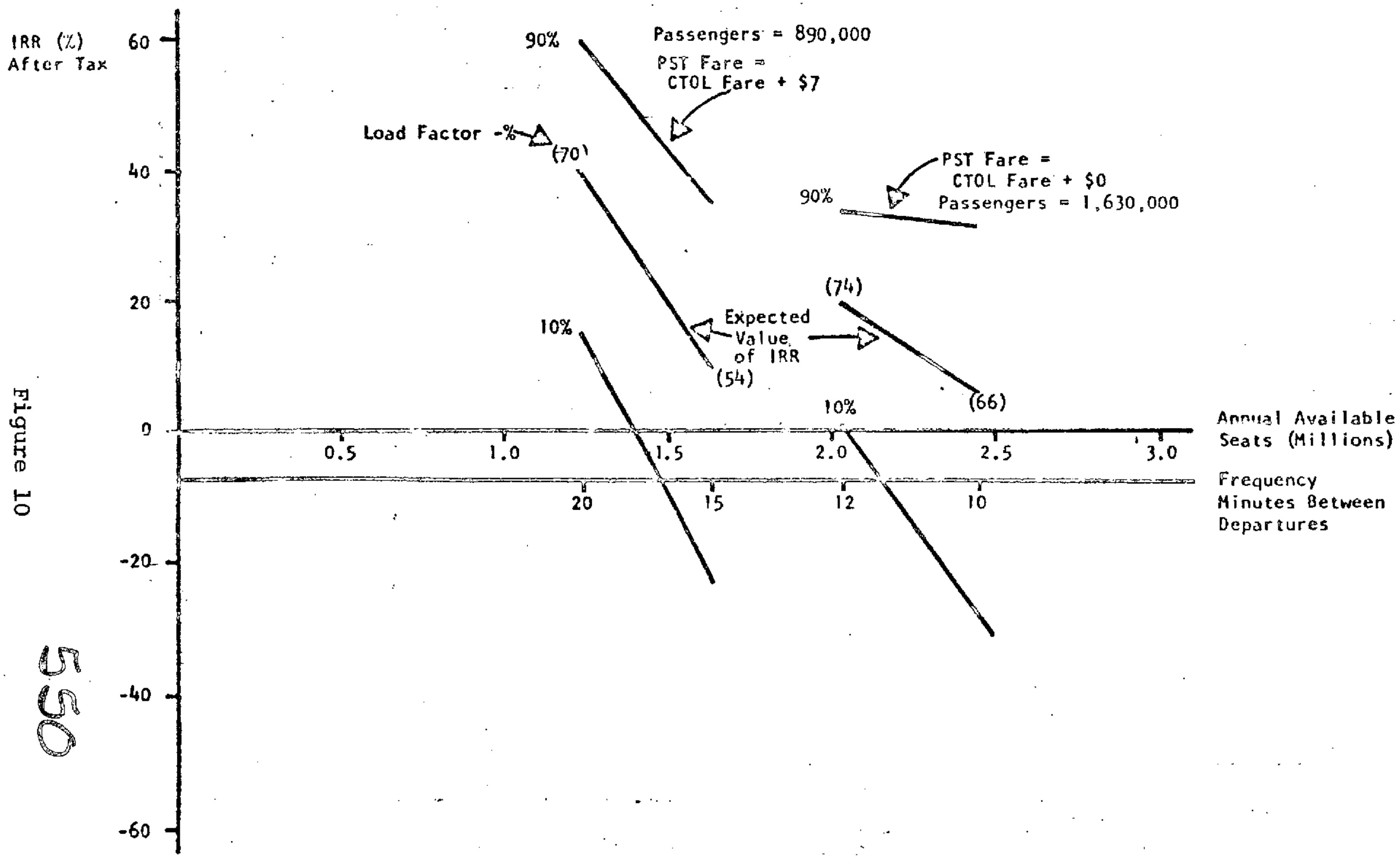

Figure 10

DHC-7 VARIATION IN IRR AND ITS RISK WITH CHANGES IN FARE PREMIUM
(Available Seats Fixed at 2,040,000 Annually)

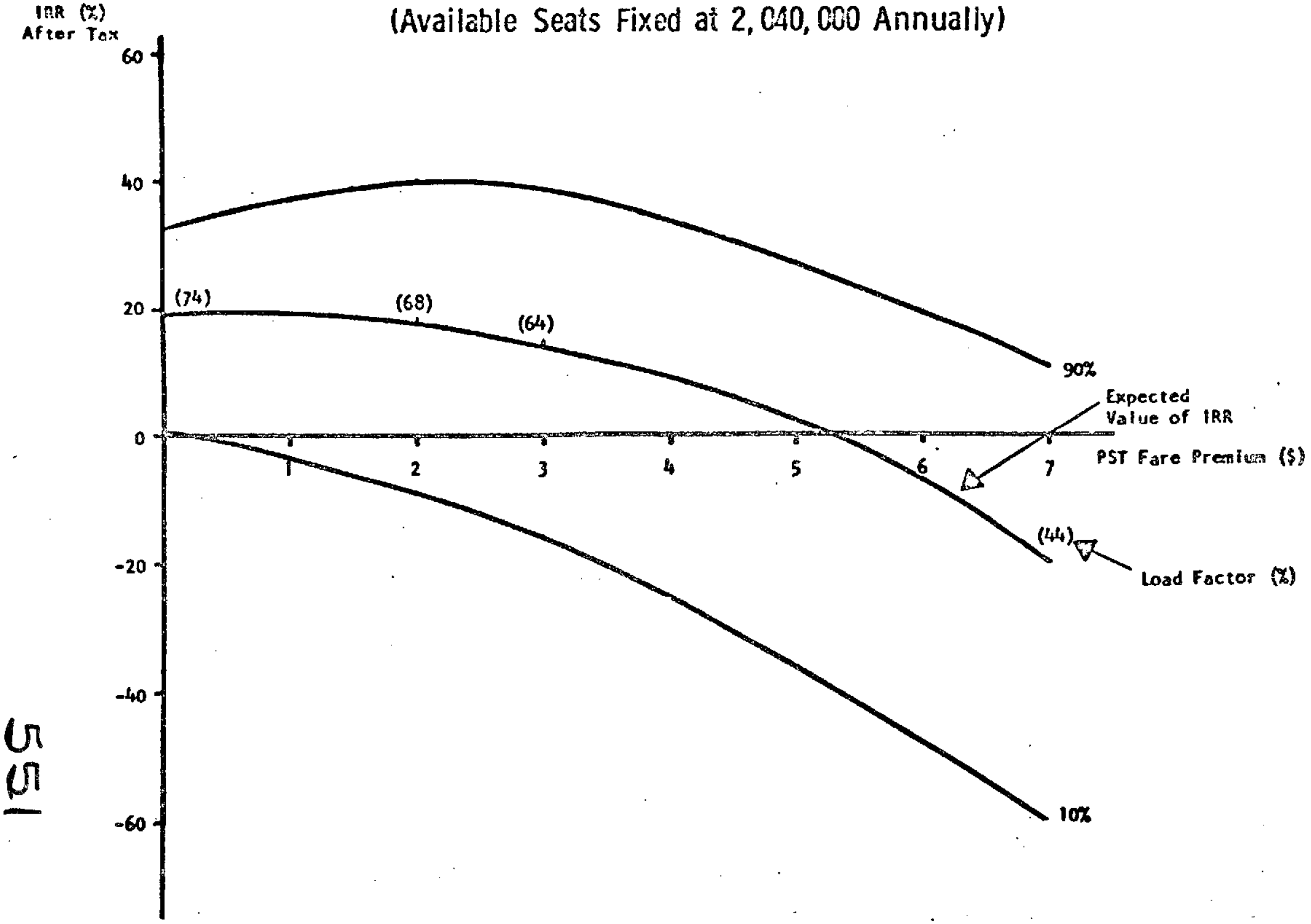

Figure 11

N73-32869

TRANSPORTATION SYSTEMS EVALUATION

by

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TRANSPORTATION SYSTEMS EVALUATION

1.0 INTRODUCTION

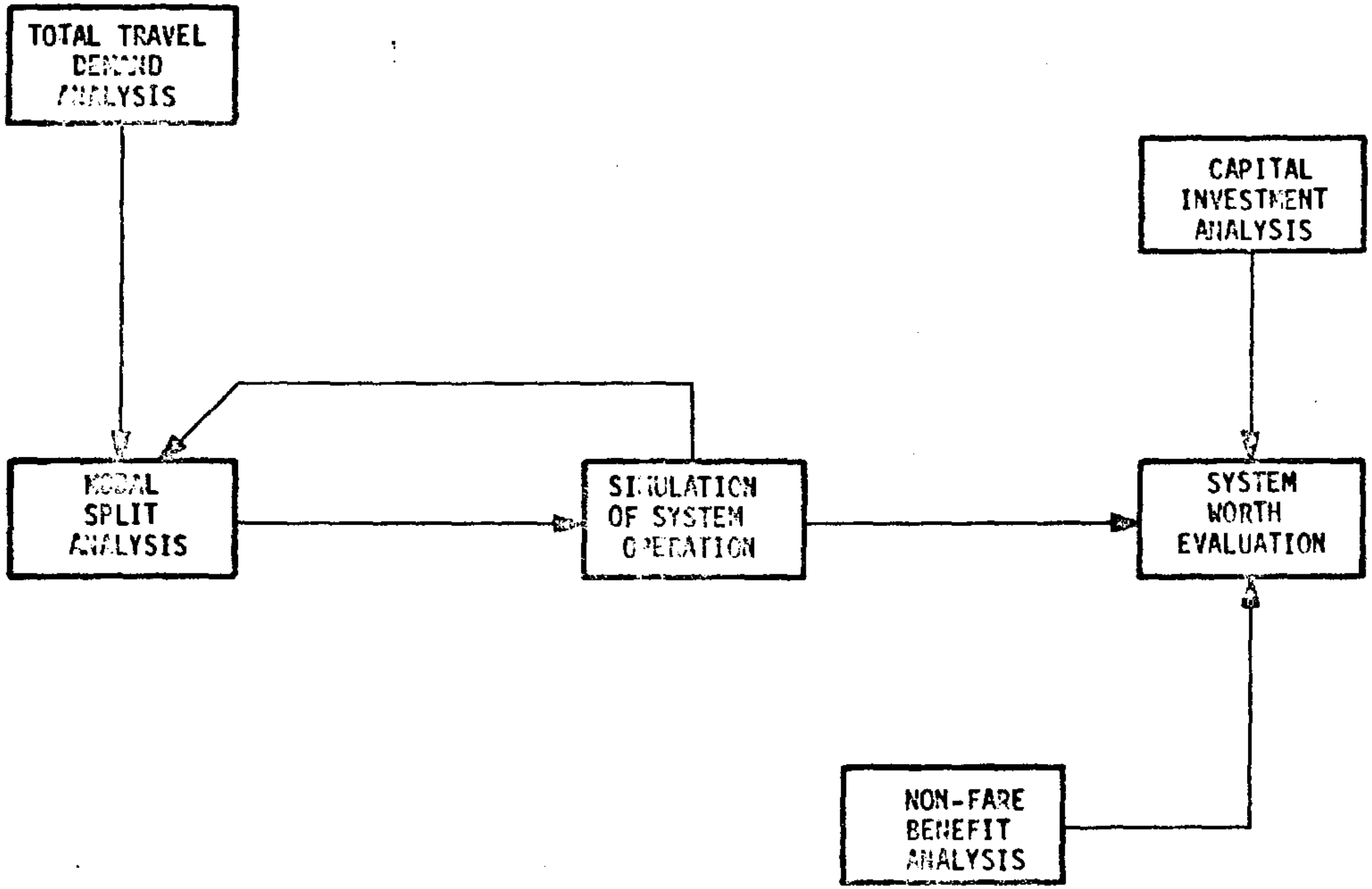
For a number of years, the Operations Research/Management Sciences staff of Boeing Computer Services, Inc., a wholly owned subsidiary of The Boeing Company, has been actively engaged in the development of analytical tools for analyzing transportation requirements and associated systems. The purpose of this paper is to present a framework for analyzing transportation systems which accounts for the interaction between demand and system performance. This framework is applicable to systems ranging from intraurban Personalized Rapid Transit System (PRT) networks to trunk airlines. It has evolved from and been used in studies of inter and intra urban air, ground, and water transportation systems to move both commodities and people.

In order to illustrate the flexibility of this methodology, intra and inter problems will be discussed in what follows. In Section 2 the framework is presented; Section 3 consists of a lengthy example showing how the approach was used to study an intraurban commuter air system. Finally, in Section 4 a proposed study using the approach to investigate Personalized Rapid Transit (PRT) is described.

2.0 ANALYTICAL FRAMEWORK

The steps required to analyze a transportation system are shown in Figure 1. The procedure begins with the calculation of travel demand. Then, based upon assumed performance, the demand is split between travel modes. Next, the system is simulated and performance is calculated. This performance level is fed back and a new modal split is calculated. When assumed performance and calculated performance are equal, the cost and revenues of the system are calculated. Capital costs and non-revenue benefits are also calculated. Finally, the system is evaluated based upon accurate estimates of service level, capital costs, non-revenue benefits and operating costs and revenues. Each of the above functions will now be described in more detail.

TRANSPORTATION SYSTEMS ANALYSIS



2.1 TOTAL TRAVEL DEMAND ANALYSIS

The first step of the analysis is to calculate total demand for travel for the region under study. Past and forecasted demographic and geographi characteristics of the study areas together with current travel patterns form the basis of the analysis. In particular, land use forecasts may enter the analysis at this stage.

To begin the demand analysis for the intraurban problem, the study region is broken into analysis zones by the analyst. Information describing each zone is fed to the program. Base year travel information from a travel survey (if available) is also given to the model. The model calculates total travel (by all modes) between all zone pairs. The analyst produces time of day and day of week distributions of demand.

The intraurban demand model consists of two parts; Trip Generation and Trip Distribution. The former creates a forecast of total trips produced in and attracted to each analysis zone. The trip distribution portion spreads the trips (calculated in the trip generation phase) over all zone pairs. It is this trip table which is needed by the modal split model.

Demand forecasts for the airlines are based upon the CAB traffic surveys and econometric forecasts of basic economic variables. For the domestic trunks, for example, the first step is to calculate total RPM for the desired year from the forecast of GNP and other economic variables. Next, the demand is assigned to city pairs. The assignment for a given city pair depends upon the share of the total RPM carried by that city pair in the past. Different growth rates are forecast for different city pairs depending upon whether the market is new or mature. The result of the assignment is total origin and destination travel for each city pair.

2.2 MODAL SPLIT ANALYSIS

The function of the modal split module is to apportion the total demand, previously calculated, to the various travel modes available. Required inputs are user costs and times for each mode to be considered, and users attitudes towards the competing modes. Output of the module is a market share forecast for each mode. This forecast is based upon assumed performance levels and hence is a preliminary estimate of market shares. After the system is simulated and true performance calculated, a new modal split must be performed.

2.2.1 INTRAURBAN MODAL SPLIT

A marginal utility approach forms the basis of the intraurban modal split model. The utility of a mode to a given user is calculated as a function of its time and cost and the income of the user. Attitudes toward travel modes can be incorporated into the model. The marginal utility of one mode over another is simply the difference between the two utilities. The percentage of travellers taking one mode instead of another is calculated from this marginal utility.

To calculate the market share for each mode, the marginal utility analysis is applied to each zone pair separately. Access and egress times and costs, waiting times, parking costs, line haul times and costs are all calculated for each zone pair. From these, the utilities of each mode and hence the market shares can be determined. In addition to market share, the model calculates demand for transit by station pair. This is the information needed by the simulation model. This approach is used for intraurban systems as well as short haul air systems in which auto, bus, and train are significant competitors. For long haul air systems a different approach is taken.

2.2.2 INTERURBAN MODAL SPLIT - PASSENGER PREFERENCE ANALYSIS

For nearly all interurban markets the total demand for air service can be calculated from the CAB surveys, as was described in the demand analysis section. The modal split problem in this case involves assigning demand to the competing airlines. Historically this was done according to number of frequencies offered. With the advent of significant differences between equipment (e.g. wide and narrow bodies) simply using relative frequencies to calculate market share produced incorrect answers. Our technique involves carrying out surveys to obtain passenger reaction to the equipment and then calculating market share from these ratings, airline image and frequency. To finish the demand calculation, the market share must be multiplied by the true O & D traffic previously computed, to obtain daily O & D traffic for each airline for each city pair. The final step is to convert the O & D into segment flow.

In order to calculate the type and effects of passengers equipment preferences, we have carried out several surveys. These include in-flight as well as mock-up surveys on several different airlines. Over 14,000 people have responded to these surveys.

The basic tool we have used to quantify peoples' subjective feelings is a survey form which asks a respondent to rate certain aspects of his trip on a scale from 1 to 9. Descriptors are furnished for each aspect to define the scale. For example, when rating seat comfort, a rating of 1 is defined to mean narrow, cramped and hard, 5 means moderate width and leg room and 9 means ample width and leg room. The resulting ratings are amenable to statistical analysis. This technique has been used in situations other than travel surveys. For example the Air Force uses it for personnel evaluation, as does BCS, and it has been used in the white goods industry.

Our surveys have covered a wide range of equipment, both wide and narrow aircraft in many configurations. The mock-up surveys tested reaction to characteristics such as seat comfort, spaciousness, and cabin appeal as well as many other aspects of an aircraft. The in-flight surveys tested these reactions as well as the reaction to flight experience variables such as smoothness and service.

The mock-up and in-flight surveys produced similar results. The relative importance of the characteristics common to both sets of surveys were the same. In particular, it was found that seating comfort, spaciousness, and cabin appeal ratings were sufficient to predict overall flight ratings in the mock-up survey. To these, service and flight smoothness need to be added to predict overall ratings for the in-flight survey.

In order to rate equipment for which no survey has been conducted, relationships between physical characteristics and passengers attitudes have been produced from survey data. For example for a given pitch, seat comfort ratings corresponding to various seat widths used in the surveys are used to produce a curve of rating as a function of width. Such curves can be produced for several pitches. When a new airplane is being considered, its seat comfort rating can be obtained from its seat width and pitch by using the curves.

One of the questions asked on the in-flight surveys requested the time interval within which a passenger was willing to re-schedule his flight in order to fly on the particular aircraft he chose. From the responses to this question we produced curves showing the percent of people willing to re-schedule their flights as a function of the deviation from the desired departure time. Different curves apply to different aircraft. These curves allow one to predict flight loads for different equipment given the schedule and the passengers arrival rate curve.

One main purpose of the surveys was to produce data allowing more accurate market share calculations. A computer program was written including time of day demand, variations, equipment preferences, and airline image in the market share calculations. This program gives roughly the same answer as the simple formula shown in Figure 2. In the formula P_A is the preference for flight A, including the equipment rating and airline image.

The formula and simulation model were both applied to a market (JFK-LAX) for which on board load data was available. Both the simulation and the formula gave answers which differed from the observed loads insignificantly.

Using either the formula or the computer simulation one calculates the market share for each airline in each market. These percentages are multiplied by the total O & D air travel, previously calculated, for each city pair. The resulting O & D demand can then be converted into segment flow (on board loads) using our segment flow model.

TO DETERMINE MARKET SHARE

- FOR COMPETING AIRLINES WITH SIMILAR IDENTITY & ABOUT EQUAL SCHEDULE ADVANTAGE:

MARKET SHARE
FOR ONE FLIGHT OF TWO $= \dfrac{P_A}{P_A + P_B}$

MARKET SHARE
FOR ONE FLIGHT
(A) OF SEVERAL $= \dfrac{P_A}{P_A + P_B + \ldots\ldots\ldots P_N}$

- IF CLOSEST FLIGHT SEEKERS (C%) ARE INCLUDED:

MARKET SHARE
FOR ONE FLIGHT
(A) OF SEVERAL $= (1 - C) \dfrac{P_A}{P_A + P_B + \ldots\ldots P_N} + \dfrac{C}{N}$

- FURTHER CORRECTIONS CAN BE MADE USING AIRLINE IDENTITY FACTOR

FIGURE 2

.3 SYSTEM SIMULATION

So far we have shown how demand can be calculated and split between competing transport modes for a variety of transportation systems including intraurban transit and airlines. The process described produces an interim estimate of modal split based upon assumed system performance. The system must be simulated to get actual performance. This information is then given back to the modal split module. The process ends when assumed and actual performance coincide.

The market share forecast produced by the modal split module, in addition to the specifications of the system are the inputs required by the simulation module. For a new system, the simulation must be done by actually having the computer assign passengers to vehicles, move the vehicles to their destination, etc. For existing systems, an analytical approach may be satisfactory. The result of the simulation is a set of operational data showing how the system performed. This includes vehicle requirements, loads, and utilization. Another result is the cost and revenue information required to calculate operating profit. The average time a passenger was forced to deviate from his desired departure time is also calculated. This "average passenger waiting time" must be compared with that assumed in the modal split calculation.

Once the simulation has been run, complete information regarding system operation is available. This information includes: average vehicle utilization, number of vehicles used and vehicle loads, among other operational statistics. For a transit system, labor requirements are calculated from the operational data and then labor and non-labor costs are calculated. Finally, G & A costs are added to get full system operating costs.

For an airline, the routing and scheduling done by the simulation model allows accurate cost calculations. Cash DOC (excluding hull insurance and depreciation) is calculated from the ATA or some similar formula for each flight. Depreciation and insurance are calculated for each aircraft. Thus no utilization assumption is required. Further, having all details of the system operation (e.g. number of peak hour movements at each airport) allows one to base the IOC calculation upon system elements which actually cause IOC.

2.4 CAPITAL INVESTMENT

The capital investment module determines the cash required for debt service for each year the system operates. The vehicle requirements have been determined by the operating simulation. Other capital expenses, (e.g., guideway construction, computers, station construction) are required inputs to the model.

For a municipally owned transit system, this module balances capital requirements against available funds. During the construction phase, any capital expense not covered by specified grants is assumed to require municipal bonds. The capital investment module "issues" such bonds when needed. For the operating period, the module calculates yearly operating surpluses necessary to cover debt service. The module also calculates the present value of this stream.

For an airline we have available a financial analysis program which treats taxes, fleet additions and retirements, investment tax credit and all other financial aspects of airline operation.

2.5 SYSTEM WORTH EVALUATION

The results of the previous four modules together with the results of the non-fare benefit analysis come together in the system worth evaluation. This process is not computerized. It requires an analyst and must be specially tailored to each application. Usually several different transportation systems are compared with respect to some criterion, e.g., maximum profit, within certain constraints, e.g., adequate service level and sufficient transit ridership. The aim is to find a balanced transportation system for the study region. Usually many systems need to be processed through the model before an adequate system worth evaluation can be made.

The economics of a transit system don't tell the full story. In some cases community values will be better served by a system with poorer economics but better non-fare benefits. In some cases the non-fare benefits are directly measurable economically, e.g., taxable real estate retained rather than lost to parking. In some cases the economic benefits are harder to measure. Where possible, these benefits are evaluated economically by the non-fare benefits module.

Figure 3 shows how the results of the capital investment and simulation modules interact. The capital investment module gives the operating surplus required, whereas the simulation module shows the operating surplus achieved. If an insufficient operating surplus is achieved, some aspect of the system must be modified, e.g., fare level, number of vehicles, size of vehicles, station locations. This modification will effect modal split, so that an entire new analysis is required.

2.6 SUMMARY OF FRAMEWORK

Figure 4 shows the structure of the entire model. Any transportation study must cover all the elements shown in this chart. The major advantage of TSEM (Transportation System Evaluation Model) is that all the elements are linked together so that interactions between the elements is considered. The fine level of detail treated by TSEM allows accurate systems evaluation, which in turn makes possible intelligent transportation planning.

3.0 EXAMPLE - INTRAURBAN AIR SYSTEM

A study which Boeing performed for NASA shows clearly how the methodology described previously can be applied. The purpose of the study was to test the feasibility of using V/STOL aircraft in commuter service. All aspects of the system were to be studied. In addition to the base case results, many sensitivity studies were to be conducted. Important areas for future research were to be identified.

CASH FLOW ANALYSIS

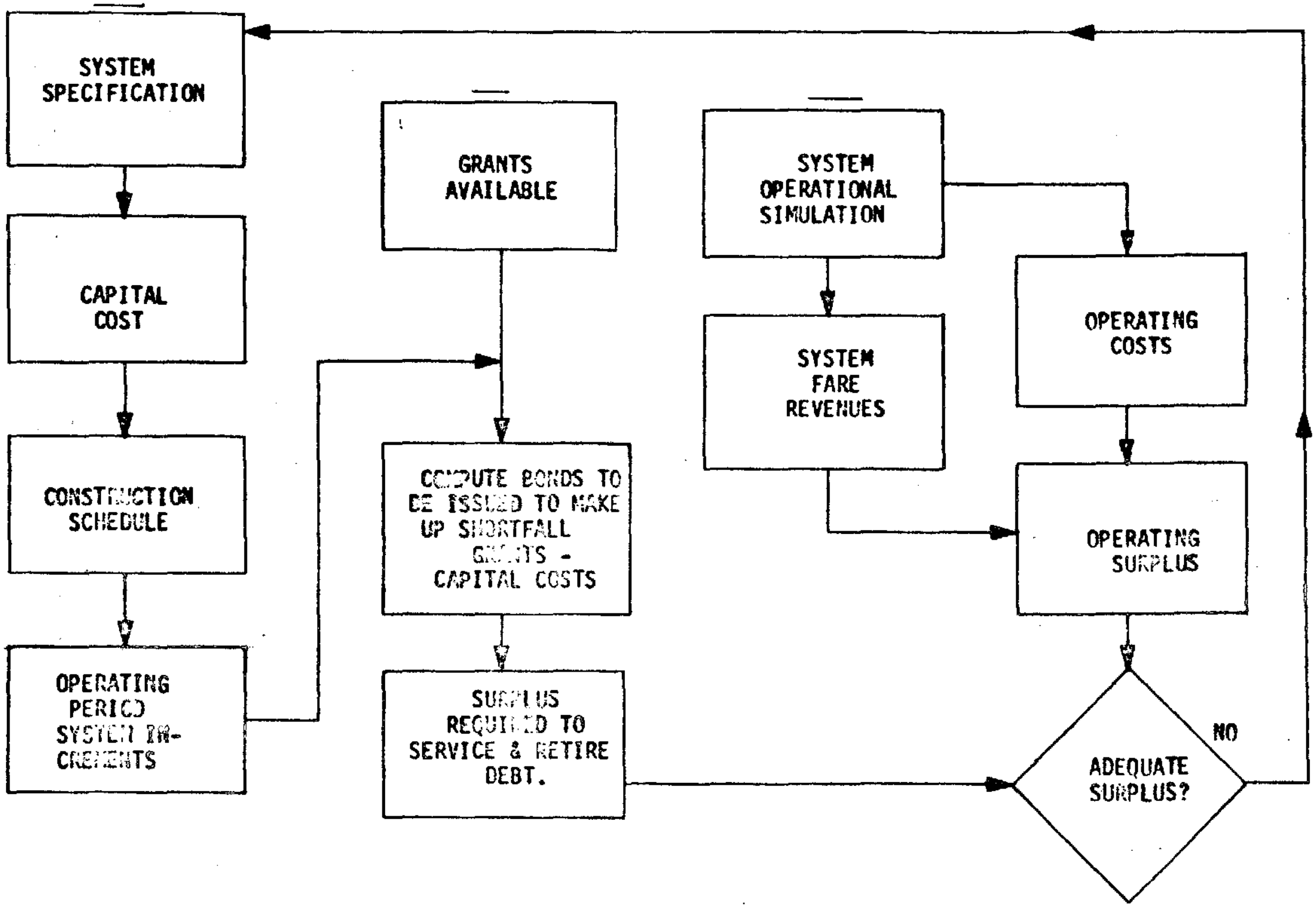


FIGURE 3

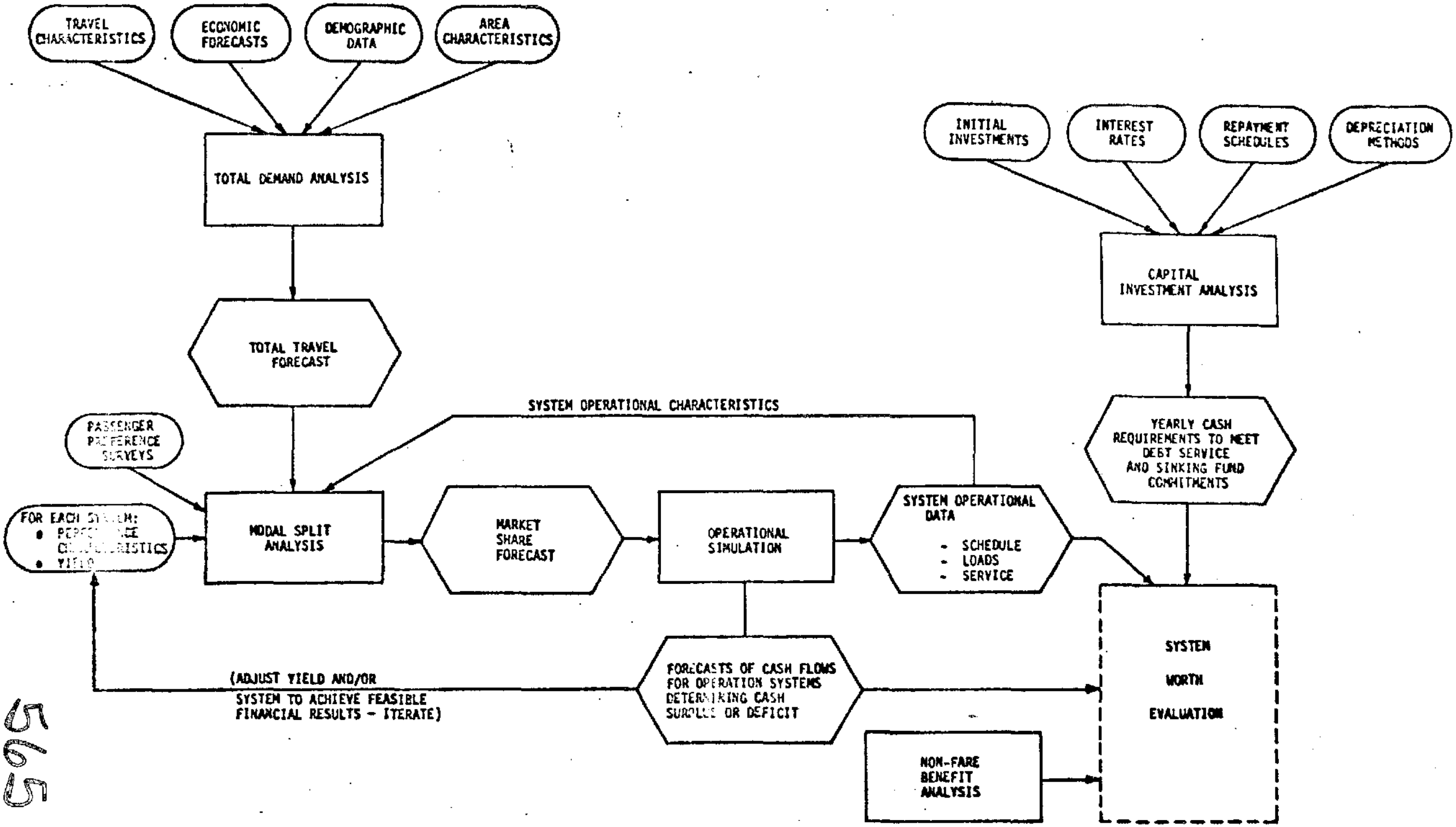

TRAVEL CHARACTERISTICS
ECONOMIC FORECASTS
DEMOGRAPHIC DATA
AREA CHARACTERISTICS
TOTAL DEMAND ANALYSIS
TOTAL TRAVEL FORECAST
INITIAL INVESTMENTS
INTEREST RATES
REPAYMENT SCHEDULES
DEPRECIATION METHODS
CAPITAL INVESTMENT ANALYSIS
YEARLY CASH REQUIREMENTS TO MEET DEBT SERVICE AND SINKING FUND COMMITMENTS
SYSTEM OPERATIONAL CHARACTERISTICS
PASSENGER PREFERENCE SURVEYS
FOR EACH SYSTEM:
• PERFORMANCE CHARACTERISTICS
• YIELD
MODAL SPLIT ANALYSIS
MARKET SHARE FORECAST
OPERATIONAL SIMULATION
SYSTEM OPERATIONAL DATA
- SCHEDULE
- LOADS
- SERVICE
SYSTEM WORTH EVALUATION
(ADJUST YIELD AND/OR SYSTEM TO ACHIEVE FEASIBLE FINANCIAL RESULTS - ITERATE)
FORECASTS OF CASH FLOWS FOR OPERATION SYSTEMS DETERMINING CASH SURPLUS OR DEFICIT
NON-FARE BENEFIT ANALYSIS

FIGURE 4

The study covered the nine county San Francisco Bay area. Two time periods, 1975 and 1985 were studied. In each time period 2 STOL and 2 VTOL concepts were investigated.

The scope of the study was quite broad covering all aspects of an air transportation system. Aircraft design, travel demand, modal split, aircraft operation, and economic evaluation were the major tasks of the study.

These are also the basic blocks in the methodology presented earlier. Vehicle design wasn't mentioned in the methodology, but in order to choose a design the analytical procedure must be applied to each candidate.

In some respects the intraurban system resembles a domestic trunk airline. Characteristics of a typical intraurban system are listed below:

Daily Passengers Carried	48,551
Total Daily Flights	2,292
Average Passenger Trip Distance	23.4
Aircraft Required	73
Average Load Factor	.45
Number of Terminals	24
Number of One Way Segments	65

Both in passengers carried and daily flights the system rivals such an airline. Of course, the fleet size is much smaller than that of an airline, showing the large number of daily flights made by each aircraft. The largest difference between the intraurban and trunk airline is, of course, the average segment length.

Figure 5 is a picture of one of the STOL aircraft designed for the study. Its most interesting feature is the large number of doors. The plane is configured like a European train without any aisle. Each compartment has a door on each side of the aircraft. This design came about as a result of simulations showing that gate time was a critical variable in the system. The weight penalty caused by multiple doors was more than paid for in the reduced gate time they allowed.

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AUGMENTOR WING STOL

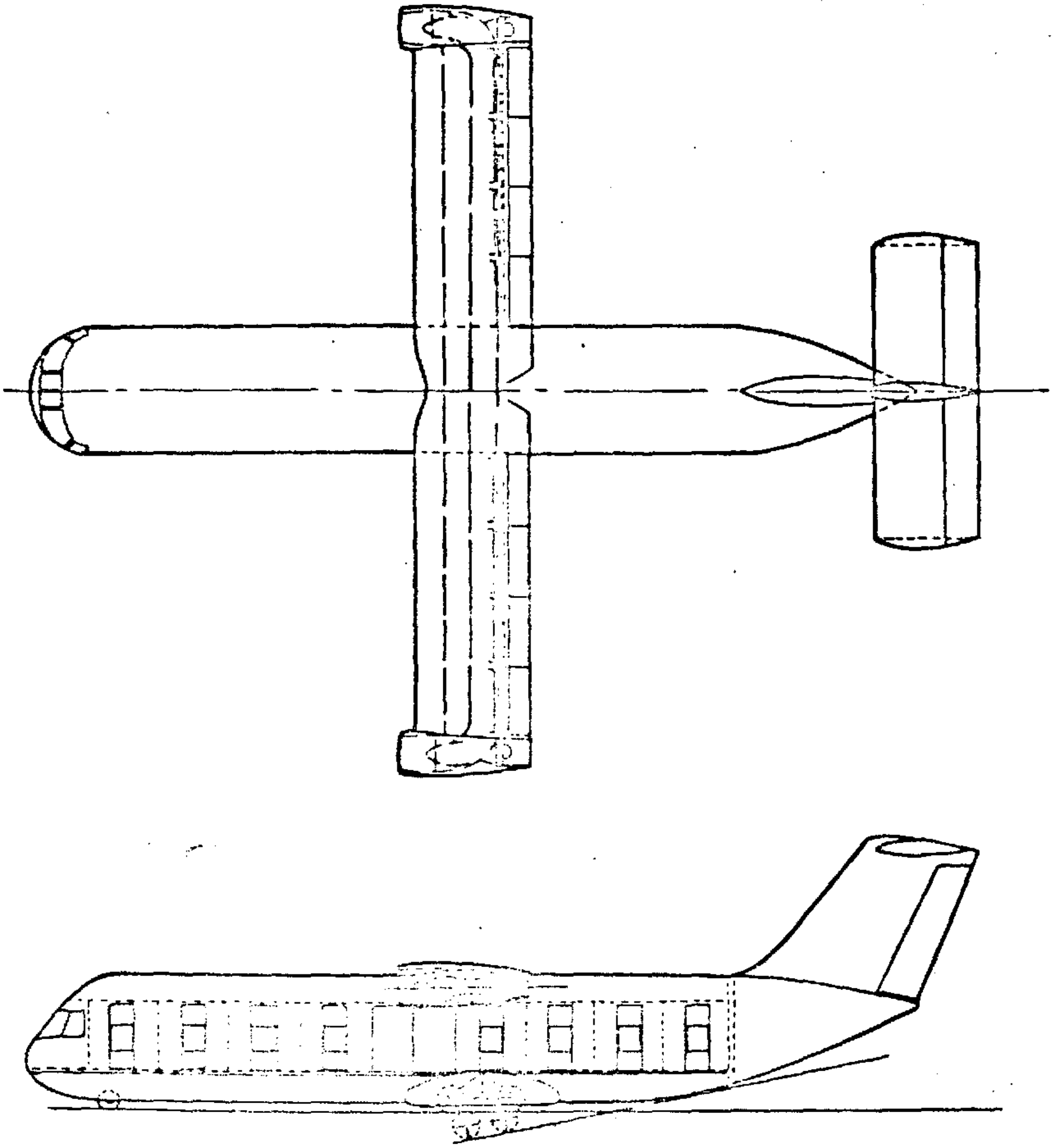


FIGURE 5

3.1 MODEL STRUCTURE

Since little historical data exists for intraurban air systems, a detailed simulation of the system was required. A demand/modal split model was built to calculate station pair demands. A routing and scheduling model was produced to simulate the operation of the aircraft within the system. An economic module was created to take the routes, schedules, and flight loads and calculate revenues and costs. This is exactly the process described in the preceding general discussion.

Figure 6 shows some of the data flow within the model. The traffic generator for this study was a set of input demands. The modal split will be described later. Note that the waiting time assumed in modal split (as part of the trip time) is compared with the waiting actually achieved by the scheduling module. If they don't match, a new modal split is performed and a new schedule produced. Once the two are equal the economic evaluation takes place.

The zoning of the study region and total demand for travel by all modes for each zone pair in the Bay area had been forecast by the Metropolitan Transportation Commission before our study began. These forecasts of total travel were used in our study. They had also conducted a home survey of transportation. From this survey we developed time of day demand curves.

A plot of demand by time of day was made for each zone pair from data collected in the home surveys. However, since there were only about 100,000 trips to distribute in more than 2 1/2 million time slots (using 1/2 hour intervals for each zone pair), most zone pairs had very sparse curves. A pattern emerged, however. One curve was used from all zone pairs to downtown S.F., a second was used from downtown S.F to all other zones, a third curve was used between all other zone pairs. These 3 curves adequately represented the survey data.

TRANSPORTATION NETWORK MODEL

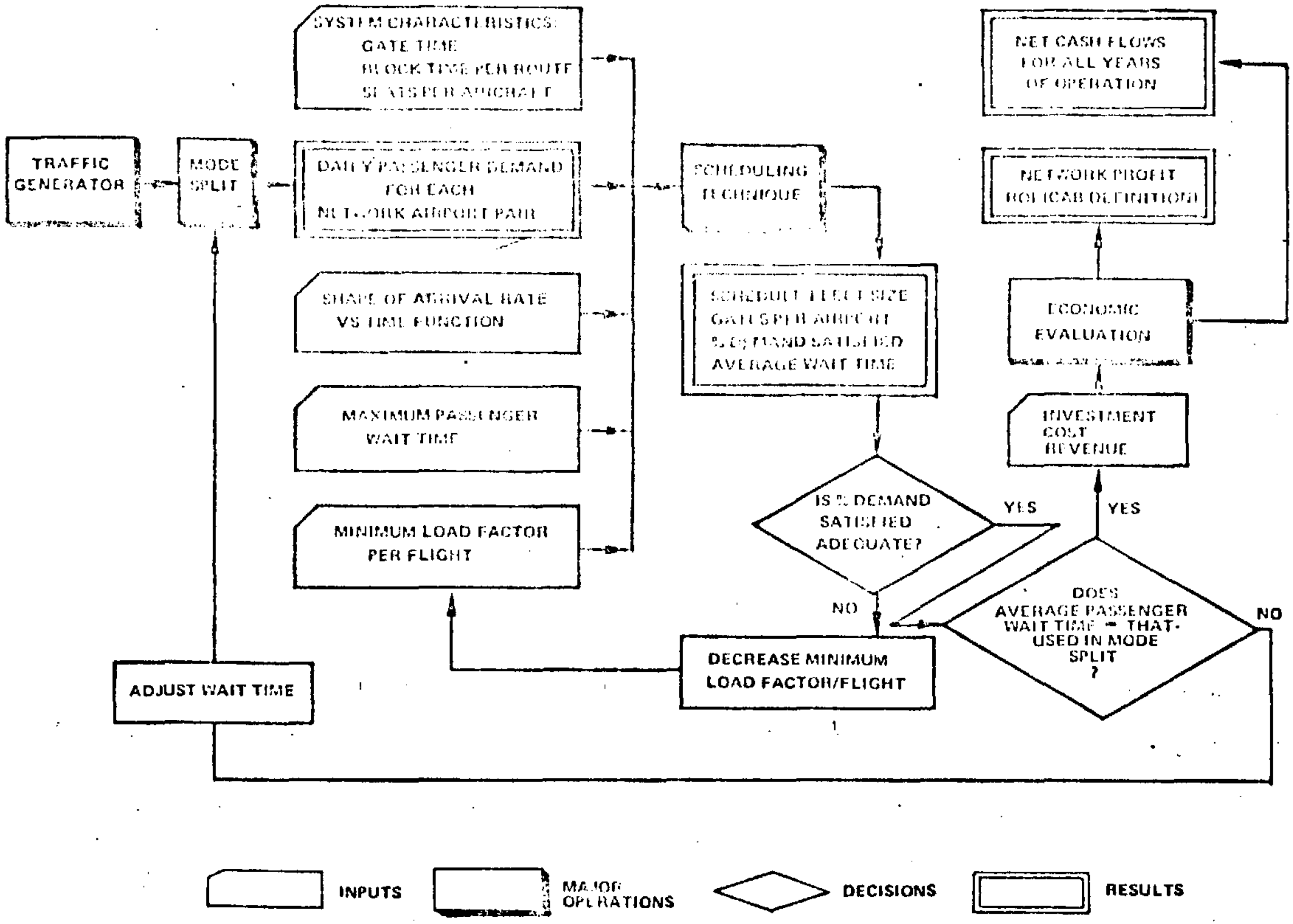


FIGURE 6

The demand (properly speaking modal split) model calculated demand for V/STOL between each port pair. The model works exactly like the intra-urban modal split model described earlier. Each zone pair is treated in order as follows: nearest V/STOL ports to the centroid of origin and destination zones are found, costs and times for auto and V/STOL trips are calculated and a diversion curve is entered with the cost and time differences to calculate the percentage of demand choosing V/STOL. This percentage is multiplied by the total zone pair demand and the result is added to the appropriate V/STOL station pair demand.

The diversion curve used in this study was a plane, with cost difference and time difference as independent variables, percent diverted the dependent variable. Of course, negative diversion and diversions of over 100% were excluded.

The demand model calculated travel demand between all V/STOL port pairs. Figure 7 shows the length distribution of these trips for the base case (1975 augmentor wing STOL aircraft with 49 seats). Also shown is the demand fed to the simulation model. This consisted of all port pairs with traffic of 250 passengers per day. The demand actually carried during the simulation is also plotted. The model only carries demand when it makes some sense to do so. The requirement was that all aircraft achieve at least two hours of utilization per day.

Because the system was being simulated, all aspects of the operation were calculated. This allowed the IOC to be assigned to variables which caused IOC to be incurred such as number of gates. For each cost category (e.g., aircraft servicing, ground facilities) coefficients were determined for each independent variable (terminals, departures, gates, etc.). The cost for each category was the sum of these coefficients multiplied by the variables. Total IOC is the sum of all cost categories. Cash DOC curves were produced for each design to be evaluated.

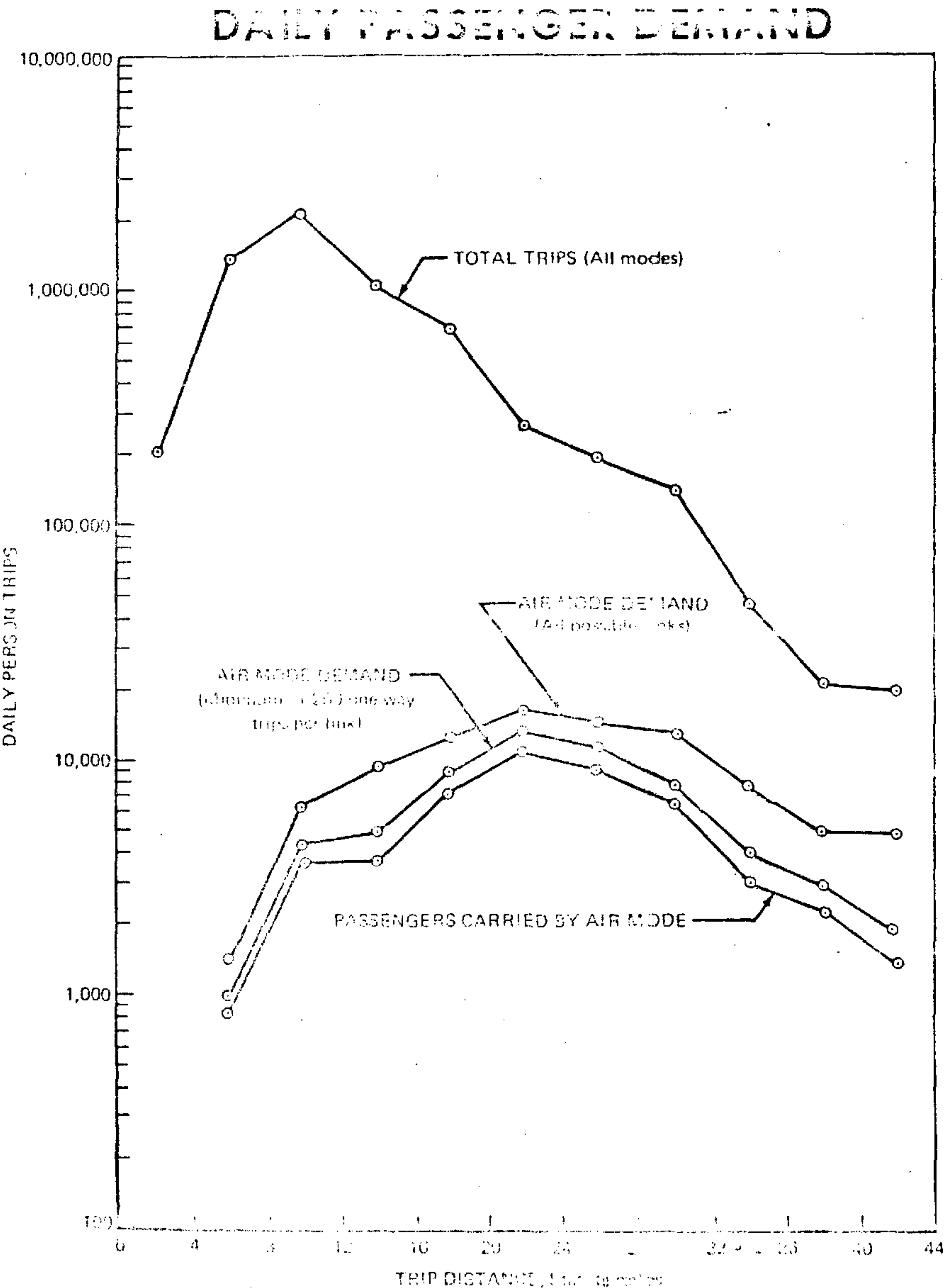

DAILY PASSENGER DEMAND
10,000,000
1,000,000
100,000
10,000
1,000
100
DAILY PERSON TRIPS
TOTAL TRIPS (All modes)
AIR MODE DEMAND
(All possible links)
AIR MODE DEMAND
(Minimum of 25 one way
trips per link)
PASSENGERS CARRIED BY AIR MODE
0
4
8
12
16
20
24
28
32
36
40
44
TRIP DISTANCE (Statute miles)

FIGURE 7

3.2 RESULTS AND SENSITIVITIES

The results for the 1975 aircraft are shown in Figure 8. The small STOL aircraft make an operating profit but the debt service requirements cause substantial losses. The helicopters lose less because of the reduced land requirement for ports.

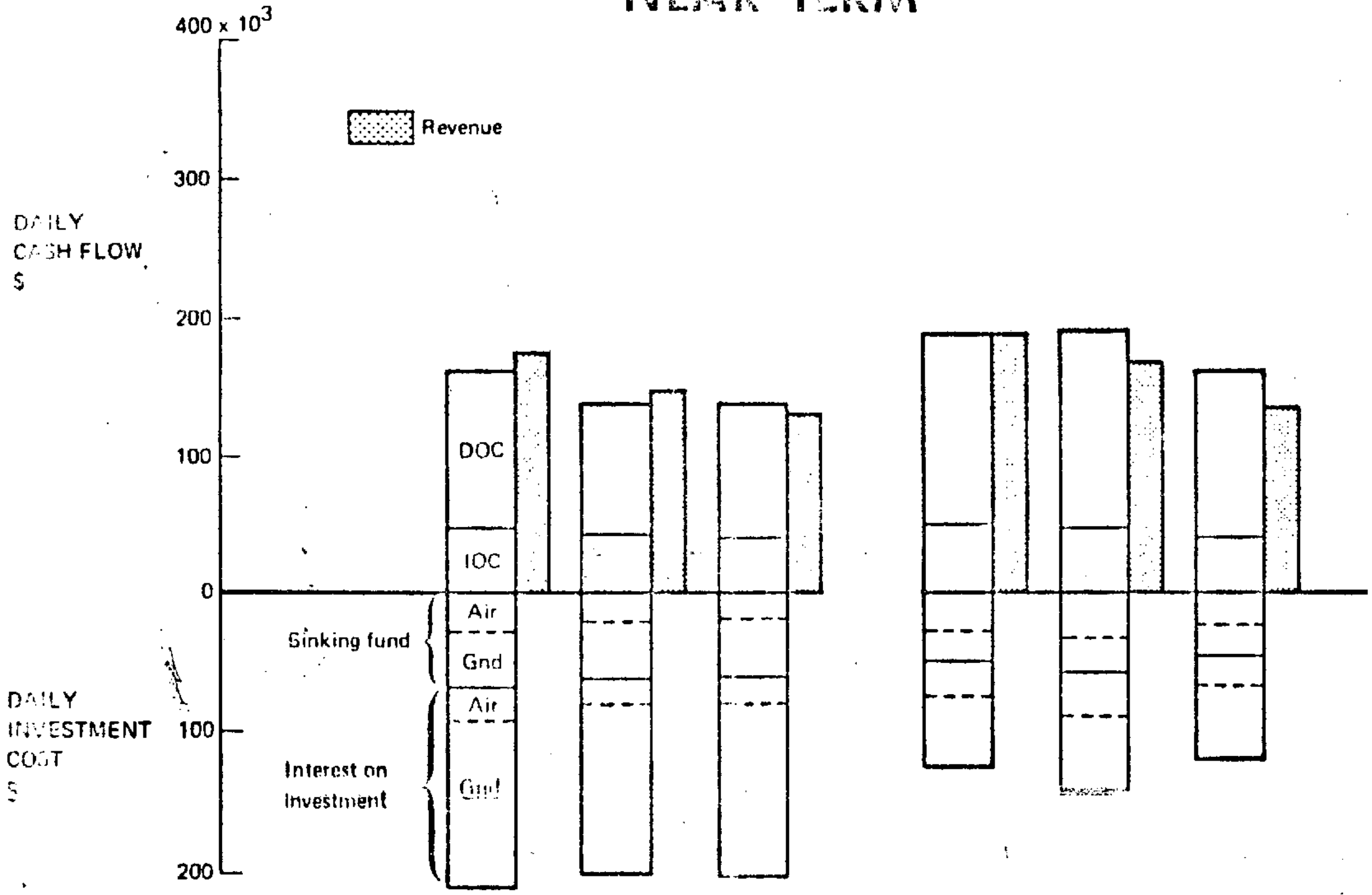
Figure 9 shows cash flows for the best aircraft. Profits from concessions located in V/STOL ports have been included in revenues. In 1980 both VTOL and STOL aircraft require subsidies, 19 million per year for the helicopter and 25 million per year for the STOL. By 1990 the STOL subsidy is 16 million and the VTOL makes a profit.

A number of simulations were run using time of day demand curves with different peaking characteristics. The results show that both fleet size and profit are quite sensitive to the peaking characteristics. A flat time of day demand curve led to a requirement for 51 aircraft and an operating profit $23,000 per day. The standard case required 76 aircraft and produced an operating profit of $2,000 per day. If the peaking were three times as severe as in the standard case, 82 aircraft would be needed and a $5,000 per day operating loss would be sustained.

The demand and simulation models were run for several different fare levels. The demand grows rapidly as fares are reduced and the loss per passenger decreases. The total loss increases slightly as the fare is reduced. At 70% of the base fare the system carries 173,000 passengers instead of 49,000 and the loss per passenger is $1.53 instead of $4.05.

The 1975 aircraft were flown in the 1990 market and the results compared with the 1985 aircraft in the market to measure the effect of technology change. Both the 1975 and 1985 STOL aircraft experience the same demand; a slight reduction in loss per passenger is achieved by reduced DOC in the 1985 aircraft. The 1985 helicopter has a faster block speed than does the 1975 vehicle and hence attracts more demand. This in addition to the lower DOC of the 1985 vehicle more than offset its higher purchase price. The 1985 helicopter loses almost half of what the 1975 vehicle loses per passenger.

CONCEPT ECONOMIC COMPARISON
NEAR TERM



Vehicle	Augmentor wing STOL			Helicopter		
Passengers	49	95	153	50	98	150
Net loss per day	$194 000	$190 000	$208 000	$128 000	$163 000	$147 000
Loss per passenger	$4.05	$4.70	$5.80	$2.42	$3.55	$3.85

FIGURE 8

ANNUAL CASH FLOW

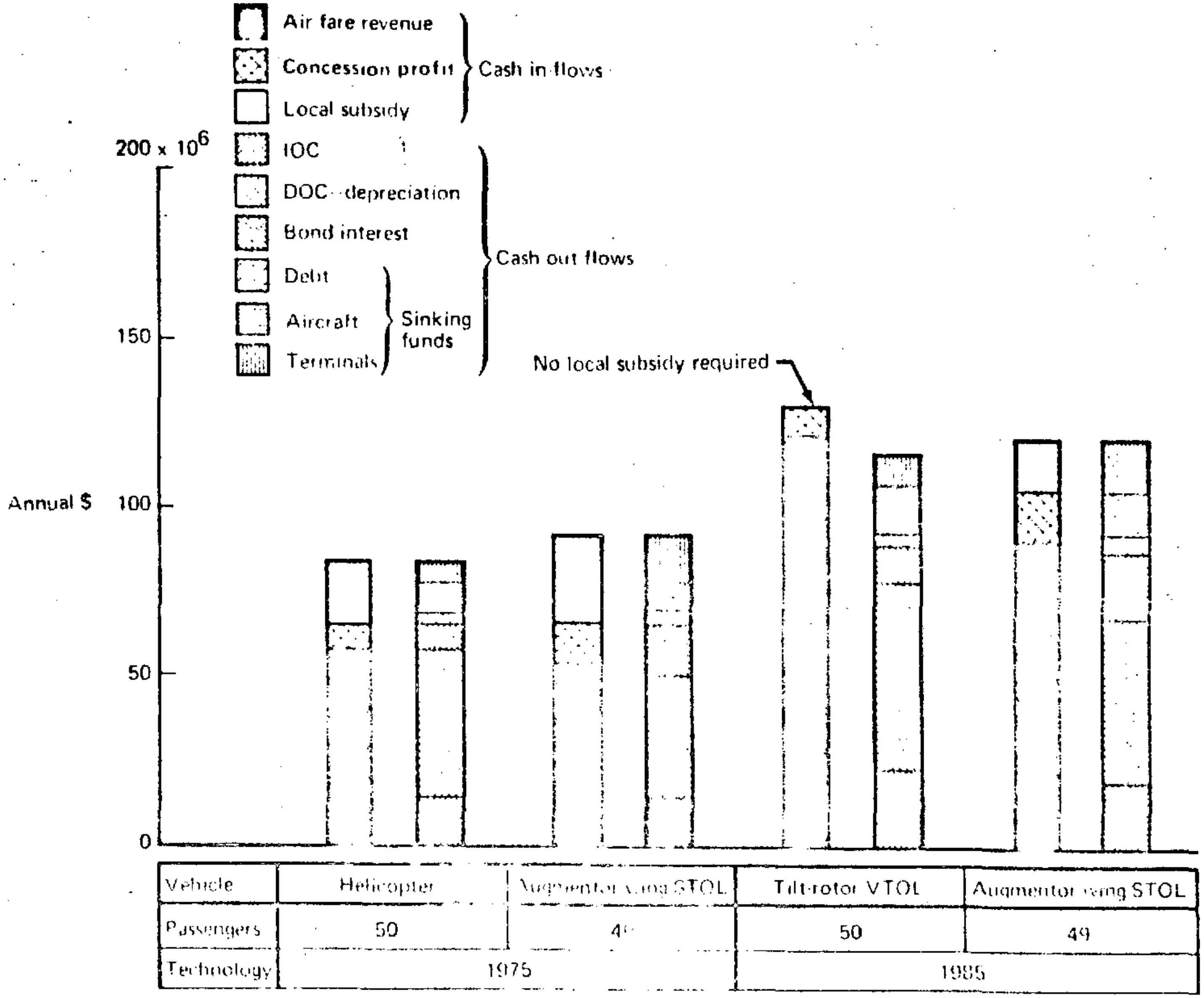


FIGURE 9

Simulation model runs were made using different gate times (turnaround times). The results were quite dramatic: going from 3 to 8 minutes of gate time increases the loss per passenger from 4 to 5 dollars. This effect is due to the lower peak period utilization of the aircraft which requires larger fleets to serve the same demand. The need for short gate times led to the multi-door design of the aircraft.

One run through both demand and simulation models was made including the BART system as well as the automobile as a competitor to V/STOL. Because of its low fare BART is a tough competitor. The demand for STOL shrinks and the loss per passenger climbs from $4.05 to $6.93.

Many sensitivity studies similar to those just described were carried out. Some of the results of the sensitivity studies were:

Low gate time is critical to the system
Cruise speed is important up to 250 KN
Commuter type peaking increases costs substantially
Downtown ports contribute most to the system
System cannot compete over the same segment with BART
Costs are lowest at very short field lengths
Lower fares (to a point) reduce the loss per passenger

Both the base case results and the sensitivity studies required the use of the demand and simulation models. This example shows the need for using the methodology described in Section 2, including all the interactions between elements. Had the analysis for this study been done in aggregate form, the base case results would have been suspect and the sensitivity studies could not have been performed.

4.0 APPLICATION OF TSEM TO A MAJOR CITY

A proposed study for a major U. S. city shows application of the methodology described in Section 2. In this case TSEM (Transportation Systems Evaluation model), our integrated intraurban model, will be used.

The objectives of the study involve preliminary design, evaluation of a PRT system, and a comparison of PRT and non PRT solutions to the transportation problem. Several transportation studies of this city have already been made. Zones have been created and 1985 trip tables (total demand) have been produced. The study will be based upon this data.

The first function of TSEM will be to aid in the preliminary design. A base case will be designed and run and then many modifications (different vehicle sizes, station locations, station capacities, headways, vehicle speeds) will be tried. The modal split and simulation modules will be cycled for each modification until convergence is obtained. All these runs will be made at a base fare level.

Once the system has been adequately refined, several fare structures will be tried. The service levels, ridership and operating profits will be calculated. The "best" fare will be chosen and the resulting system evaluated, including the non-revenue benefits.

Next, the service level, costs, and benefits of a freeway solution will be calculated and compared to the PRT solution.

The demand module will then predict demand for the future time periods. Modal-split and simulation modules will calculate system performance and costs in those years. The capital investment module will predict debt service requirements. Non fare benefits will be analyzed for each evaluation year. Finally, cash flows over the life of the system will be determined and this will permit final system evaluation.

5.0 SUMMARY

We have presented a methodology for the analysis of transportation systems consisting of five major interacting elements. The analysis begins with the causes of travel demand: geographic, economic, and demographic characteristics as well as attitudes toward travel. Through the analysis, the interaction of these factors with the physical and economic characteristics of the transportation system is determined. The result is an evaluation of the system from the point of view of both passenger and operator. Service levels, economic and non-economic aspects of the system are ascertained.

The methodology was shown to be applicable to the intraurban transit systems as well as major airlines. Applications of the technique to analysis of a PRT system and a study of intraurban air travel were given. In the discussion several unique models or techniques were mentioned: i.e., passenger preference modeling, an integrated intraurban transit model and a series of models to perform airline analysis.

N73-[illegible]

WORLD AIR TRAVEL DEMAND
1950-1980

By

George N. Saremes
Lockheed-California Company

Presented
At The
1972 Summer Workshop
On
"Air Transportation Systems Analysis and Economics"

July 1972

Conducted By

Flight Transportation Laboratory
Massachusetts Institute of Technology

Sponsored By

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology

INTRODUCTION

The Lockheed Aircraft Corporation, as a manufacturer of commercial air transports, is vitally interested in following the development of air travel throughout the world. Reasonable expectations as to the future developments are required as planning inputs for Lockheed's Commercial Air Transport Programs. Lockheed's air travel forecast requirements range from overall projections of world traffic by major areas for broad market planning to more detailed forecasts of individual carriers' city-pair peak traffic to determine each airline's aircraft needs. Generalized area forecasts, for example, U.S. domestic, transatlantic, intra-Europe, serve as the basis for specific airline and city-pair forecasts, while the city-pair forecasts provide feedback to the more generalized area forecasts.

This discussion will cover total world traffic as distributed over broad major flows. We, at Lockheed, usually forecast total world scheduled traffic as reported by the International Civil Aviation Organization (ICAO). While ICAO statistics are available on a global basis, these show domestic and international traffic by country of airline registration and do not reveal the actual traffic flow. For example, traffic between Taipei and Hong Kong carried by TWA would show up under U.S., while passengers carried by Japan Air Lines over the same route would show up under Japan.

Lockheed has compiled a twenty-year history of the actual world's major air traffic flows as a basis for forecasting the future of world air travel. In addition to the basic data sources (ICAO, IATA, EARB, OAA, airport and civil aviation authorities, immigration and tourist organizations), individual airline traffic statistics have also been used to help allocate traffic over specific flows.

Since the environment within which the airline industry operates is very dynamic, you can see how essential it is to continuously evaluate and update the various forecast results. In this current updating of Lockheed's ICAO world forecast, our goal was to identify and measure all major air traffic flows and still be consistent with ICAO reported traffic data.

SUMMARY

Total World

Total world scheduled air passenger traffic carried by the airlines of the International Civil Aviation Organization (ICAO), excluding the USSR, increased from 17.4 billion passenger miles in 1950 to 237.4 billion in 1970. This represents an average annual growth rate of 14% during the past two decades. The USSR became a member of ICAO in 1970, and Aeroflot – the only Russian airline – reported 49 billion passenger miles for 1970. This traffic, which encompasses both domestic and international travel as well as some non-scheduled flights, is not included in the ICAO world totals shown in this report.

Based on air traffic development over the past two decades and expected changes in future air travel service in the many areas of the world, including the continued expansion of non-scheduled services, world scheduled air traffic will grow at a somewhat lower rate than in the 1960's. Lockheed's forecast of ICAO world scheduled revenue passenger miles amounts to 650 billion in 1980; this represents an average annual increase of 10.6% for the 1970 to 1980 period.

Significant shifts between scheduled and non-scheduled traffic are occurring in various traffic categories. While it is difficult to measure non-scheduled traffic in many areas of the world, we estimate that it amounted to some 50 billion passenger miles in 1970, with about half composed of European inclusive tour traffic and transatlantic traffic. Most of the other traffic is composed of U.S. domestic and military charter.

Assuming the present type of non-scheduled service continues, as well as a decrease in military charter, Lockheed forecasts that non-scheduled passenger traffic will grow at an annual rate of 15% during the 1970's, totaling about 200 billion passenger miles by 1980. Non-scheduled traffic by scheduled, supplemental and charter airlines is expected to increase its share relative to scheduled from 21% in 1970 to 31% by 1980.

Major Flows

For the first time, all major world air traffic flows were analyzed, including those areas for which no systematic traffic statistics are available.

Actual 1970 traffic has been utilized as a base for those areas regularly reporting traffic (ICAO, IATA, EARB, OAA, the U.S. CAB). Estimates have been made for all other major traffic flows on the basis of other available data, such as airport and civil aviation authorities, immigration and tourist organizations and airlines.

Lockheed's forecast of world scheduled traffic was developed by preparing forecasts for about 48 unique traffic flows; these were then combined into 13 major flows. Every effort has been made to reflect realistic traffic growth patterns for these regions based on their own particular characteristics.

FORECASTING METHODS AND PHILOSOPHY

I would like to continue this presentation with a discussion of various techniques used in forecasting. These techniques are applicable to air travel anywhere in the world; and, in fact, most of these techniques are applicable to forecasting in general, regardless of whether it is for travel or other consumer items.

Philosophy of Forecasting

Before discussing the alternative methods of forecasting, I would like to discuss the "philosophy" of forecasting. The question I would like to introduce is: Can we forecast the future? Can we really know in advance what will happen tomorrow, next week, next summer or even ten or twenty years out? Furthermore, what can we know about the future? In what detail can we know about it, and to what degree of certainty can we foresee the future?

There are several aspects to cover before giving my views. First, there is the role of the forecaster — whether it be an individual, or a group, or some organization that wants knowledge of the future. This plays a very significant role, especially in analyzing and predicting the behavior of people as individuals or in groups. Since the analyst is part of the process that is being analyzed, he cannot detach himself from the analytical process. This is unlike the detachment possible in analyzing and trying to predict physical phenomena, such as the movement of stars or the moon, or experimenting under controlled conditions in a laboratory. The biases, the self-interests, the motivation of the analyst make it almost impossible to be 100% objective.

Another important consideration is that a forecast can be self-fulfilling. Once a forecast is made, if the decision-making officials in the various organizations that are affected plan on the basis of this forecast, it can well be that this forecast will be realized. Forecasts are usually based on certain assumptions of the future; and one of these has to be the required policies that must be undertaken for a forecast to be realizable.

When it comes to forecasting any event involving human behavior, I have come to the conclusion after many years of involvement in this endeavor, that the best we can do is predict what can potentially happen in a broad degree under a given set of circumstances — a given set of assumptions. The greater the detail that we would like to know, the greater the probability of being wrong in the future.

For example, if we want to forecast the number of tourists or air travelers to certain parts of the world, we must first make certain assumptions relating to the general social, political, economic environment, the climate, that is required to make these events potentially happen. Secondly, there must also be assumptions regarding specific policies that are required for certain events to happen.

The former set of assumptions which deal with the broader social, political conditions are usually beyond the control of any one airline or any one single government agency. The latter, however, are subject to the control of an airline or a government agency and something can be done about them.

Therefore, what we ought to strive for are not forecasts, but goals. In other words, let us establish what we want to happen in the future and then determine what we must do to make these things happen. For instance, an airline might determine that it wants to have so many passengers between two cities in a certain time period. Projections of the total traffic potential between these

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points would be made on a basis of the most likely economic conditions that would prevail in the time period under consideration. And these assumptions would also need to include fare levels at which this potential demand could be realized.

These factors are usually beyond the control of any one airline, so a very realistic approach must be taken. Nevertheless, given this assumed environment the airline can set up realistic goals of traffic that it would like to achieve within this environment. It would have to establish the proper schedules, service patterns, advertising policies, marketing strategies to achieve this potential, so that the goal they would like to have could be realized.

It may seem that I am taking a very negative attitude with regard to our ability to forecast accurately. However, I would prefer to be positive in stressing that forecasts disguised as goals can be attained with the realization as to the extent to which we can control our own destiny.

Moreover, to be able to determine the impact of our actions on the development of future air travel is no easy task. It requires not only analytical insight into cause and effect, but the ability to measure these effects with some precision.

Regardless of all the hazards of forecasting — and there are many — we must forecast the future. In fact, any decision that is made has an implied forecast associated with it, even though no explicit forecast is made.

I believe, however, that setting up goals enables us to go from the present to the future in a more orderly and efficient manner.

Forecasting Techniques

I would next like to cover some of the forecasting techniques. There are about as many techniques as there are forecasters. Since everyone in the world is a forecaster, there are millions of forecasting techniques. However, I believe these can be put into about four broad groups.

Trend Analysis. The first method of forecasting is trend analysis, or extrapolating from the past into the future. It can be as simple as drawing a line on a piece of graph paper, or it can become more complicated through the use of computerized programs using second and third degree relationships.

Regression Analysis. The next method is regression analysis, in which we try to ascertain the relationships between a dependent variable (the one which you are trying to explain or forecast) and independent variables. In this approach broad economic indicators and service factors have been used to forecast the future of air travel. Again, this method can range from very simple linear relationships of the dependent variables to one independent variable to a very complex system of multi-correlation techniques using non-linear relationships. However, regardless of how complex any regression analysis is, any form of regression analysis is basically a very sophisticated form of trend analysis. Furthermore, regression analysis, or correlation analysis as it is often called, does not determine cause and effect relationships. It merely says that certain things happen together, and from that we imply that there are cause and effect relationships.

Market Analysis. A third general type of forecast which is a little more sophisticated than regression analysis, I lump under the category of market analysis approach, in which detailed socio-economic characteristics of the population, its income, age, education and occupation are used to determine the future patterns of travel. This method attempts to determine to some degree cause and effect relationships. It also requires, however, a continuing body of detailed survey data.

Simulation Analysis. Finally, the fourth group, which I call simulation analysis, is an attempt to duplicate mathematically the various forces affecting tourism — air travel, or whatever you are trying to forecast. This method is also called econometric techniques, and perhaps it may be a better term, because almost any method that we now use does use to some extent mathematical formulas, and so almost any technique can be called econometric.

Evaluation of Alternate Techniques

An evaluation of these four methods has been made in terms of data requirements, advantages and disadvantages and ease of computerization.

Trend analysis is the simplest. You don't have to have much data. All you need is five or ten years of data on the item you are trying to forecast. It is very fast and very inexpensive, but it is very subjective. In other words, the way you feel today will influence your forecast today. You go home and have a good night's sleep and feel rested and come in tomorrow and you might feel a little cheerier — the sun is shining, the world is well, and you look at it and say, "Gee, why was I so pessimistic yesterday?" and you change the forecast. Also, it can be readily computerized too if you have a long time period of events.

The regression analysis is a little more sophisticated. A little more detailed data is required. In addition to historical data on your dependent variables, you also need historical data on your independent variables. Also, you need forecasts of your independent variables, and this is quite difficult to achieve sometimes. For example, if you have to forecast traffic related to the Gross National Product of a particular country and if that forecast is wrong, obviously, even though your relationship may be perfect, your forecast is not valid. In fact, this was one of our problems in trying to forecast U.S. domestic traffic last year. Most of our forecasts of U.S. domestic traffic are tied to the economic conditions of the country, and our own forecasters and the government had difficulty in telling us when the turnaround was going to come. So, when the economic upswing lagged, the traffic forecasts associated with it lagged. The problem then is that you have to have good forecasts of independent variables.

The regression method is still subjective in that the years you choose to analyze can significantly affect the results. If you choose ten years which happen to be part of an upswing, you would have one kind of result. If you broadened your base and included fifteen years in which there were several early years of lower growth, you would have a different result. Therefore, even in these mathematical techniques, there is a considerable bit of judgment as to what data to use and how to use it.

Again, I would have to point out that here there is no explicit cause and effect relationship, though we feel that the factors used are likely candidates. We only observe in the past that these various variables reacted to each other in certain ways. Cause and effect relationships are not certain. They are just implied.

One good thing about this method is that you can perform some sensitivity analysis. If I were unsure of what GNP were going to be in the next five years, I could take two or three different growth rates and see the impact on my forecast. This way, at least, we have a band of what the probabilities of reaching the forecast can be. Finally, computer programs for this technique are readily available. In fact, if you buy a computer, they will give you the programs with it.

The market analysis method has tremendous data requirements. Travel survey data are required to get the socio-economic characteristics of travelers and non-travelers over a period of time. A nation's population distributed among the same characteristics must also be available for the survey periods as well as for the future.

These data are not always available and are expensive and time consuming to obtain. Thus, it can take quite a few months to do a forecast for just one area.

This method does have certain advantages in that the data and analyses can be used in determining marketing strategies and advertising policies.

To my knowledge, this method has not been computerized, although I think it could be done relatively easily. Because the data problem is so enormous, it has not been worth the effort to computerize this method.

The simulation technique has not been successfully used to forecast traffic. The question is not only one of techniques or computers. It is primarily the complexity of the real world and the difficulty in attempting to duplicate all the decision-making processes that are involved when people take a trip: Should they take a trip, or spend their income some other way? Where should they go? When? With whom? For how long? Which mode? — ad infinitum.

This process would also have to be followed sequentially by time period, with all the lead and lag relationships. As you can see, the simulation method is at present way beyond us.

LOCKHEED FORECAST OF WORLD TRAFFIC

So much for the discussion of alternate techniques and the problems related to their use. How did we arrive at our world forecast?

As I mentioned earlier, we analyzed all major traffic flows throughout the world. In fact, some 48 different flows were analyzed. In my discussion today, I will cover our total world forecast and several of the major area forecasts, including U.S. domestic, transatlantic and intra-Europe.

Factors Affecting the Development of Air Traffic 1950-1970

Based on the analyses of past air traffic, we feel that the most important factors which influence the growth of air travel are economic conditions, price of air travel and the quality of air service. Specific variables utilized in our forecasts include:

- World's Economy – Constant dollar Gross Domestic Product (GDP) for the major nations.
- Standard of Living – Constant dollar GDP per capita for the major nations.
- Price of Air Travel – Revenue per passenger mile, in constant U.S. dollar prices.
- Quality of Air Service – Average speed, aircraft size and fatality rates.

The rate of growth of the world economies, as measured by various indices, provides the most important factor affecting the rate of growth of air travel. The price of a ticket, especially in relation to other goods and other modes of travel, is also an important and easily measurable factor.

For any given route or market, other factors, such as competitive pressures from other modes of travel, are important in deciding whether a traveler will fly. For predominantly business markets, various factors which reflect how well businesses are doing, such as profitability and rate of production, are reliable for forecasting.

Although these quantitative factors are important in developing suitable air travel forecasting models, it is important to realize that subjective factors, which may bear heavily on the environment within which the industry operates, must also be included.

During the past two decades, the factors which have had a significant impact on air traffic growth have developed quite rapidly. The world's economy, in constant prices, grew at an annual rate of almost 5% and per capita income at 3%. At the same time, markedly improved air service was offered at considerably lower fares.

World Gross Domestic Product grew at an annual rate of 4.9% between 1950 and 1960. The 1960's showed an identical annual growth rate increase. The U.S. economy grew at an average annual rate of 3.3% from 1950 to 1960 and 4% from 1960 to 1970. GDP of other major industrialized nations grew at a faster rate, with Japan showing a remarkable growth of almost 10% per year for these two decades.

Per capita GDP varies greatly among the world's nations. This measure of the standard of living varies widely among the major industrialized nations, ranging from almost $3900 for the U.S. to about one-third of this amount for Japan. The world average is only $680.00.

The average fare throughout the world decreased by 9% between 1960 and 1970. After adjusting for consumer price level increases, the average fare in 1960 constant dollars decreased a substantial 31%, or an average annual decrease of 3.6%. Some selective fares, such as on the North Atlantic and the Pacific, fell even faster. Comparatively, the 1950's showed general fare level increases, although fares held generally steady on a constant dollar basis.

While the price of an airline ticket decreased substantially, the quality of service, as measured by the speed, size and comfort of the aircraft, has increased with the introduction of jet aircraft. ICAO carriers' average seats per aircraft have increased 7% in the 1960's, from 59 to 101 seats. Speed increased almost 60% for the average aircraft mile flown. This translates into shorter travel times, especially on the longer segments. Together, these two factors – speed and size – result in an aircraft productivity some 2.7 times greater in 1970 than in 1960.

Added comforts and conveniences to the passenger cannot be quantified. In general, the kind of service which the carriers have provided to the passengers during the first decade of jet aircraft has improved. In addition, longer range jet aircraft have opened new markets for non-stop flights, thus reducing total trip time even more.

Safety, a very important psychological factor in air travel, has also shown significant improvement, as measured by the number of fatalities per 100 million RPM's.

In summary, during the past two decades, people's incomes have increased at a fast rate, while fares have gone down substantially (especially in relation to other goods) making air travel more attractive. At the same time, the quality of service has improved, as shown by significant reductions in flying time, added passenger comforts and a significantly greater number of non-stop flights.

Air travel is dominated by Americans and Europeans. From the subsequent discussion of the major factors that influence air travel, this is understandable since the technologically developed areas of the world account for about 90% of world air traffic. These developed areas account for over 80% of the world's economic activity, as measured by the Gross Domestic Product, while accounting for only approximately 30% of the world's population. These areas are characterized by industrialization, high income levels, a high degree of literacy and urbanization. They include most of North America, the temperate part of South America, Europe (including the USSR), Japan, Australia and New Zealand.

The relationship between air travel and population and economic activity may be easily illustrated. The illustrations show that the rate of growth of the world economies provide the most important factor affecting the rate of growth of air travel. Economic activity of a country, measured by Gross National Product, correlates highly with that country's generated air traffic. On the other hand, a large population alone is not the basic requirement in achieving high airline travel. For example, India, the second largest country in terms of population, is substantially smaller on the basis of both GNP and air travel.

The United States, substantially smaller in population than India, is by far the largest in terms of both GNP and air travel generated. The GNP of the U.S. accounts for almost one-third of the total world's GNP. U.S. domestic air traffic plus U.S. citizens traveling outside of the U.S. account for about 55% of the world's air passenger miles.

Forecast of World Air Traffic 1970-1980

Scheduled world traffic is expected to increase 10.6% per year for the 1970 to 1980 period, from 237.4 billion passenger miles to 650 billion. In 1975 it is expected that 390.0 billion passenger miles will be flown, an average increase of 10.4% per year over the 1970 level. The second half of the decade is projected to grow at 10.8% per year.

Scheduled traffic by the world's airlines during 1970's is expected to continue at a fast pace under the impetus of a growing world economy and the introduction of wide-bodied jet aircraft. This rate will be lower than experienced in the 1960's, reflecting our assumption of the continued expansion of non-scheduled air services.

World Gross Domestic Product (GDP) is expected to reach almost $4 trillion (measured in 1964 U.S. dollars) in 1980 compared to the 1970 base figure of almost $2.5 trillion. Thus, we see that world wide economic growth during the 1970's will continue the pattern of the 1960's. The major change is a partial slowdown in Japan's phenomenal growth; despite this slowdown Japan's rate will still be twice the U.S. growth rate. Despite growth in other parts of the world U.S. will still be the dominant economic power, as shown in the pie chart comparison.

As a result of the anticipated expansion of the Japanese economy, together with a low birth rate, Japan's GDP per capita in 1980 will be 40 percent greater than that of Western Europe. However, Japan's GDP per capita will exceed Europe's, equal Australia's but will still be less than 60 percent of the U.S. GDP per capita. Average world GDP will increase 3% annually from $680 in 1970 to $912 in 1980.

While service factors will continue to improve, these will be at a lower rate than during the 1960's. Passenger comfort will increase; speed will not increase significantly until supersonic aircraft are available for service. The improvement in technology will result in aircraft that are better airport neighbors. The wide-body jets will have quieter and cleaner engines, and the increased capacity will ameliorate airway and airport congestion.

Although aircraft productivity will continue to increase, it will not increase at the rate experienced with the initial introduction of jet aircraft. As indirect costs are expected to increase at a faster rate than direct, fares in current prices will not decrease as during the past decade. Fares, in constant prices, however, are expected to decline. The fatality rate during the past decade decreased to an extremely low level; however, continued emphasis will be placed on improvements in air traffic control procedures, airport landing aids and emergency facilities.

The biggest unknown is the future of non-scheduled traffic including inclusive tour packages. If the scheduled carriers elect to compete with non-scheduled services by reducing fares on scheduled services, our forecast will fall short of actual future scheduled traffic. If, on the other hand, the scheduled carriers elect to compete by substantially increasing their charter operations, our forecast of scheduled traffic will be too high as non-scheduled travel exceeds the forecast 15% growth rate.

Considering these factors, world airline scheduled traffic will continue to grow at a somewhat lower rate than the 13.4% experienced during the 1960's. There are many positive factors that will contribute to the continued growth of air travel throughout the 1970's. At present, a large portion of the adult population has never flown. The continued increase in worldwide real income per capita, more leisure time, and higher levels of worldwide education will spur air travel demand. Pleasure travel is expected to show the most rapid growth in the next decade. Increasing GNP and international trade also will provide a strong impetus to air travel among businessmen. In spite of improvements in communications, there will continue to be no substitute for personal meetings and face-to-face contact in the conduct of business. Highly competitive ground transportation is not expected in the 1970's except for Japan.

The technologically underdeveloped areas of the world (Africa, Asia (except Japan), Central America and the non-temperate areas of South America) will increase their share of the world's population during the next decade. Even though economic productivity in the underdeveloped areas will be growing at a faster rate than in the developed areas, increases on a per capita basis will be smaller. The bulk of the world's economic activity, and hence air traffic, will continue to be accounted for by North America and Europe, even though air traffic growth rates in the less developed areas will be greater. For this reason, only U.S. domestic, transatlantic and Intra-European traffic will be discussed in detail.

U.S. Domestic Traffic

U.S. domestic traffic during the 1960's increased 12.3% with continental traffic growing at about 12% and mainland to Alaska and Hawaii growing at about 15.5%. This average hides tremendous variations in growth during the past two decades. The past 20 years of domestic traffic, may be broken up into four distinct periods, each with its unique annual average growth rate:

1950-1957	17.8%
1957-1961	5.2%
1961-1968	16.0%
1968-1971	4.9%

1950-1957

The period between 1950 and 1957 was one of uninterrupted growth in passenger traffic. Although there was an actual decline in economic activity in 1954, the airlines were unaffected. During this period, fares in constant dollars (deflated by the Consumer Price Index) fell 17 percent; simultaneously, service improved as represented by a 38 percent increase in average air speed. Direct operating costs per available seat mile declined, and the trunk carriers actually averaged a rate of return equal to or greater than the 10.5 percent standard set by the CAB.

1957-1961

The rate of economic growth slowed down during the 1956-1957 period, and in 1958 GNP actually fell. The result was that, for the first time since 1948, air traffic (in 1958) showed no growth. In addition to the slowdown in the nation's economy, air fares began to increase. Between 1957 and 1961 the airlines increased air fares 11 percent in order to offset rising costs. Costs had increased, despite improved productivity of aircraft, due to the greater capacity required to serve the many new routes awarded CAB. Load factors fell as the airlines continued to increase seat miles, even though traffic growth slowed down. During this period, operating costs were fairly constant; but, due to the decline in the rate of traffic increase, the return on investment dropped sharply, reaching a low point in 1961 with barely more than a 1 percent return, despite a continuing increase in yields.

1961-1968

With the strong upturn in the nation's economy from 1961 onward, traffic grew rapidly, achieving about the same levels of growth as in the early and mid-1950's. As jets became the dominant aircraft, operating efficiencies increased, better service was offered, and direct operating costs per seat mile dropped 16 percent between 1962 and 1968. Air yield, which reached a peak in 1962, started to drop rapidly; the passenger tax was reduced from 10 percent to 5 percent in 1962. As a result, real fares dropped 28 percent. The rate of inflation was less than 2 percent per year during this period of rapid growth. The rate of return started climbing, reaching 10 percent by 1964 and exceeding it in 1965 and 1966.

As airlines achieved high ROI's, the CAB increased competition by putting three carriers on most major routes. Between the increased productivity of the jets and increasing competitive scheduling resulting from the new route awards, available seat miles doubled in the four years between 1964 and 1968. To fill up the seats, the CAB exerted pressure on the airlines to reduce fares, especially through special discount and promotional fares. These fare discounts were probably greater than they should have been; for, while direct operating costs per seat mile were falling, indirect costs began to increase as airlines improved ground facilities and offered better inflight service (movies, improved meals, etc.), and costs associated with congestion began to appear. Airline profits and ROI started falling - the latter falling to 5.5 percent by 1968, even though traffic was growing rapidly.

1968-1971

The slowdown in domestic air traffic from which we have just emerged began during the last half of 1969, even though the year ended up 9.2 percent ahead of 1968. New and often excessive route awards (e.g., nine carriers serving the U.S. mainland to Hawaii) continued into 1969. Seat miles increased 16 percent compared to the 10 percent growth in passenger miles. Economic activity slowed markedly in 1969, and GNP showed only a 2.8 percent increase for the year as a whole. GNP, during the 4th Quarter of 1969, actually fell below the prior quarter for the first time since the 1961-1962 recession. Consumer price increases continued to accelerate during the late 1960's, reaching over 5 percent in 1969. Real passenger fares, ending their six-year declining trend, remained constant as fare increases granted by the CAB roughly equalled the rate of inflation. Nonetheless, airline profits decreased 5 percent and the ROI slipped under 5 percent.

Early in 1970 it had been anticipated that there would be a moderate economic recovery during the second half of the year. In actuality, there was no recovery during 1970; GNP actually declined. Inflation continued unabated; airline costs continued to escalate; real fares increased slightly, and the passenger tax was increased from 5 to 8 percent to pay for airport and airways improvements. Airline profits turned into losses.

Domestic traffic remained virtually static during 1970 and 1971. Trunk carrier traffic actually declined in 1970. The industry was also plagued by strikes of airline personnel as well as air traffic controllers, which cost the industry about 1 billion revenue passenger miles. In fact, traffic got worse during the second half of 1970, paralleling the pattern of economic activity.

Ironically, the 1970-1971 period resembles the 1958-1961 period when the first generation jets were introduced into service. A slowdown in the economy reduced traffic. Capacity increased, not only due to great competition from new route awards but also due to increased aircraft productivity as B747's were introduced into service. One major difference is the current high level of inflation, a rate of over 5%. Airline costs increased at an even greater rate. Due to reduced traffic growth, the CAB was slow to award further fare increases. The airlines, thus, were squeezed between falling revenues and soaring costs, resulting in their present poor financial condition.

Forecast 1972-1980

The economy finally turned around during the latter half of 1971. Air traffic during the first half of 1971 fell below 1970. Despite the 6% fare increase granted in May 1971, summer traffic was about the same and traffic finally began increasing during the last quarter. The domestic traffic recovery has continued into 1972. The first half is up about 12%, and this rate is expected to continue the rest of the year.

As may be seen from the foregoing analysis, the two most important variables influencing air traffic are the condition of the nation's economy (as measured by GNP) and the price for air service — passenger yield — measured in average revenue (including tax) per passenger mile.

These two independent factors are relatively simple to project on a long-term basis — GNP reflects the general trend of the economy and passenger yields reflect the long-term cost of providing the service.

However, projecting short-term values for these factors is extremely difficult, as to a great extent they reflect Government policy. It is next to impossible to predict the exact timing of various governmental actions.

Nevertheless, our view is that the economy will continue improving through 1973 and 1974. Passenger yields will increase to keep up with inflation, which is expected to continue through the end of 1973. Air traffic will continue a strong upward trend through 1973 and 1974. In the last half of the decade it is expected that traffic will increase at about 9.5% per year.

Our current forecast was prepared using regression analyses. Many independent variables were considered, including: GNP (in both current and constant dollars), disposable personal income (both current and constant dollars), population, unemployment trends, current and constant dollar yields, corporate profits, savings rates, stock prices, retail sales and a quality service index. The variables yielding the best fit of the past were current dollar disposable personal income, constant dollar yields, corporate profits and unemployment.

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Our forecast through 1980 is based on a 6.9% annual increase in disposable income, a 7.8% annual increase in corporate profits, a steadily decreasing unemployment rate (e.g., 5% in 1974, 3.8% by 1980) and a yield that remains the same in constant dollars.

Beyond the analysis of past history, there are positive factors which may be expected to contribute to the continued growth of air travel in the decade of the 1970's. Paramount among these is the real need for such service. Gross National Product will increase by over 50 percent in the next ten years. The volume of business resulting from such an increase will provide a strong impetus for air travel among businessmen. In spite of improvements in communications, there will continue to be no substitute for personal meetings and face-to-face contact in the conduct of business. The continued increase in acceptance of air travel by the U.S. population will be accelerated by larger numbers of young people who have been exposed to air travel, either through military service or by youth discount. While about 50 percent of the U.S. population has flown commercially today, this percentage will continue to increase over the next few years.

The influence of increased GNP will be more pronounced when viewed from a per capita basis. With population growing at about 1 percent per year, and GNP in real terms anticipated at 4 percent, one can visualize the increase in disposable income which will result. This increased income, coupled with the push for more leisure time, will spur air travel demand. It is in the area of increased pleasure travel that the most rapid growth in air travel demand will result.

Transatlantic Traffic

Transatlantic scheduled air traffic from the U.S. and Canada to Europe has been one of the fastest growing travel markets in the world. During the 1950's it grew at an average annual rate of over 19%, virtually knocking out sea travel. During the 1960's under the impetus of expanded jet service which not only decreased travel time but lowered fares 36% in constant prices, transatlantic air traffic increased at an average rate of almost 16%.

During the latter part of the 1960's, charter traffic by both scheduled and supplemental carriers grew rapidly. During the 1960's charter traffic averaged 30% annual growth, reaching 26% of the total transatlantic market. The combined scheduled and charter market grew at an annual rate of 18% almost as high as the 19% experienced by scheduled traffic in the 1950's, when the market was first developing.

Our transatlantic scheduled traffic forecast for 1980 of little over a 10% annual growth rate reflects a continuing switch to charter travel. Charter traffic, on the other hand, is expected to grow at an annual rate of almost 17% with the expectation that charter will account for almost 39% of total transatlantic air travel by 1980.

The forecast is based on current types of scheduled and charter services. Continued relaxing of restrictive charter policies would result in an

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even faster charter growth rate and in a lower growth rate for scheduled traffic. The new combined scheduled/charter traffic would be higher than the present 12% forecast.

This forecast of scheduled traffic is based on a separate analysis of U.S. and European originating traffic. U.S. originating traffic was found to be related to U.S. consumer expenditures (in constant dollars), total trip cost (including hotels, meals, tours and transportation) and charter traffic. European originating traffic was found to be related to an index of Western Europe GNP (OECD countries) in constant Western European currencies, a weighted index of trip costs in constant currencies and charter passengers.

Our analysis indicates that European originating traffic will grow at a substantially higher rate than U.S. originating traffic. Thus, European originating traffic which represented 36% of the total in 1970 will climb to 45% by 1980. This should go a long way in moderating the directional imbalance that has plagued this market for many years.

Intra-Europe Traffic

Traffic within Europe is the third largest world market. The geographic definition of Europe is that used by the European Air Research Bureau; thus, it includes the entire Mediterranean Basin (i.e., Africa north of the Sahara and the Middle East countries). European traffic to the USSR is included, but the USSR itself is excluded. Also, it includes both domestic as well as international passengers.

Some 28 billion passenger miles were accommodated during 1970, or almost 12% of ICAO total scheduled passenger miles. During the 1950's, this traffic grew at almost 16% per year. During the 1960's, this traffic grew at only 12.5% per year. This drop reflects competition from low-fare inclusive tour charters (IT Charter) that developed rapidly in the United Kingdom, West Germany and in the Scandinavian countries. This traffic is holiday travel destined to the Mediterranean area, primarily to Spain.

European IT charter traffic grew from virtually nothing in 1960 to almost 12 billion passenger miles in 1970, or almost 35% per year; it now represents about 47% of intra-Europe international traffic by Western European carriers. While charter service has generated new traffic, it has also diverted some scheduled traffic in certain markets. Our estimate is that two-thirds of IT traffic was generated and about one-third was diverted from scheduled service.

Charter traffic is forecast to grow at 15.5% during the decade of the 1970's, compared to a 10.5% growth rate for scheduled traffic. On this basis, charter traffic will exceed scheduled traffic in the near future.

It is interesting to speculate what the impact of this kind of service on U.S. domestic traffic would be if it were encouraged within the U.S.

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Other Areas

Traffic in the three areas — U.S. domestic, intra-Europe and transatlantic — represents about two-thirds of the world's scheduled traffic and most of the world's charter traffic.

Other important area markets are the U.S. to the Caribbean, transpacific, Europe to the Far East, and within Asia (Japan domestic and intra-Orient) and Australia. It would be too time consuming to go over these in detail at this time. If there are any questions relating to traffic in these areas, I will be glad to answer them.

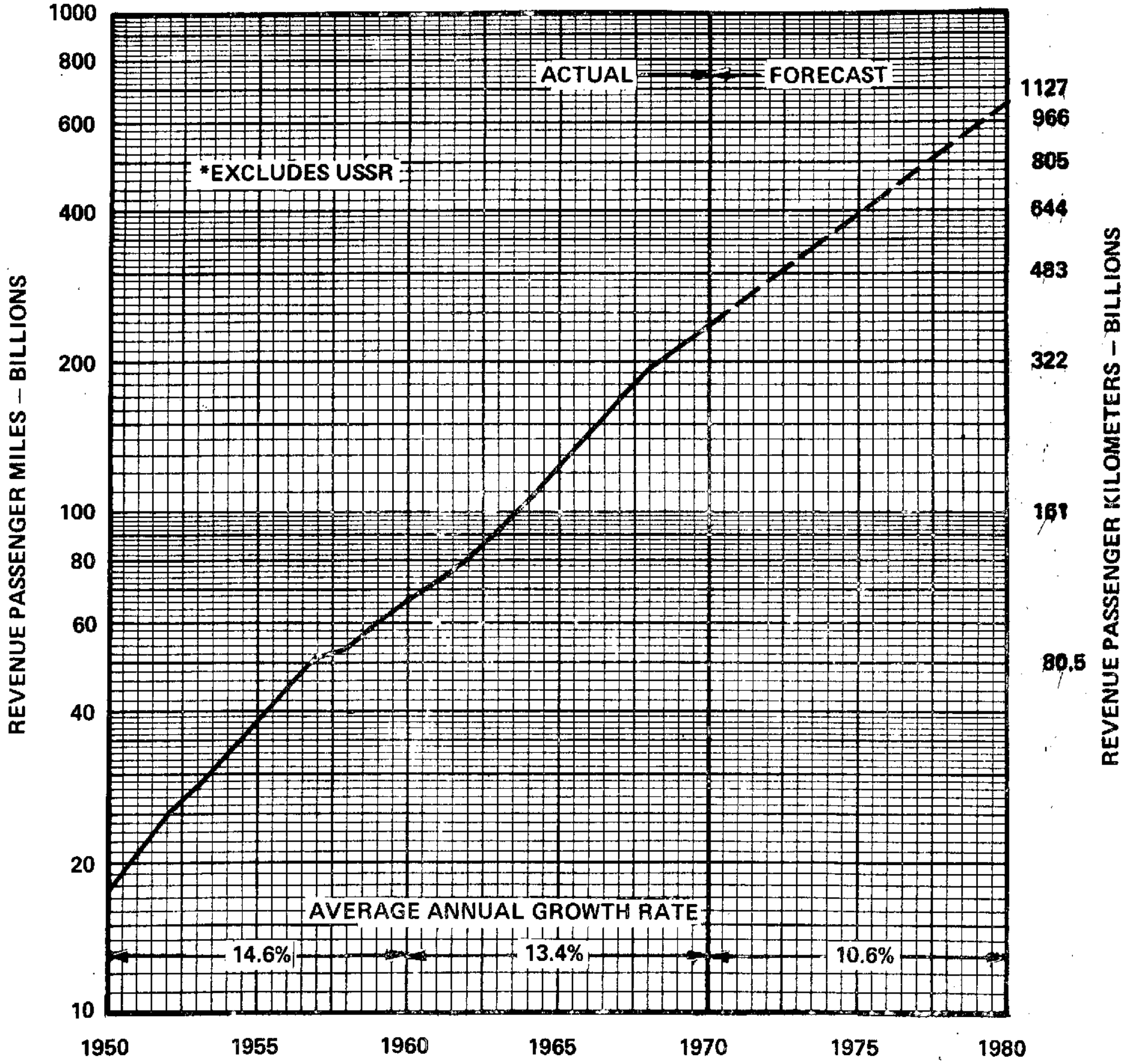
ONE LAST THOUGHT

Let me sum up briefly, giving a few highlights.

If the future were a simple extension of the past, it would be very easy to forecast; if the future were completely different from the past, it would be impossible to forecast. Fortunately, the future includes both elements; thus, we do have the potential of peering into the future.

I believe that, in spite of all the hazards involved in forecasting and all the negatives that I have given in certain areas of my talk, we can still know the future in broad terms. However, the future can also be made to our liking. I believe we can, by conscious policies, translate goals into actuality. We need broad forecasts of the future to give us the framework to give us the reference of events that are likely to happen. However, what will really happen depends on what we do. We are makers of our own destinies. I really believe that, and I think that is what planning and forecasting are all about. This is to say, you must decide beforehand what you want to do and why you want to do it; then use your analysis in order to determine the impact of what you do.

ICAO* WORLD SCHEDULED AIR TRAFFIC 1950–1980



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WORLD NON-SCHEDULED AIR PASSENGER TRAVEL

1960-1980

(Billions of Passenger Miles)

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						AVERAGE ANNUAL GROWTH RATE (%)	
	1960	1965	1970	1975	1980	1960-1970	1970-1980
EUROPEAN IT	0.6	3.2	11.9	27.0	50.0	34.8	15.5
TRANSATLANTIC	0.8	2.8	10.5	25.0	50.0	29.5	16.9
OTHER	NA	NA	27.6	53.0	100.0	–	13.7
TOTAL NON-SCHEDULED	NA	NA	50.0	105.0	200.0	–	14.9
ICAO*			237.4	395.0	650.0	13.4	10.6
NON-SCHEDULED AS A % OF ICAO SCHEDULED			21.1%	26.6%	30.8%		

* EXCLUDES USSR

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ICAO WORLD* AIR PASSENGER TRAVEL DISTRIBUTED AMOUNG MAJOR TRAFFIC FLOWS

Billions of Passenger Miles in Scheduled Service

AIR TRAFFIC FLOWS [1]	ACTUAL		FORECAST	AVERAGE ANNUAL GROWTH [2]	
				ACTUAL	FORECAST
	1960	1970	1980	1960-1970	1970-1980
U.S. DOMESTIC	32.6	104.2	255.0	12.3	9.4
OTHER NORTH AMERICA DOMESTIC	2.1	6.0	15.5	13.4	10.0
U.S./CANADA-LATIN AMERICA/CARIBBEAN	4.2	15.9	42.0	14.2	10.2
NORTH AMERICA – EUROPE	6.9	30.0	80.0	15.8	10.3
NORTH AMERICA – ASIA/OCEANIA	1.8	10.0	41.0	18.7	15.2
INTRA EUROPE	8.7	28.3	79.0	12.5	10.8
EUROPE – SOUTH AMERICA	0.8	3.4	9.5	15.7	10.9
EUROPE – AFRICA	1.2	4.0	8.6	12.8	8.2
EUROPE – ASIA/OCEANIA	2.8	10.6	32.8	14.2	11.9
AFRICA	1.2	2.4	6.8	7.2	11.0
ASIA	2.3	12.5	51.0	17.9	15.1
OCEANIA	1.8	4.5	13.7	9.6	11.8
SOUTH AMERICA	2.1	4.8	11.6	8.1	9.2
OTHER	0.2	0.9	3.5	16.3	14.6
TOTAL – ABOVE	68.7	237.5	650.0	–	10.6
TOTAL – REPORTED BY ICAO	67.3	237.4	–	13.4	–

* EXCLUDES THE USSR

[1] SEE PREVIOUS PAGE FOR DEFINITION.

[2] SEE APPENDIX FOR DETAILED FORECASTS FOR EACH MAJOR FLOW.

COMPARISON OF ALTERNATIVE TECHNIQUES

	TREND ANALYSIS	REGRESSION ANALYSIS	MARKET ANALYSIS	SIMULATION ANALYSIS
DATA NEEDS	• HISTORY OF ITEM TO BE FORECAST	• 7-10 YEARS HISTORICAL DATA INDEPENDENT & DEPENDENT VARIABLES • FORECAST OF INDEPENDENT VARIABLES	• DETAILED SOCIO ECONOMIC DATA OF POPULATION & TRAVELERS • DETAILED TRAVEL DATA FOR EACH POPULATION SUB-GROUP	• PRECISE DATA REQUIREMENTS FOR SPECIFIC TIME PERIODS
ADVANTAGES	• FAST • LITTLE EFFORT	• RELATIVELY SIMPLE MATH CONCEPTS • QUICK • SENSITIVITY ANALYSIS	• ANALYSIS OF WHO DOES AND DOES NOT TRAVEL • MARKETING STRATEGY	• "WHAT IF" ANALYSES • ONCE COMPUTERIZED FAIRLY RAPID RESULTS
DISADVANTAGES	• NOT ANALYTICAL • SUBJECTIVE	• CAUSE & EFFECT UNCERTAIN • YEARS CHOSEN AFFECTS ANALYSIS	• TIME CONSUMING • DIFFICULT TO FORECAST FUTURE POPULATION CHARACTERISTIC IN DETAIL	• TIME CONSUMING TO DEVELOP MODEL • ANALYTICALLY DIFFICULT • ADVANCED MATHEMATICS
COMPUTERIZATION	• SIMPLE PROGRAMS	• MORE COMPLEX BUT READILY AVAILABLE	• DIFFICULT • HAS NOT BEEN DONE	• EXTERMELY COMPLEX

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GROSS DOMESTIC PRODUCT

(BILLIONS OF 1964 U.S. DOLLARS)

YEAR	U.S.	CANADA	WESTERN EUROPE	JAPAN	AUSTRALIA	TOTAL WORLD
1950	389.4	24.8	242.9	22.0	12.3	949.4
1960	537.2	36.4	389.9	50.5	17.8	1,535.5
1970	796.0	66.3	598.6	140.0	27.3	2,466.3

AVERAGE ANNUAL GROWTH RATE (%)

1950/1960	3.3	3.9	4.8	8.7	3.8	4.9
1960/1970	4.0	6.2	4.4	10.7	4.4	4.9

GROSS DOMESTIC PRODUCT PER CAPITA

(1964 U.S. DOLLARS)

YEAR	U.S.	CANADA	WESTERN EUROPE	JAPAN	AUSTRALIA	TOTAL WORLD
1950	2,557	1,810	792	265	1,500	375
1960	2,973	2,034	1,164	542	1,728	513
1970	3,879	3,098	1,624	1,353	2,184	680

AVERAGE ANNUAL GROWTH RATE (%)

1950/1960	1.5	1.2	3.9	7.4	1.4	3.2
1960/1970	2.7	4.3	3.4	9.6	2.4	2.9

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AVERAGE FARE LEVELS

(U.S. CENTS PER PASSENGER MILE)

ICAO CARRIERS [1]			IN CURRENT U.S. DOLLARS			
YEAR	CURRENT $	CONSTANT $ [2]	U.S. DOMESTIC	TRANS. ATLANTIC	TRANS-PACIFIC	INTRA-EUROPE
1960	6.34	6.34	6.06	7.08	7.47	7.96
1965	5.99	5.62	6.03	5.43	6.31	8.19
1970	5.75	4.39	6.00	4.53	5.40	8.42
1960 TO 1970 CHANGE	-9%	-31%	-1%	-36%	-28%	+6%

[1] EXCLUDES THE USSR

[2] IN 1960 U.S. DOLLARS

ICAO CARRIERS*AIRLINE SERVICE FACTORS AND FARES

YEAR	SIZE SEATS PER AIRCRAFT	SPEED MILES PER HOUR	SAFETY FATALITIES PER 100 MILLION RPM'S	AVERAGE FARES REVENUE (¢) PER PASSENGER MILE	
				CURRENT	CONSTANT**
1960	59	225	1.25	6.34¢	6.15¢
1965	86	291	.56	5.99¢	5.45¢
1970	101	357	.40	5.75¢	4.26¢
PERCENT CHANGE 1960-1970	71%	59%	-68%	-9%	-31%

*EXCLUDES U.S.S.R. **1958 U.S. DOLLARS

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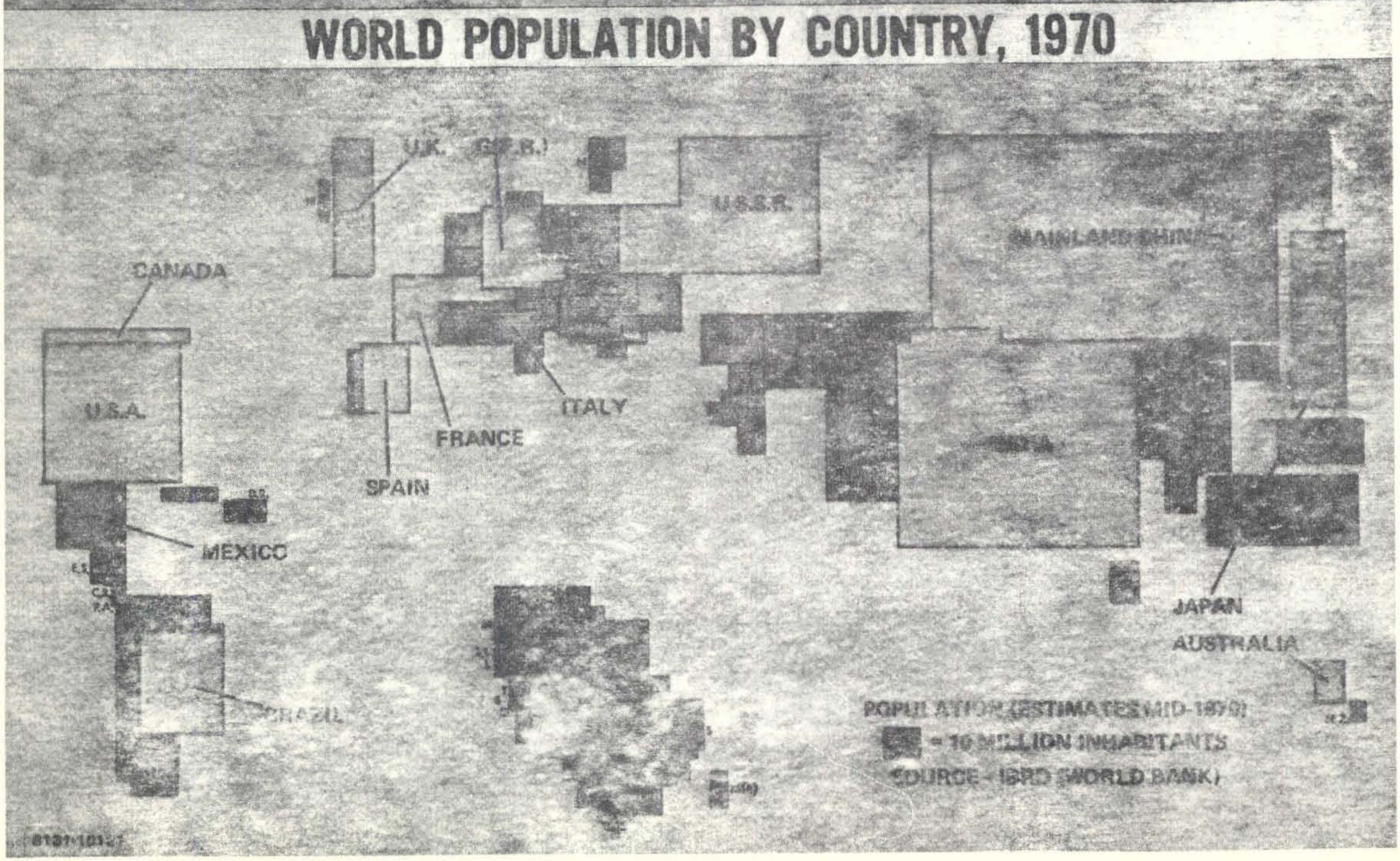
Figure 4

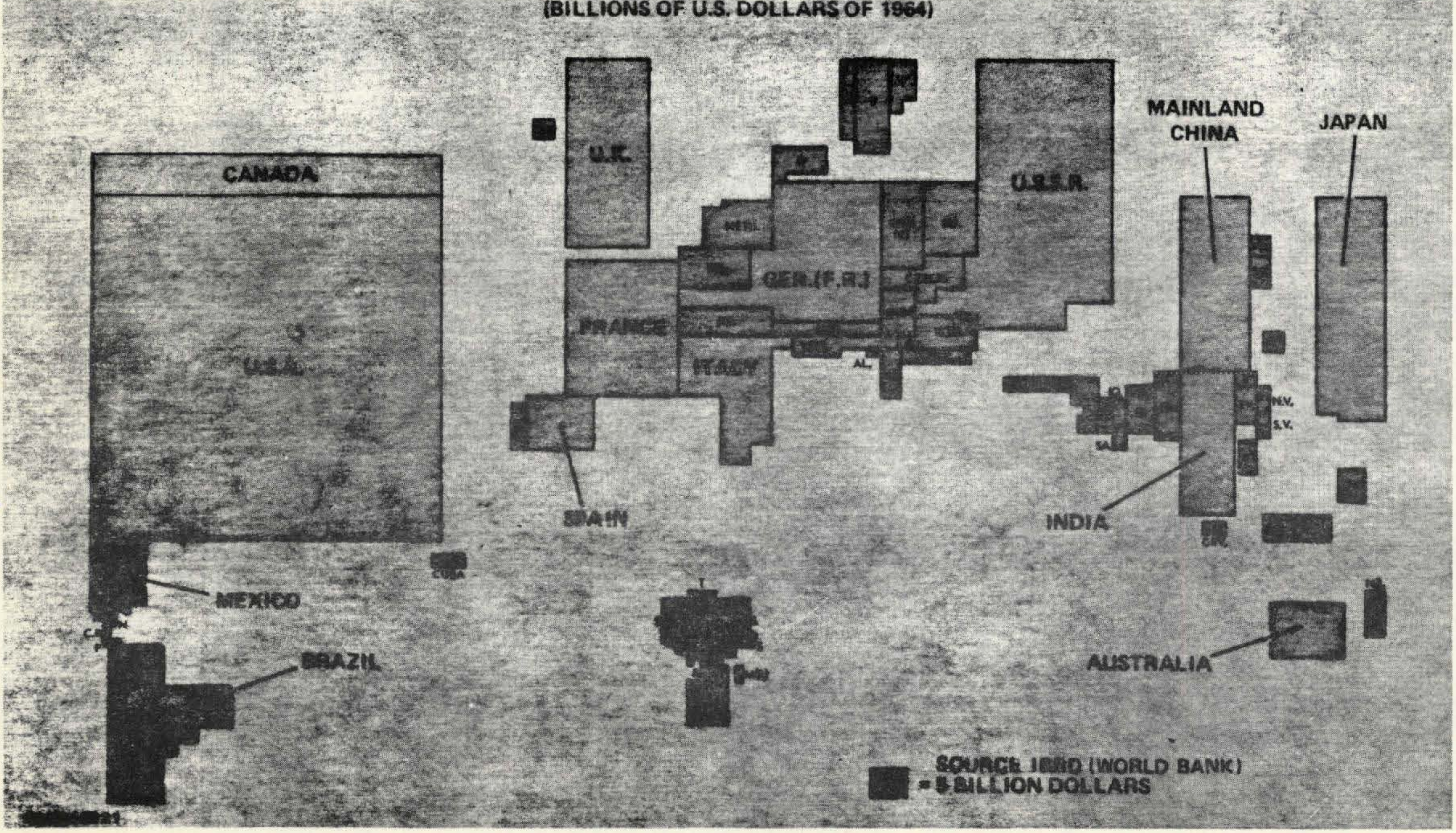


WORLD POPULATION BY COUNTRY, 1970

Figure 5

WORLD GROSS NATIONAL PRODUCT (GNP) BY COUNTRY, 1968

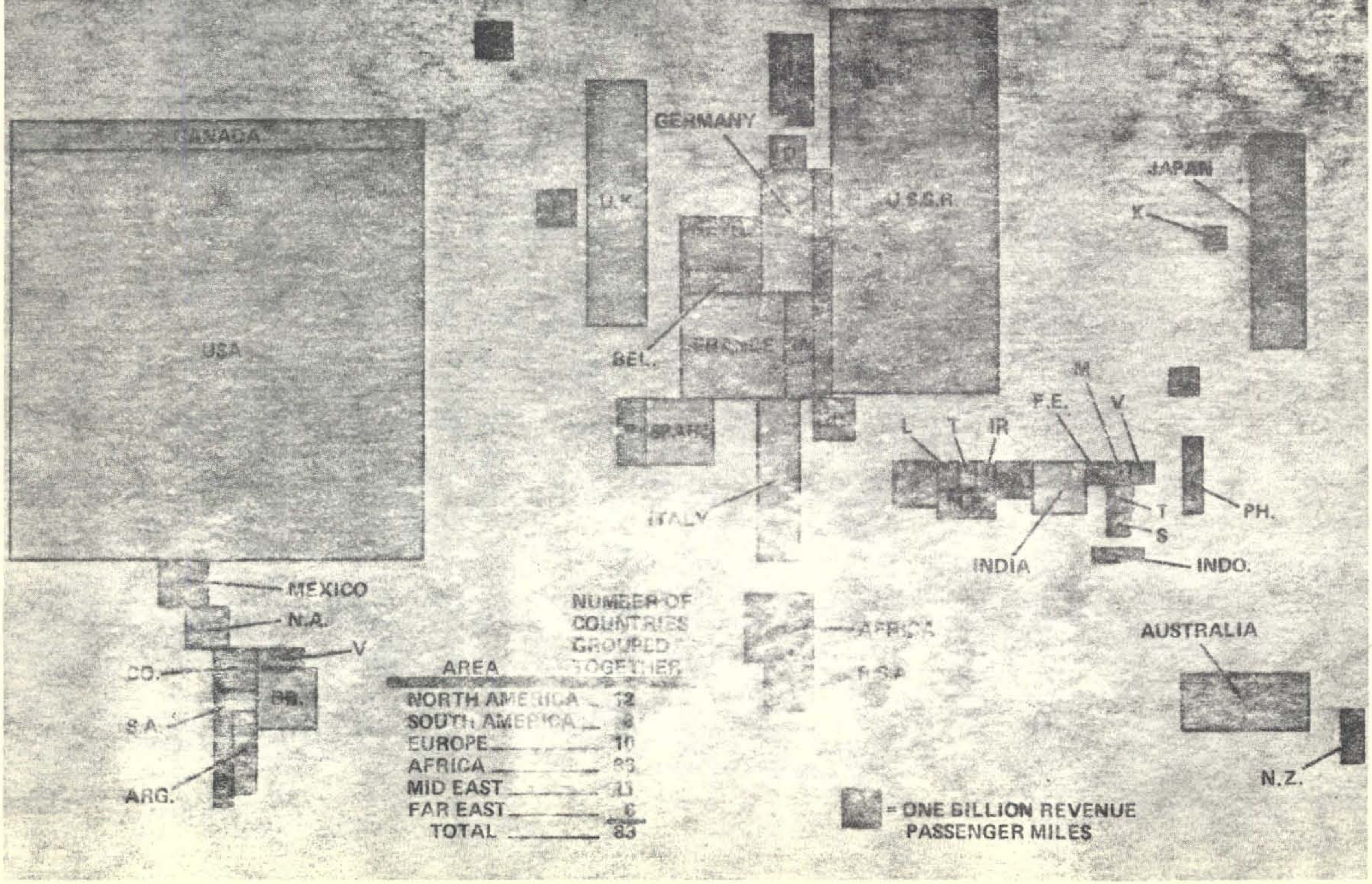
(BILLIONS OF U.S. DOLLARS OF 1964)



SOURCE: IBRD (WORLD BANK)
▪ = 5 BILLION DOLLARS

Figure 6

WORLD AIRLINE REVENUE PASSENGER MILES IN SCHEDULED SERVICES BY COUNTRY – 1970



AREA	NUMBER OF COUNTRIES GROUPED TOGETHER
NORTH AMERICA	12
SOUTH AMERICA	8
EUROPE	10
AFRICA	33
MID EAST	13
FAR EAST	6
TOTAL	83

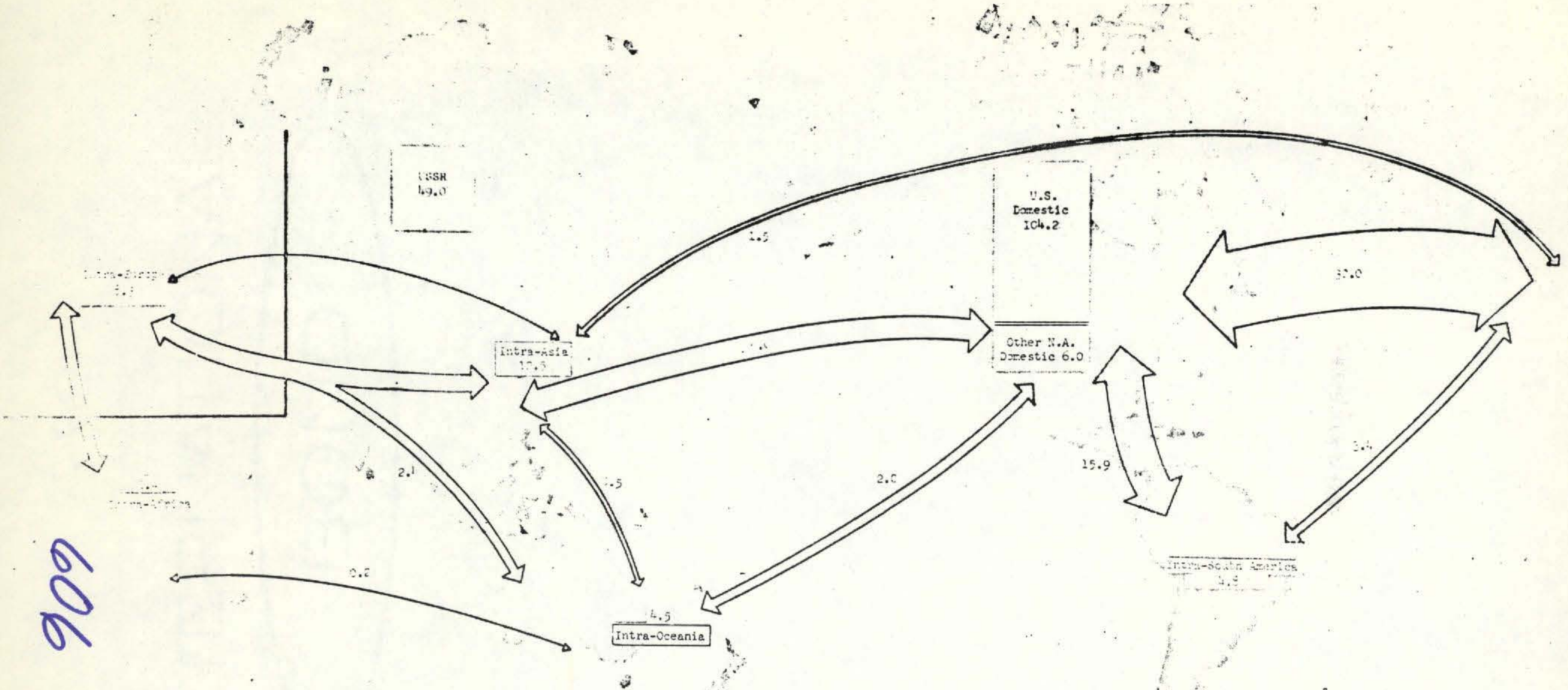


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Figure 3

WORLD AIR TRAFFIC FLOWS

BILLIONS OF PASSENGER MILES
IN SCHEDULED SERVICES

1970

GROSS DOMESTIC PRODUCT

(BILLIONS OF 1964 U.S. DOLLARS)

YEAR	U.S.	CANADA	WESTERN EUROPE	JAPAN	AUSTRALIA	TOTAL WORLD
1970	796.0	66.3	598.6	140.0	27.3	2,466.3
1975	963.8	85.5	734.0	210.0	34.0	3,124.5
1980	1,178.0	111.8	904.0	300.0	41.0	3,946.4

AVERAGE ANNUAL GROWTH RATES (%)

YEAR	U.S.	CANADA	WESTERN EUROPE	JAPAN	AUSTRALIA	TOTAL WORLD
1960/1970	4.0	6.2	4.4	10.7	4.4	4.9
1970/1980	4.0	5.4	4.2	7.9	4.2	4.8

GROSS DOMESTIC PRODUCT PER CAPITA

(U.S. 1964 $)

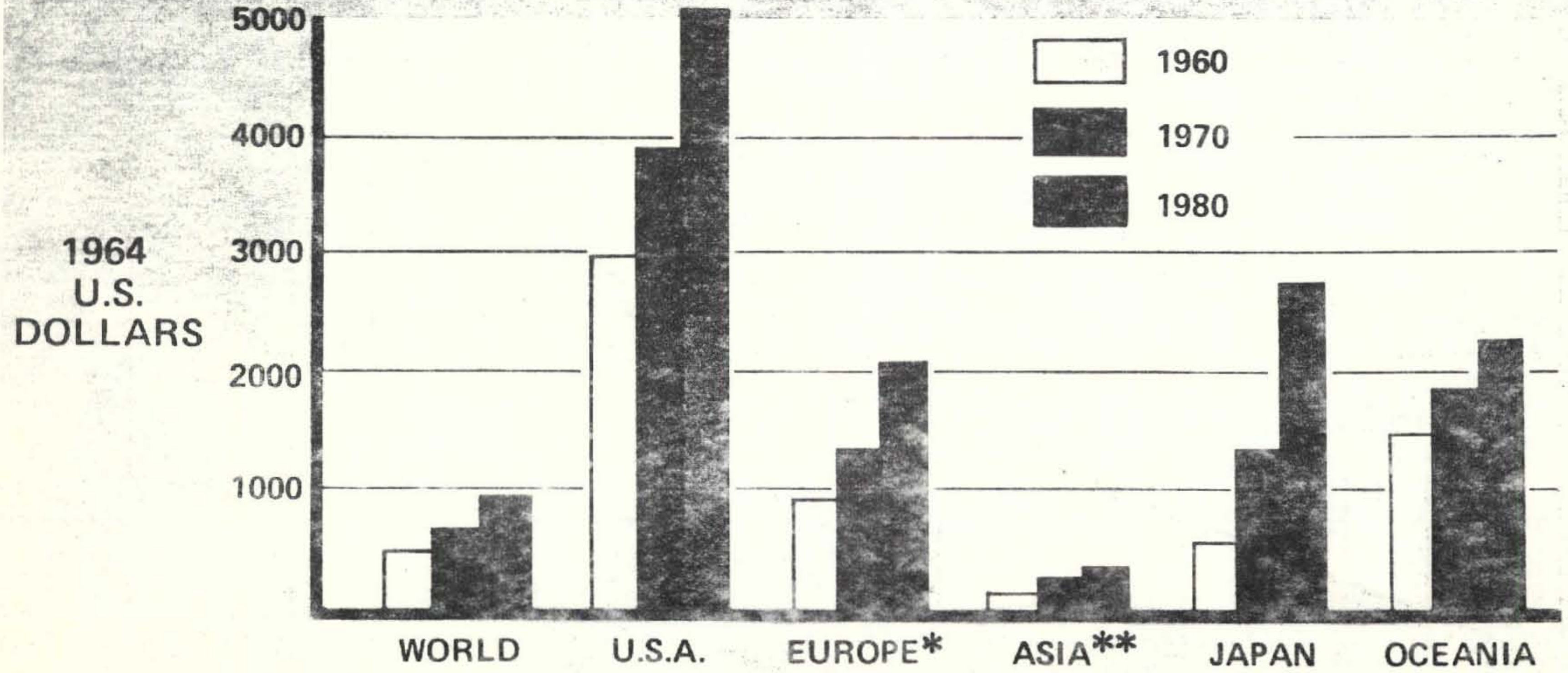
YEAR	U.S.	CANADA	WESTERN EUROPE	JAPAN	AUSTRALIA	TOTAL WORLD
1970	3,879	3,098	1,624	1,353	2,184	680
1975	4,429	3,638	1,921	1,974	2,482	793
1980	5,069	4,235	2,280	2,727	2,770	912

AVERAGE ANNUAL GROWTH RATES (%)

1960/1970	2.7	4.3	3.4	9.6	2.4	2.9
1970/1980	2.7	3.2	3.5	7.3	2.4	3.0

PER CAPITA GROSS DOMESTIC PRODUCT

WORLD AND MAJOR AREAS



* INCLUDES EASTERN EUROPE AND USSR

** EXCLUDES MAINLAND CHINA, NORTH KOREA AND NORTH VIETNAM

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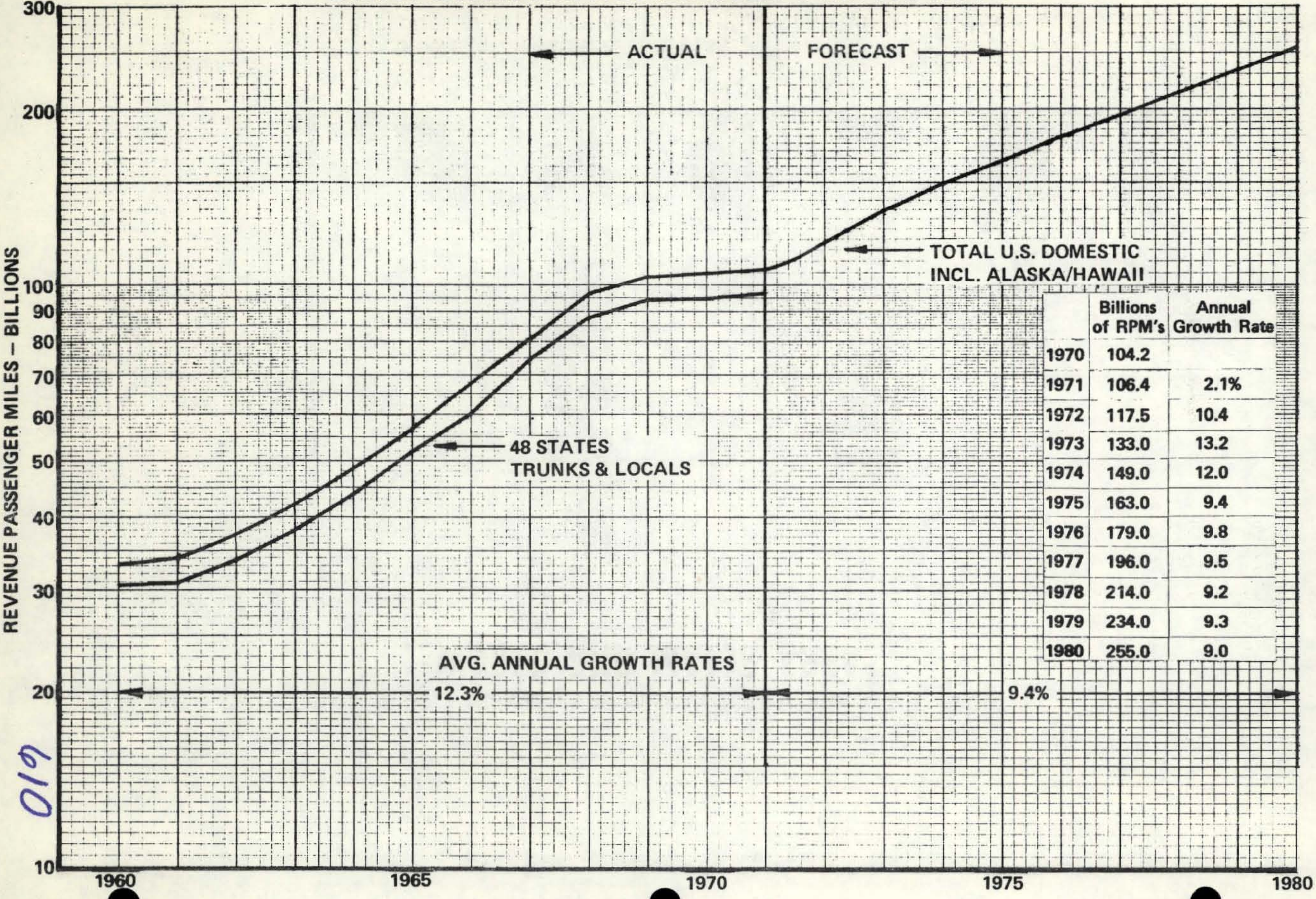
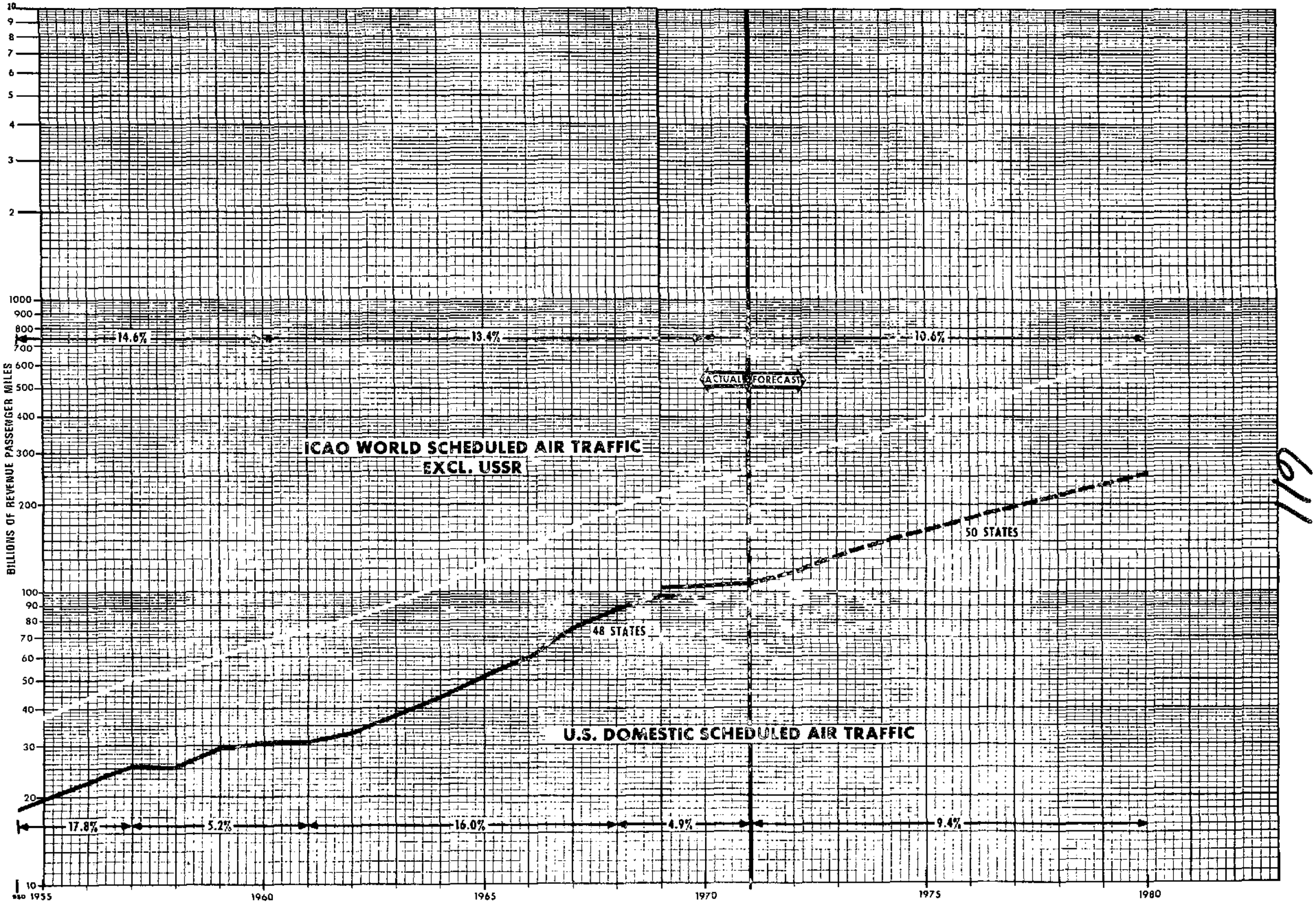
U.S. DOMESTIC SCHEDULED AIR TRAFFIC



	Billions of RPM's	Annual Growth Rate
1970	104.2	
1971	106.4	2.1%
1972	117.5	10.4
1973	133.0	13.2
1974	149.0	12.0
1975	163.0	9.4
1976	179.0	9.8
1977	196.0	9.5
1978	214.0	9.2
1979	234.0	9.3
1980	255.0	9.0



ICAO WORLD SCHEDULED AIR TRAFFIC
EXCL. USSR
U.S. DOMESTIC SCHEDULED AIR TRAFFIC
BILLIONS OF REVENUE PASSENGER MILES
ACTUAL
FORECAST
14.6%
13.4%
10.6%
48 STATES
50 STATES
17.8%
5.2%
16.0%
4.9%
9.4%
10
9
8
7
6
5
4
3
2
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
1955
1960
1965
1970
1975
1980

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NORTH AMERICA-EUROPE

SCHEDULED AND CHARTER PASSENGER MILES
(BILLIONS)

YEAR	SCHEDULED	CHARTER	TOTAL	PERCENT CHARTER
ACTUAL				
1960	6.9	.8	7.7	10.4
1965		2.8		
1970	30.0	10.5	40.5	25.9
FORECAST				
1975	49.5	25.0	74.5	33.6
1980	80.0	50.0	130.0	38.5
AVERAGE ANNUAL GROWTH RATE				
1960/1970	15.8	29.5%		18.1%
1970/1980	10.3	16.9%		12.4%

1/ CHARTER TRAFFIC OR IATA AND U.S. PLUS EUROPEAN CHARTER AIRLINES.

INTRA-EUROPE TRAFFIC

SCHEDULED AND I.T. CHARTER
(BILLIONS)

YEAR	SCHEDULED [1]	CHARTER [2]	TOTAL	PERCENT CHARTER
ACTUAL				
1960	4.4	.6	5.0	12%
1965	7.7	3.2	10.9	29%
1970	13.6	11.9	25.5	47%
FORECAST				
1975	23	27	50	54%
1980	37	50	87	57%
AVERAGE ANNUAL GROWTH RATE				
1960/1970	11.9%	34.8%	17.7	
1970/1980	10.5%	15.5%	13.1	

[1] SCHEDULED INTRA-CONTINENT INTERNATIONAL TRAFFIC OF THE WESTERN EUROPE SCHEDULED CARRIERS.

[2] INCLUSIVE-TOUR INTRA-CONTINENT INTERNATIONAL TRAFFIC OF THE WESTERN EUROPEAN I.T. CARRIERS.

DETERMINANTS OF MARKET STRUCTURE AND THE AIRLINE INDUSTRY

by William Raduchel
Harvard University

July 10, 1972

Abstract

This lecture explores the general economic determinants of market structure with special reference to the airline industry. Included are the following facets: absolute size of firms; distributions of firms by size; concentration; entry barriers; product and service differentiation; diversification; degrees of competition; vertical integration; market boundaries; and economies of scale. Also examined are the static and dynamic properties of market structure in terms of mergers, government policies, and economic growth conditions.

William Raduchel

I would like to talk about the classical economic tradeoff: efficiency vs. equity. In order to try to say something we try to set up models. One of the areas in which we do this is industrial organization: the structure, conduct and performance of one industry or a group of industries. There is quite a bit of work done here, but I don't think it's all quite applicable to the airline industry.

Now, all these models begin by assuming a) that we're dealing with firms, b) that these firms produce a homogeneous product that is not really subject to much quality variation. As a consequence of that the only attribute of this product which the firm controls is the price. Now these are sort of zeroth order assumptions, but they beg a lot of questions, particularly: What's the firm? What's the homogeneous product? and What's the price?

The firm I think is best defined implicitly: we say that it is the decision making center. Someone makes decisions controlling inputs and producing outputs. Somebody takes information (basically assumed to be prices from particular markets) and makes decisions combining these factors by taking in the inputs and produces outputs. We assume this decision maker, whoever he is, has some goal and the goal is usually that he maximizes profit, defined as the difference between revenue and cost. Now this is obviously a somewhat strained definition: between the economic firm and American Airlines there is obviously quite a bit of difference. The firm is related to the modern concept of the profit center. But you seldom have a particular group of people who make one product, control one price, and take the other prices in from the market, and produce an output.

In defense of the economics of a firm it is true that we do try to practice profit maximization. The perennial argument that the firms don't maximize profits is really rather spurious because we don't really have to claim it for most of the conclusions that we reach. We don't need the fact that the firms have a profit function where they set all of the first derivatives to zero and find a maximum. For most of the conclusions all we really need is that the firm *strives* for the maximum in profit. There *are* some questions as to how fast they get there.

The difference is between analytically maximizing the function against numerically maximizing it. The outcome is the same. All we really need to postulate is that the firm is trying for this goal; it is not necessary to reach it right away.

As we set up this kind of world we can distinguish two determinate market structures which Professor Tideman talked about earlier; these are competition and monopoly. Now I'm certain that nobody here really believes that either of these serves as a realistic model. But again, that's not really their purpose: their purpose is to provide a standard, to provide an ideal. If we had such and such a situation, we would have the resulting outcome which would have certain properties. We can then compare existing situations to these standards and try to infer from that something about the properties. In competition we end up with a long run equilibrium situation in which the only sustainable price is equal to the long run average cost which in turn is equal to the marginal cost. This is because of the requirement that the only sustainable condition occurs when each firm is producing at its mimimum long run average cost. This situation appeals to the economist as it is the most efficient solution: there's no way to make you better off without making somebody else worse off.

The contrast to this is a monopoly situation in which we can't say very much about price or quantity but we can say that the firm, if it's going to maximize profits, will balance off the gains to revenue from any action against the additional costs incurred. When these are equal, profits will be at a

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maximum. Again this raises all sorts of questions like the term over which the firm is thinking about: short or long run profits. Things may be very destructive to profits in the short run and very crucial to profits in the long run.

Most of these questions, however, are ignored and the more realistic models all deal with the world of imperfect competition. The reason that we don't talk much about the problems I guess is because you really can't say very much. You must begin to assume that the firm is really behavorial, that, after all, a firm is managed by a group of individuals. The individuals have various goals: they have stock in the company, or they do not have stock in the company. The stock may be a small part of the company's net worth; but it may be a very large part of the Chief Executive's net worth, so he would be interested in maximizing capital gains. A variety of circumstances are going to affect the behavior in the top managements: status and prestige, particularly. The results of these influences are something that we can call slack.

This again is particularly important. When we talked about the production policies that each firm was following, we assumed the firm ended up on the production function, and so it was getting the most possible output from any given set of inputs. Well, it's doubtful that the firms are always there

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and the question really is how close they are. There has been a lot of argument that in fact we have quite a lot of slack in the U.S. economy. Big firms do not get the most out of their inputs. Workers could produce more, and machinery could be used more heavily. This, of course, is a very hard thing to talk about because we don't have any measures. There's no way of telling how much a firm could have produced unless you find a more efficient firm that is really identical and find they're producing 10 times as much output as you are from the same input. Then you're inefficient. Unfortunatley you seldom have those comparisons. This means is if there is slack and you have a management that's composed of people who have a variety of goals, they aren't necessarily bound to the market. If demand falls off a little bit, they can still keep profits up by becoming a little better managers. At the same time, if the demand is really soaring, managers may take more leisure time and may not worry so much about the office. They take trips to Waterville Valley or something like that. This type of play in the system is not really talked about, and we don't really have a role for it in the competitive model at all: we assume it isn't there.

Managers also have control over quality. In the airline industry, as we will talk about a little bit later, there is really enormous control over the various other attributes in terms of the size of the steak, the size of the salads, and things like this. In a big firm you have tremendous capacity to alter the quality of the product that you produce. Related to quality is advertising. Firms compete to a large extent by different selling of their wares in the media. This helps to distinguish their product. A product which is sold only by television advertising is a lot different than a product sold by somebody who never has any access to television. It's not surprising that certain industries, particularly the drug industry or household product industries, prefer to spend 150% of the first 2 or 3 years' revenues in advertising. A good example is Comet Cleanser.

Again, this really doesn't effect the economic models because in the competitive situation the firm has to be on its long-run average. It if isn't, it is going to go out of business.

In a monopoly there's no need to advertise, because you are the entire industry so that if anybody wants to buy your product, they have to buy it from you. In this area of imperfect competition there's one strain of views which is associated with Professor Galbraith, who is probably not the most popular economist in the profession. He has stressed one point, which I think today most people are willing to accept: in this area of imperfect competion goals are important. We talked about the group which he calls the technostructure, which is just his name for the group at the top which runs the company; the management. He stresses that they have goals and that probably the foremost goal is corporate autonomy (protecting yourself). This mandates certain economic criteria: minimum acceptable profit rates and minimum growth rates (Exactly what the tradeoff is between them nobody knows.). There are such situations and these kinds of goals are formulated.

Then we have a variety of other behavioral models, satifying models. Firms don't try to maximize profits, they try to maximize some other function. In other words, they simply try to get at least a 5% increase in profits over last year. The problem with all these models is that there is very little we can say in terms of determining the outcome. In fact, we can't say whether this is going to be efficient or inefficient; we don't know. It's possible to have a firm in imperfect competition that is producing a very good product of high quality, at low cost, doesn't spend much money on advertising, and has all the nice economic attributes. Equally so we could have an opposite firm that produced a horrible product, bad quality and high prices; it was able to maintain a position by very wasteful advertising.

How do we apply this to the airline industry? Well, I decided what we really wanted to do was to try to answer five questions:

1. What is the industry?
2. What is the product?
3. What is the market?
4. What is the competition?
5. Within the industry itself, what are the means of competition?

First, what is the industry? It's a variety of industries. There are the trunk carriers. These are the major airlines. These were created and designed to provide basic city to city transport between major city points, major population centers. The next level is what is called the regional carriers. These were created to be feeder airlines to bring air service to the rest of America and to provide ways for the people in these areas to get to central cities and to major population centers to get on trunks and then go back. In order to do this, a subsidy program was set up by the Federal Government to guarantee that these airlines would serve small cities that otherwise couldn't justify it.

There have grown up, in addition to these, a variety of others. There are supplemental carriers which basically do a charter business or freight business. These are very important internationally but less so domestically. There are carriers which carry only freight; for example, Flying Tiger Airlines. The regional carriers are North Central, Mohawk, Allegheny, and Ozark, etc.; and supplementals are something like World. Lately there are the third level carriers, which are the air taxis, the small airlines.

Allegheny Airlines is the regional carrier which has been very successful in using third level carriers as a means of reducing its obligations to serve small points. Under contract Allegheny yields its route to a commuter company which agrees to call itself Allegheny Commuter Airlines. In turn, Allegheny performs certain services for them. What you have are third level carriers feeding into the regional carriers, which in turn are becoming more and more like trunk carriers. Regionals now often serve major cities; they often provide service between major population centers as well and are very apt to be competing with trunks on certain routes.

Finally, there is the category of intrastate carriers, particularly in California, Alaska, and Hawaii. They are hard to classify; for some of them are quite large and some are quite small.

The obvious product is transportation. You get on an airline and move from point A to point B. What matters also is how convenient it is to make reservations, what the ground arrangements there are when you get to the airport, and was it a convenient trip? You may fly American both ways, even though an Eastern flight is more convenient because your car is parked at an American garage, which is a 15 minute walk from the Eastern terminal. There are a variety of things on the ground which would affect your choice of which plane you take such as the time your plane takes off and the type of plane you get. If you get a DC9, you'll feel cramped; so you want a 727. Also what inflight service do you get? Do you get a snack or do you get a whole meal?

Again, this complicates the product. All the airlines really have to provide is transportation, and they have to provide transportation either 6 abreast or 4 abreast. That's all they are legally required to do; everything else is completely under their control. At a time of strict economic conditions they can cut down on a lot of the extras. Alternatively, when traffic is booming, when they're trying to get more people on and when they make certain that they don't lose you because they thing that you re going to be travelling alot, they provide varieties of frills which really don't cost very much, although they are not cheap. (The average cost of a lunch in coach is something like $4.50 where the average cost of a snack is $3.80; there's not a great deal of difference. On the other hand, when United Airlines cut out serving Macademia Nuts on their trip from Hawaii, they saved a total of several hundred thousand dollars over giving you a package of regular nuts.) Since they fly so many, even

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minor changes in service can mean major total cost considerations. This is the slack I was talking about before. The airlines as an industry are characterized by an enormous degree of variability, particularly with respect to passenger service.

In times of economic turndown, a greater share of the passengers are people who really have to fly. They are not passengers that have alternatives in terms of not flying! They are going to fly any way. You may not have to give them good service. As you get more marginal customers who don't have to fly, you have to keep them happy and at the same time keep everybody else happy. This means that you provide unofficial services.

Next, what is the market? Again, you separate this by purpose, (business vs. personal), and city pair (because it's clear that there are thousands of markets in the U.S. which are basically each city pair: Boston-Washington is one market, Boston-New York is another, Washington-Chicago, Washington-L.A.--these are all different markets.) It's not fair to say that there is only one market for airline travel, because again you have different proportions of business and pleasure travellers on each route and too many different considerations involved. In pleasure travel, again to

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Washington, people are much more likely to take the car because it's a shorter flight and they can drive it very easily in one day. For California, it's a different situation; you're likely to have a great proportion of your travellers wanting to go by air. You have to distinguish feeder routes, which connect rural areas, to the population centers or the trunk routes. On international flights, you have questions about how long the flights are, whether it is a non-stop flight (or 7 stops along the way). Again you can have markets in which the airlines can decide to service only business customers. If there are some pleasure customers they take them, but they direct their appeal to business or vice versa.

What is the competition? Well, obviously there are the other carriers, if there is more than one on a particular route. There are trains in some areas, buses, and passenger cars. Particularly for personal travel the auto is the greatest competitor. For business travel I would suggest that one of the biggest competitors is no travel at all. Telephone, teletype, telex, or various other things substitute imperfectly but work almost as well when air travel is expensive.

How do the carriers compete? Well, here you have as many ways as have been listed so far. There are all those things that vary services or quality. They can vary advertising;

they can vary their prices. This is a regulated industry where prices are all established--technically they are not, but in effect they end up being the same as if established by the Civil Aeronautics Board. However, in certain cases an airline is able to compete in price when its cost structure is different from the cost structure of one of its competitors, Some carriers may be able to support a lower fare. The marginal profits of certain operations is higher in some airlines than it is in others. American, for example, claimed for years that the youth fare (they were the initiator of it) was profitable, where some of the other airlines said this wasn't true and that they found it to be expensive. If cost structures are different, (you fly a different aircraft on a route or the destinations are both intermediate stops on longer routes), then you can offer special discount fares which the other carriers really can match only at much greater costs.

There is a problem in competition because there seems to be some evidence that the proportion of seats you sell on certain routes does not vary directly with proportion of seats you offer. If you decide you want to go from a 10% to a 15% market share you may have to double your capacity from, say, 20% to 40%. There is a nonlinear relationship between the capacity you offer and the number of seats you sell. This particularly favors the established airline, the dominant airline will tend to become more dominant. The more capacity he is able to offer, the more seats he's going to be able to sell because people get used to it. People learn that Eastern flies every hour on the hour or American flies every half hour on the hour, but the other airlines only every two hours. So, if they want to take the next flight, they just call that airline first.

And, of course, airlines compete with various types of aircraft. There is a lot of competition in advertising offering DC10's with their lounges, or 747's with their lounges, as opposed to some other type of plane. The airlines have a variety of ways to compete but none of them are really directly price related, though they cost the airlines various amounts of money. It is very hard to say anything about which type provides which benefits for such and such a cost. If we do want to characterize the industry, I think we can say a couple of things largely dealing with this idea that you have to have a large capacity to guarantee a large share of the seats. It is what's called a heavy fixed-cost industry. The marginal cost, the additional cost of putting you on a plane when the plane is not full, is obviously very close to zero. Except for the amount of food and beverage service you may get on board and maybe a couple of minor things, such as losses on baggage, etc.--that's it: and the entire cost is peanuts. In the short run you have a fixed number of planes which are on set routes, these routes are scheduled flights (you must fly them according to the regulations) and so there's very little you can do. Even your labor is fixed (you have strict contracts on your labor). It takes time to train a pilot. You cannot overnight say, well, "I'm busy tomorrow on this flight so I'm going to take a 707 out and put a 747 in." You may not have a 747 pilot or a whole 747 crew. You may have the aircraft but you don't have the labor to switch. You have a very restricted industry which really has to live within the constraints of the schedule. There is very little ability to get around it. As a consequence you have massive price discrimination. The people flying on the same plane are paying a large variety of fares, particularly on a long flight such as from N.Y. to the West Coast. You have family plans, you have youth fare, you have military fares, you have military stand-by, military reserved, youth fare reserved, so the airlines get to pick and choose by offering different types of service and different contingencies under which they may or may not board you. They get to offer these lower fares to people who might otherwise take another way. Eastern's Leisure Class, I guess, is a particularly good example.

The other thing that is characteristic of the airlines is cross subsidization. There is no passenger who pays exactly average costs. Every passenger is being subsidized by some other passenger or he in turn is subsidizing some other passenger. This is particularly true on the regional carriers where there is a formal subsidy program whereby the CAB each year requests Congress for enough money to subsidize these carriers so that they don't lose money for servicing small points which board very few people. What the CAB does is grant route strengthening awards. The way you stabilize an airline in financial trouble is to give it a profitable route. What this means, of course, is that the people who are flying on that route are making money for the airlines and in turn are being used to subsidize fares on another route. Everybody charges the same fare. In California there is PSA (Pacific Southwest Airlines) which is an intrastate carrier which flies you from L.A. to San Francisco and vice versa for about ½ of the fare that you would pay if you were flying an interstate carrier subject to CAB rules. The CAB pricing formula is basically a certain fixed amount for each ticket plus so many cents per mile, and the so-many-cents per mile varies with how long the flight is. There are much cheaper fares at PSA, so there has been considerable question about how justified the high fares are from Washington to Boston. If you had PSA flying Washington to Boston the fare would be just half as much.

The last thing that we want to talk about is the fact that we are dealing with the regulators. The trunks and the regional carriers are completely under the control of the CAB. The CAB has numerous powers. They must approve all tariffs. This means they must set all prices. To determine if a tariff is fair or not they determine what should be rate base of the company. By this they add up in some way to determine the total amount of capital invested in the firm. Secondly, they try to determine the fair rate of return. Now both of these are nearly impossible questions to get a completely solid analytical answer to. How do you value planes? Do you value them at their new cost? Replacement costs? What you sell them for in the market? How do you evaluate a fair rate of return? There are some risks involved for the airlines certainly because of the fact that they are scheduled carriers; they must fly.

The most important power is the power to gain control of routes. The CAB controls which route you are able to fly. Now this can be crucial. If you're a regional carrier and you just bought some long distance airplanes and you're flying a lot of short hauls, you may desperately need some longer routes. North Central Airlines, for example, flies nonstop Milwaukee-New York, which is totally non-regional service. These routes were given in an effort to strengthen the airline so they could lower the subsidy. What this means in effect is that these people who fly North Central from Milwaukee to New York, or Minneapolis to Denver are in effect subsidizing the people who fly on North Central from Grand Forks to Hibbing and something like that. When you're flying on these puddle jumps you're being subsidized by the larger, longer routes. The same airplane which is flying you on the short haul may as soon as it gets to Milwaukee or Minneapolis or Madison turn around and become a long haul plane and fly to New York. How do you once again separate the costs? You can't do it. Anything that you came up with would be purely a matter of convention.

The CAB also controls entry, but the more important issue is that they control mergers. This relates to the economies of scale. If you get larger and larger airlines, are they going to be more efficient in providing service? There is some argument for this: you use your plane more intensively, you can guarantee the use of your pilots, you have one reservation center, you may be able to handle a lot of people, and a lot more cities very easily. Once you set up the software and the hardware to handle all your division centers, it's good enough to handle maybe double or triple what you have so that there are clearly some economies of scale. Is competition good? Is service to an area really improved by having competition? Well, what is all this saying? There really are an enormous amount of things that you have to consider when you try to determine analytically whether should we do this or that. The issues involved are extremely complex. They involve the industry, the product, the market, what the competition is on the route, and, particularly here, social concerns. In Washington National you have the noise pollution of the planes flying over Georgetown. In fact there are some safety factors involved; there have been a couple of air crashes that have been attributed to trying to lower noise in flight procedures.

On the other hand it is clear that a flight from Boston to Dulles is not the same as a flight from Boston to National for most people. So the product that the airlines provides is in terms of transportation from inner city point to inner city point. It involves a lot of variables which are beyond the airlines' control in a direct sense is limited.

Objectives of the Airline Firm: Theory

James T. Kneafsey
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 of Technology
Friday, July 14, 1972

I. Introduction: Models of the Firm

Most analyses of dynamic pricing strategies in the economics literature have adhered to the assumption that business firms seek to maximize profits. Newer models of the behavior of large corporations have recently been developed in which a variety of assumptions about business motivation have been inserted into traditional static frameworks, steady-state growth models of the firm, and non-maximizing "behavioral" analyses. These new models have paid increasing attention to the nature and determinants of the forces governing the size and growth of the companies of which they are composed. In particular, the theoretical models of the growth of the firm are rapidly becoming more rigorous, comprehensive, and widely accepted.

Since firms in the trunk airline industry compete in money and capital markets with numerous other firms in both the regulated and unregulated sectors of the economy, these models of firm behavior can be applied directly to the airline industry. The subject under discussion will revolve around alternative formulations of managerial goals which airline firms may be pursuing in practice. The focus will be on the consideration of different objective functions which the companies may be following in lieu of profit maximization. Since these models reflect the behavior of any <u>single</u> firm in any industry, the analysis is one of partial equilibrium which assumes the activities of all other competitors as given.[1]

This paper has two general purposes. It is intended mainly to provide a frame of reference from which alternative hypotheses can be stated concerning the objectives which managers and executives in the airline industry may be pursuing. It also incorporates as comprehensive a list as possible of alternative objective functions and demonstrates graphically that each separate objective may result in its own unique price (fare) and output (volume) combination when equilibrium occurs.

II. Some Simplified Specifications of Alternative Objective Functions

Using the revered goal (objective) of profit maximization as a base, we propose to analyze the following alternative objective functions:

A. Short-run profit maximization
B. Revenue maximization
C. Sales maximization (break-even)
D. Volume maximization

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[1] This restriction is severe with respect to the scope of economic questions, both analytical and practical, that can be answered. Economic analysis also seeks to investigate important subjects which concern systems of many firms, or of all firms, which require consideration not only of how all firms individually behave, but also of how their individual activities interact with and constrain each other in markets, broad sectors and the whole economy.

E. Cost minimization

F. Constrained sales maximization

    1. Minimum value profits

    2. Ascending buffer

    3. Descending buffer

G. "Satisficing"

H. Other specifications (non-graphical)

    1. Utility maximization

    2. Growth maximization

    3. Stockholder equity maximization

    4. Security maximization

    5. Market share equalization

Each case will be examined separately to determine the resulting price-output combination which optimizes each alternative objective function. By nature these models are simplistic yet the underlying importance of the basic demand-supply relationships is reflected in the sharply different results of each model. In essence the shapes of the revenue and cost functions (or demand and supply) determines the optimal price-output combination for each alternative objective.

A. <u>Short-run Profit Maximization</u>

Revenues are derived from the demand function and are depicted in Figure 1 (top) as a concave function (to the origin), that is, RR = P x Z where P is fare and Z represents output (or volume of passengers). Assuming that fares can be changed and that the law of demand applies ($\partial Z / \partial P < 0$), R reaches a maximum at point B.

However, to generate profits, a knowledge of costs is necessary. If costs are a function of volume, they can be depicted typically as CC in Figure 1 (top). Profits are simply the algebraic difference between RR and CC at each alternative level of Z, and are maximized when RR exceeds CC by the greatest amount (point A in Figure 1), the result being a profit curve π (Figure 1, middle). The equating of marginal costs (MC) and marginal revenue (MR) (Figure 1, bottom) for those of you who prefer to think in unit terms will occur exactly at point A.

B. Revenue Maximization

With the shape of the present RR curve, revenues are maximized at its peak (point B in Figure 1, top). This result also obtains where MR = 0 because additional Z can only occur with a decline in revenues as a result of the law of demand in operation. MR is simply the slope of the RR curve ($\partial RR / \partial Z$).

C. Sales Maximization (break-even)

There are different variations of the sales maximization hypothesis. In this case we are referring simply to carrying as many passengers (Z) out to the break-even point C. For reasons of market penetration, the airline may neither be interested in the short-run in profits nor in revenues, but rather it is interested in trading off less profits or less revenues for more customers.[2]

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[2] The typical distinction between cost in the economic sense and in the accounting sense should be made. In economic terms, CC includes as a component a normal rate of return such that π really refers to "excess" profit. In the account sense, CC is the conventional income statement figure which excludes profit.

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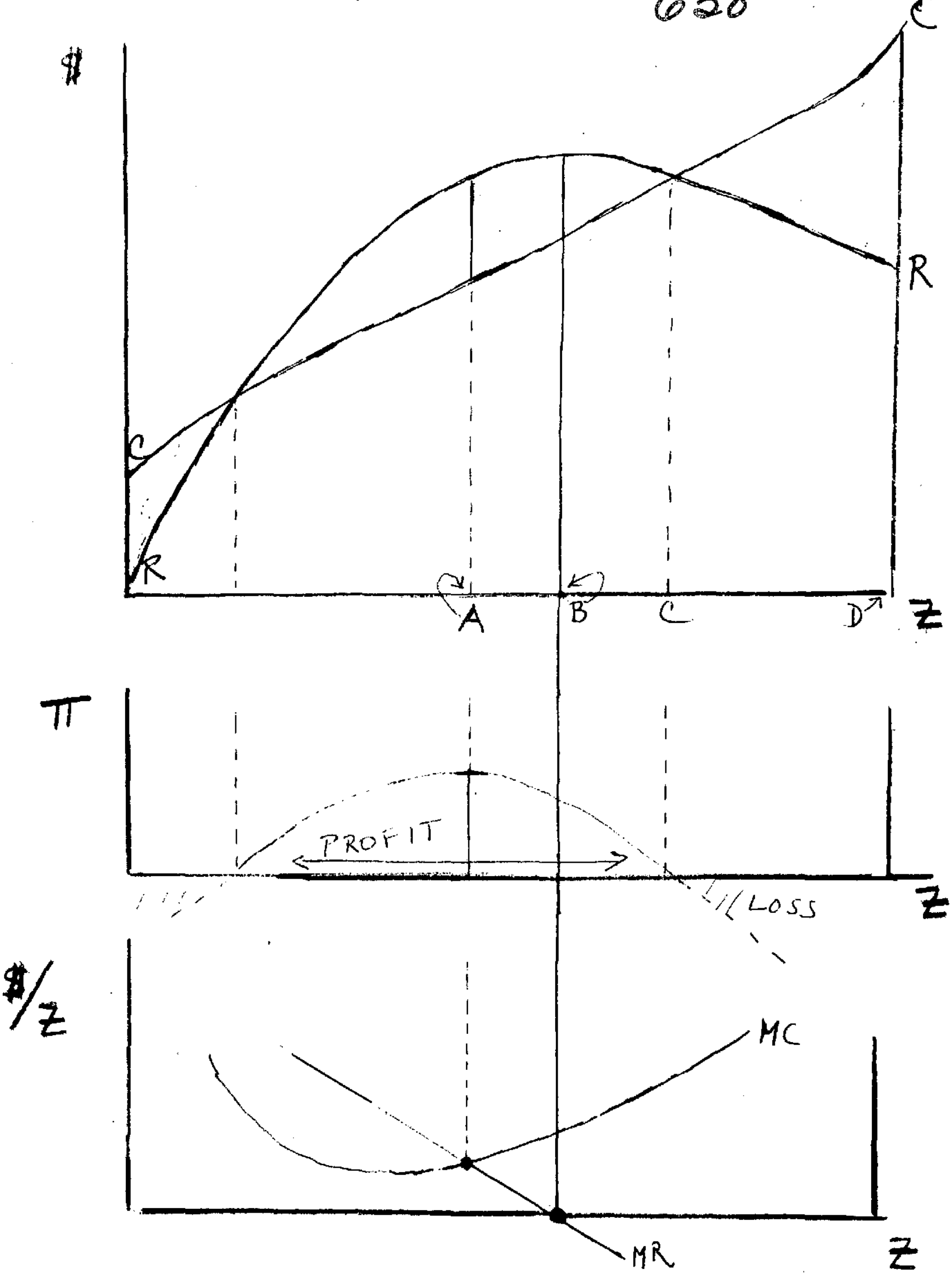

Figure 1: Total Dollars ($), Profits (π), and Dollars per Unit ($/Z) Plotted Against Output (Z)

D. Volume Maximization

An extension of the sales maximization hypothesis is that an airline firm may wish to carry as many passengers as possible, even if it results in a short-term loss. The result is in effect an objective of maximizing all available capacity (point D in Figure 1, top). Note that a large bias would be incurred with the pursuit of this objective function with the present revenue and cost relationships.

E. Cost Minimization

Sometimes companies become extremely cost conscious and pursue the goal of cost minimization (point E in Figure 2). This output level occurs at the bottom of the average cost curve (AC) where MC = AC. It is an objective completely independent of demand influences, unlike the goals discussed above. A danger which companies occasionally and regrettably experience is that they may minimize themselves to death if revenue considerations are ignored. If the demand curve (AR in unit terms or RR/Z)lies far below where it does in Figure 2, then cost minimization as a corporate objective still would not help. As it turns out in the present case, total profits are depicted by the hatched area in Figure 2.

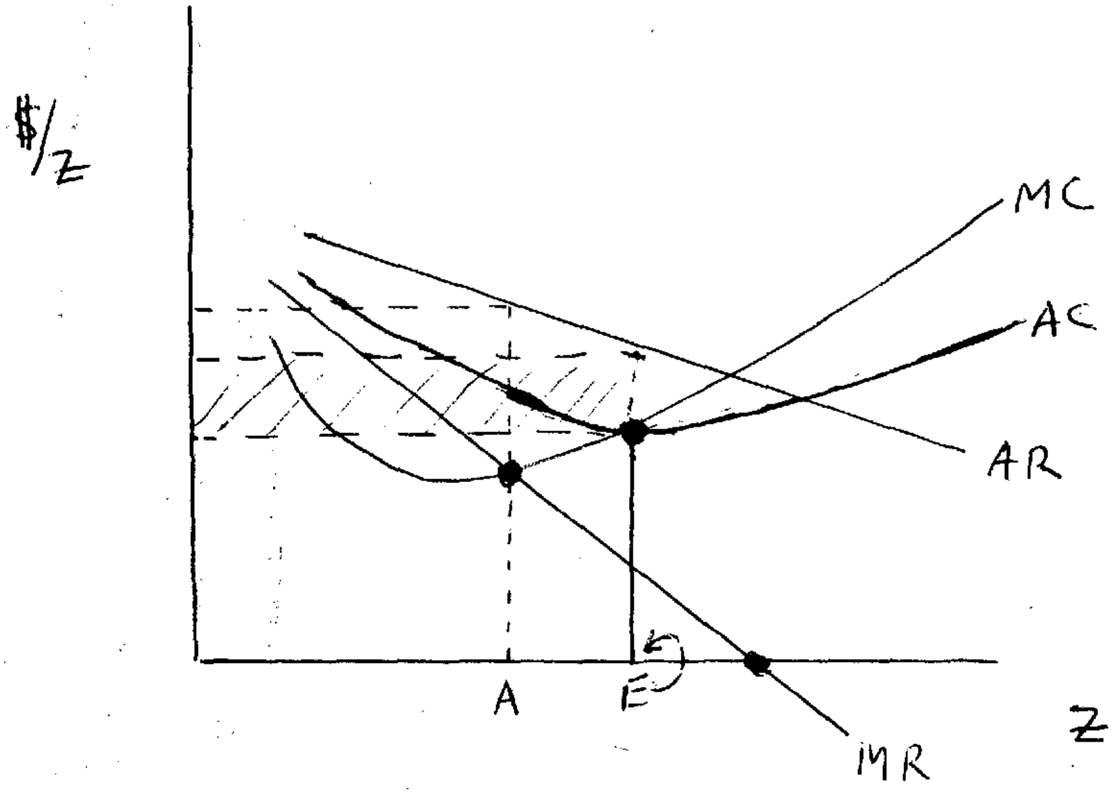

Figure 2: Dollars per Unit ($/Z)
Plotted Against Output (Z)

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F. Constrained Sales Maximization

1. Minimum Value Profits

This hypothesis has been advanced by a number of economists with W. J. Baumol in the vanguard. In the most complete statement of his proposition, Baumol argued that firms with market power tend to maximize sales subject only to the condition that profits not fall below some specified minimum value.[1] In Figure 3, profits are maximized at A. However, if management feels that a certain level of profits is satisfactory or even necessary to maintain (OM in Figure 3, bottom) irrespective of volume (Z), then the company's goal is over-fulfilled at volume OA. It can increase volume to O(F1) while earning at least OM in profits, enjoying higher "sales" than it would under a short run profit maximization policy. If the company's managers insist on earning profits of ON before seeking to satisfy other objectives such as sales maximization, they will not be in a position to increase revenues beyond the short-run profit maximizing level since the profit objective lies out of reach. The most important implication of this analysis is that if firms in the airline industry in fact strive to increase revenues for its own sake and if they require less profit to meet capital needs (e.g., OM in Figure 3), then they can charge lower fares and offer more volume than they would under the goal of profit maximization. Two variations of this objective are the ascending and descending buffer objectives.

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[1] See William J. Baumol, Business Behavior, Value, and Growth, rev. ed., New York: Harcourt, Brace and World, 1967, pp. 45-82 and 86-104.

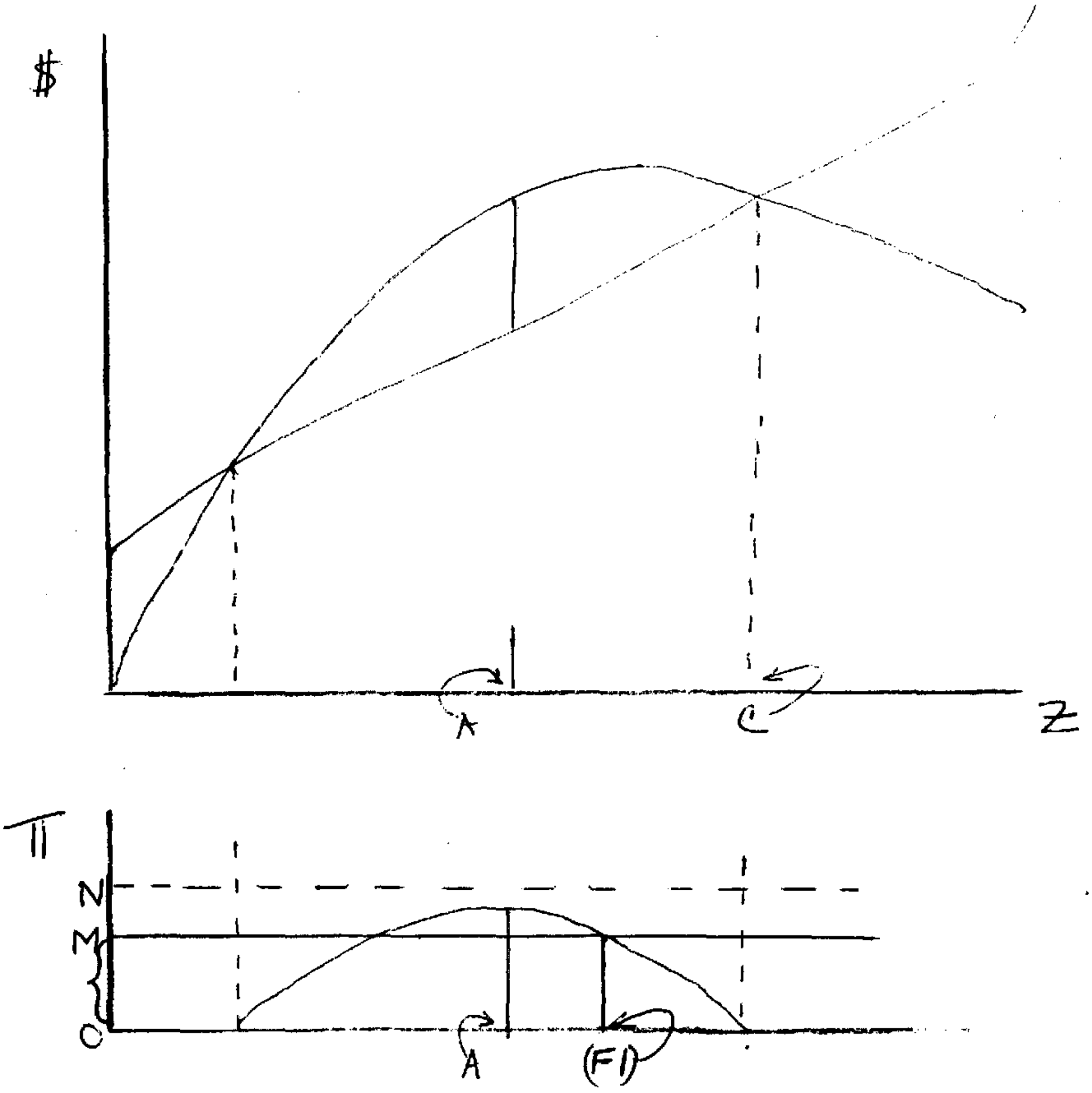

Figure 3: Contrained Sales Maximization

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2. Ascending Buffer

In Figure 3, OM represents a "buffer" of profits which the firm desires to earn. These profits may be used for unexpected financing purposes, for dividend declarations, or for retained earnings. As long as OM is earned, the company will sacrifice additional profits for more sales. In Figure 4, KK represents a buffer stock of profits which increases with volume 2. With more and more volume presumably the firm should be in a stronger position to increase dividends or to finance additional expenditures. An allowance for this growth is reflected in the rising slope of KK. In this case the company will select volume (F2) in Figure 4, where sales are maximized subject to the buffer (KK) constraint.

3. Descending Buffer

Alternatively firms may be willing to sacrifice substantial short run profits in order to generate volume which would result in a buffer stock LL that varies negatively with volume. If volume during a given period is decreased sharply, say as a result of a strike, the company may wish to have a larger profit buffer at low ranges of Z. As volume increases though, the tradeoff with profits becomes apparent and the company would opt for output (F3) in Figure 4.

G. "Satisficing"

In the early 1960's, several economists in the Graduate School of Administration at the then Carnegie Institute of Technology developed the "behavioral" theory of the firm. At the heart of this theory lies the concept of "satisficing", usually attributed to the work of Herb Simon.

Essentially satisficing refers to the fact that firms may not be maximizing at all but rather may be pursuing a number of goals simultaneously resulting in accepting a "satisfactory" level of profits. Graphically, this means that the firm can select any volume in Figure 4 as long as some satisfactory level of profits is attained. In the case of pursuing any profit at all, the range would be QC within which the firm would be "satisfied".

H. Other Specifications (non-graphical)

Numerous other objectives could be pursued by firms in practice either individually or jointly. These goals might include the maximization of a firm's utility function, of its rate of growth of output, or of its stockholders' equity. Since ownership and management are separate functions of airlines and other large companies, an important objective to analyze might be the maximization of the management's own security and stability. Also, the companies might be satisfied with maintaining or increasing market shares as an objective independent of any other one.

The goals in this section cannot be demonstrated graphically as we have done with the other alternatives. For those objectives which we have discussed, a summary version of each alternative volume appears in Figure 5.

III. Conclusion

No one has yet succeeded in demonstrating conclusively whether or not airlines or other business firms behave in the ways and for

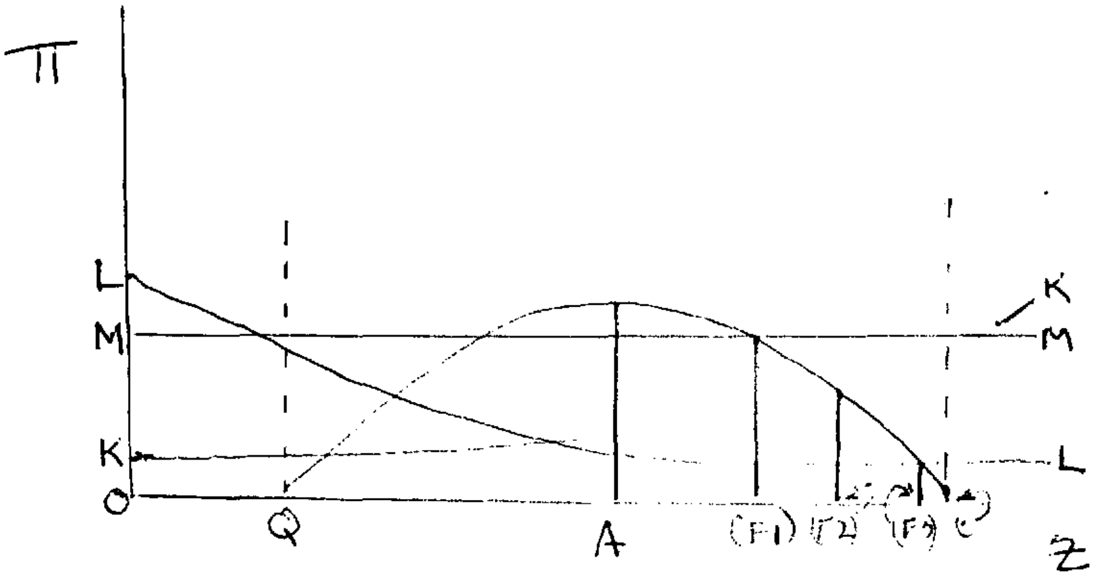

Figure 4: Ascending and Descending Buffer Objectives; and "Satisficing"

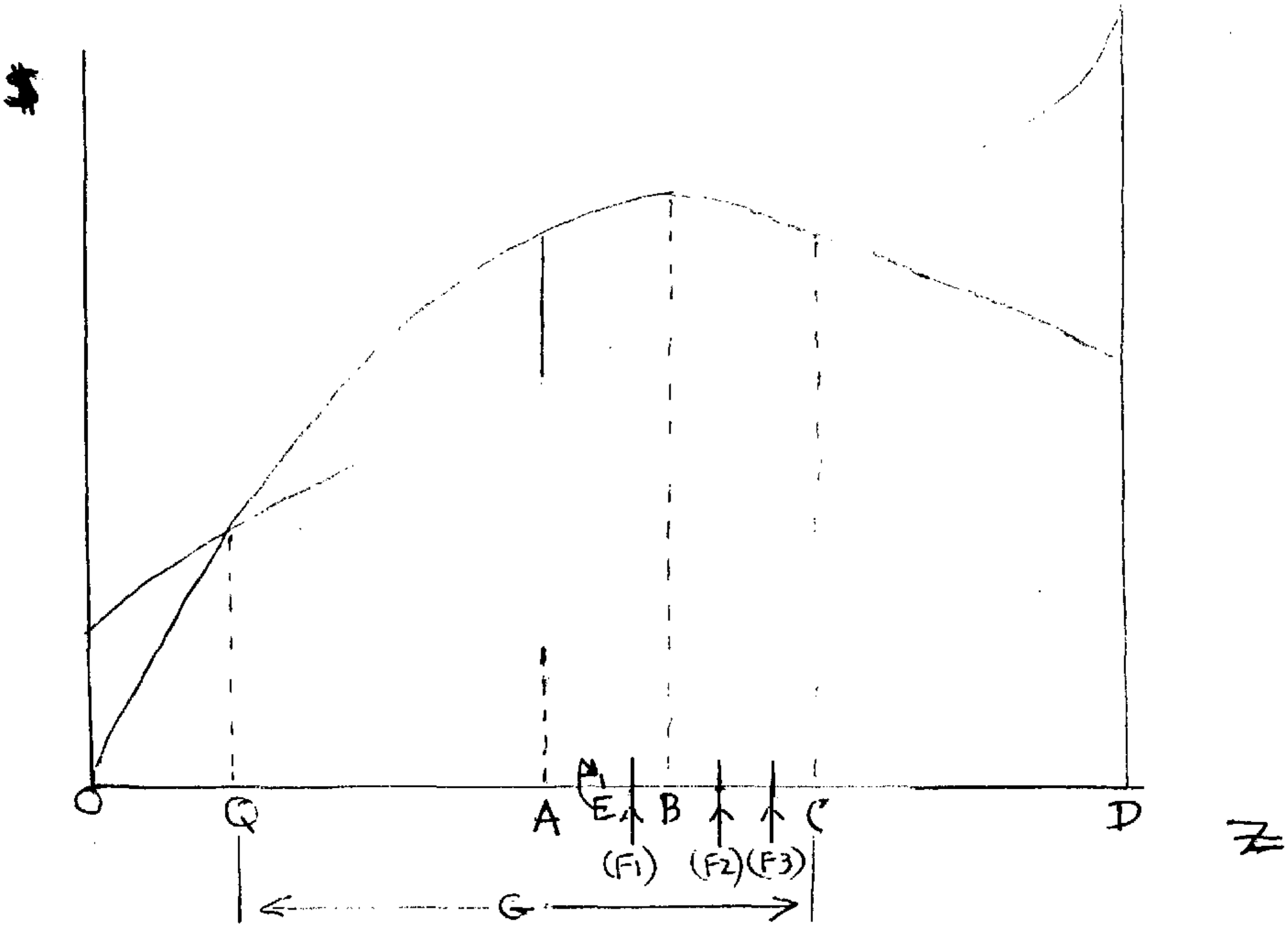

Figure 5: Objectives of the Airline Firm--
Summary (See pp. 2-3)

A - Short-run profit maximization
B - Revenue maximization
C - Sales maximization (break-even)
D - Volume maximization
E - Cost minimization
F1 - Minimum value profits
F2 - Ascending buffer
F3 - Descending buffer
G - "Satisficing"

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the reasons postulated in the above models of selecting alternative objective functions. One obstacle to enlightenment is that the behavioral differences between long run profit maximization and various short run alternative goals are so subtle that econometric tests with existing data are not sufficiently powerful to discriminate among the contending hypotheses. Since it is clear that airlines do pursue one or more of these objectives in practice, the present state of knowledge certainly must be extended through more sophisticated econometric research and by more detailed case studies than any heretofore attempted.

PROBLEMS OF EXCESS CAPACITY *

by George Douglas
University of North Carolina

July 12, 1972

Abstract

This lecture discusses the problems of excess capacity in the airline industry and focuses on the following topics: load factors; "fair" rate of return on investment; service-quality rivalry among airlines; pricing (fare) policies; aircraft production; and the impacts of excess capacity on operating costs. The lecture also will include a discussion of the interrelationships among these topics.

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Excess Capacity, Service Quality and the Structure of Airline Fares

by George W. Douglas[*]

I. INTRODUCTION

A characteristic common to most scheduled transportation systems, is that "demand" only rarely equals "supply." Because of the discrete nature of the "supply," or capacity offered, and the stochastic nature of demand, the equilibrium of any scheduled transportation system is characterized over time by "excess" capacity. A measure commonly used to denote this excess capacity in the airline industry is the average load factor, the ratio of the number of passengers carried to the number of seats available. Moreover, since the costs of a scheduled transportation system are largely determined by the capacity offered, the cost per passenger is quite sensitive to the average load factor.

The average load factor in the scheduled airline industry has, in the past, been implicitly regarded as an exogenous parameter, characteristic of the nature of the industry and not subject to control by the airlines or the regulators. Following that assumption, average and long run marginal costs per passenger can be defined, with respect to the costs of capacity and the given average load factor. One might describe in this manner the costs and fare determination procedure as followed by the C.A.B. in the past.

It can be shown, however, that the system's equilibrium average load factor, rather than being exogenous, is determined endogenously by the market, given the costs and fares facing the carriers. In competitive markets, the existence of scheduling competition tends to bring about an equilibrium ALF at or near the "break-even" ALF defined by the costs of production and the fare level chosen. Similarly, the average load factors in non-competitive markets are higher, *ceteris paribus*, but their level is also related to the costs and the fare level chosen by the regulators. Most airline markets, moreover, can operate over a significant range of prices, or fare, each price level defining, in equilibrium, the average load factor of the system. Only recently has the C.A.B. recognized that by setting fares it implicitly determines the average load factor of the system, and that the setting of explicit load factor standards for use in computing fares is desirable and proper.[1]

We will seek to describe in this paper the issues relevant to the selection

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[*] *Assistant Professor of Economics, University of North Carolina at Chapel Hill. The author wishes to thank James C. Miller III, of the U.S. Department of Transportation, with whom many of these concepts are shared, and which were in part developed jointly. The author bears sole responsibility, however, for the views expressed here.*

[1] See C.A.B. Order 71-4-54, April 12, 1971. In this decision on the "Load Factor Phase" of the General Fare Investigation, the Board's decision reversed the Examiner's opinion and established for the first time desirable load factor standards for ratemaking purposes of 55% for Trunks, and 44.4% for the Local Service Carriers.

of load factor standards, and by analyzing the implications of the ALF for the system's level of service quality, suggest various characteristics of an efficient price structure.

II. SERVICE QUALITY AND THE AVERAGE LOAD FACTOR

Although a scheduled transportation system can feasibly operate over a wide range of average utilization, we should expect that the quality of service provided to be closely related to the excess capacity offered. The aspect of quality of crucial importance for us in this regard, relates to levels of delays incurred by passengers using the system. These delays arise from two sources: (1) that a departure is not scheduled at the time a passenger desires to depart, and (2) that the preferred flight might be filled, causing the traveler to take another, less desirable flight. From the first source, we might compare the scheduled departure times with the daily profile of desired departure times, and compute the absolute values of the time differentials. The mean absolute difference between the travelers' desired departure times and the scheduled departure time we denote as "frequency delay." The expected frequency delay should be a function then of the pattern of desired departure times for the route, and the number of flights scheduled.[2] As the daily frequency of flights increases, we would expect frequency delay to be decreased.

The second source of delay encountered is a queuing phenomenon, generated by the fixed scheduled capacity faced by the stochastic demand. We would expect that as additional flights (capacity) are offered, the probability of being delayed and the expected time of the delay would be decreased.

The sum of these two kinds of delay we denote as expected "schedule delay," measuring the expected absolute difference between a traveler's desired departure time and the actual departure. The level of expected schedule delay can be considered a characteristic of service quality, and is a significant determinant of air travel demand, particularly in short to intermediate distance markets, where substitution among modes is feasible. As the capacity is increased by increasing the flight frequency (of a given aircraft type), we would expect the stochastic delay and frequency delay to both decrease, thereby decreasing schedule delay. However, as frequencies are increased, the average load factor would decline (in spite of the additional travel induced by the better service), thereby increasing the average cost per passenger.

We have simulated these delay processes (described in the appendix) and can approximate the level of frequency delay by:

$$(1) \quad T_s = 92F^{-.456}$$

The stochastic delay is approximated by:

$$(2) \quad T_s = .445\left(\frac{N}{\sigma}\right)^{-.645}\left(\frac{S-N}{\sigma}\right)^{-1.790}$$

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[2] Ideally, we might expect that the flights would be scheduled so as to minimize T_f for any given number of flights. In practice, constraints on scheduling flights over a route, and potential "clustering" effects of competition may prevent the actual scheduling pattern from being locally efficient.

where S = capacity (seats) per aircraft,

N = mean flight demand,

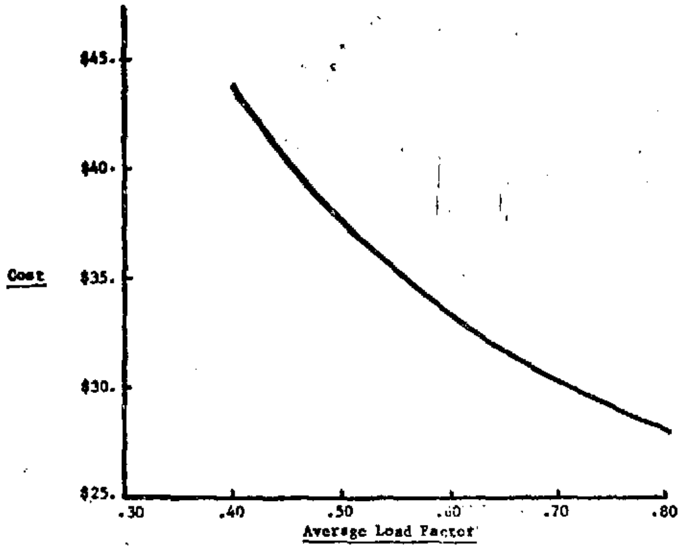
σ = standard deviation of flight's demand

Expected schedule delay, T, is the sum of expected frequency delay and expected stochastic delay

(3) $T = T_f + T_s$

For a route with the distance and the aircraft type specified, we may compute the relationship between the cost per passenger, and the average load factor, as described in figure 1. The operating costs were estimated using a model developed by the C.A.B., which relates the cost per passenger to the ALF, and the performance and factor price parameters of the various aircraft types.[3] For a specific level of mean daily demand (and its variance), we can then compute the expected schedule delay for any assumed level of capacity (or the ALF). On table 1 we indicate the levels of these delays that might be expected for a hypothetical route. As might be expected, as excess

Average Cost as Related to Average Load Factor



Hypothetical Trip:
Distance = 600 miles
Aircraft = Three Engine Turbo-Fan

FIGURE 1

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[3] Civil Aeronautics Board, Costing Methodology, Version 6 (August 1970) and Domestic Fare Structure: Costing Tabulations for 1969 (Sept. 1970).

EXPECTED DELAYS PER PASSENGER;

Hypothetical Route with
Distance = 600 miles
Avg. Passengers/Day = 800
Aircraft = Three Engine Turbo-Fan

ALF	Stochastic Delay	Frequency Delay	Schedule Delay	Cost/Pax
.40	6.90	23.86	30.76	43.84
.44	9.07	24.92	33.99	40.99
.48	11.87	25.93	37.80	38.61
.52	15.54	26.90	42.44	36.59
.56	20.40	27.82	48.22	34.85
.60	26.97	28.71	55.68	33.34
.64	36.05	29.57	65.62	32.01
.68	48.96	30.40	79.36	30.84
.72	68.03	31.21	99.24	29.79
.76	97.60	31.99	129.59	28.85
.80	146.63	32.74	179.37	28.00

Delays measured in minutes per passenger.

Cost is weighted average of coach and first class costs, inclusive of "fair" rate of return on capital.

TABLE 1

capacity is reduced, and approaches the mean demand (i.e., the ALF increases) the stochastic delay increases exponentially. On figure 2, we graph the relationship (in this market) between the average load factor and the expected level of schedule delay.

With the information contained in figures 1 and 2, we are now prepared to relate the costs per passenger with the level of expected schedule delay, or service quality. This "tradeoff" relationship is depicted in figure 3. This might be interpreted as the opportunity locus facing the regulators; if a high fare is chosen, the market equilibrium will generate a low ALF, and a high level of service quality; reduction of the fare implies an equilibrium with a higher ALF and a greater delay (or a lower level of service quality).[4]

III. THE OPTIMAL REGULATED PRICE STRUCTURE

Having the information necessary to describe the technical tradeoff between price (cost) and service quality, the selection of an "optimal" price

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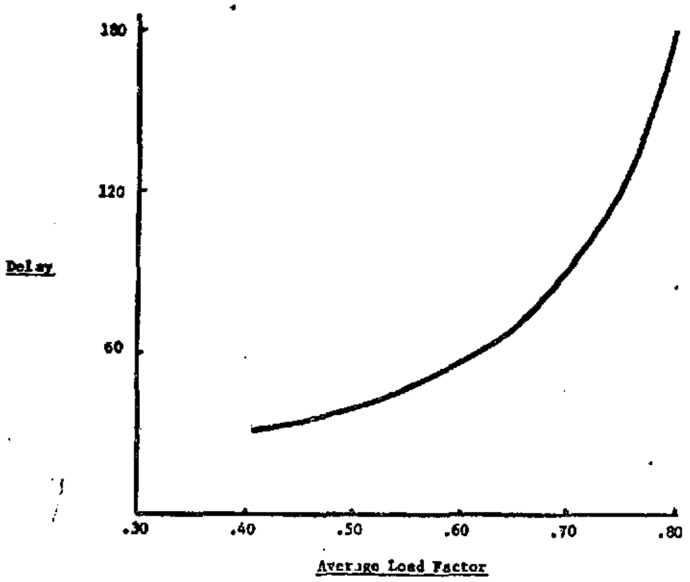
[4] The tradeoff curve is drawn over a broad range, and without regard to demand elasticities. Since we assume that total revenues must equal total costs, the range of feasible points of equilibrium would be constrained to be between some critical boundary prices. The feasible range, however, is rather wide in most markets.

Expected Schedule Delay as Related to Average Load Factor



Hypothetical Route:
Distance = 600 miles
Mean Demand = 800 passengers daily
Aircraft = Three Engine Turbo-Fan

FIGURE 2

and implicit quality level may be investigated. It appears on first glance to be a straightforward maximization problem, in which one should choose that point where the technical tradeoff is consistent with that of the customers' preferences. This is a particularly difficult problem, however, if, as in this case, quality differentiation is constrained.[5] The regulators must select a quality level for a population of customers whose preferences for quality may be diverse. The level chosen then, must compromise those aspects of service quality that are not separable among these customers.

The simplest approach to this problem is to attempt to discover the tradeoff preferred by the typical traveler, or the implicit value the traveler places on time he is delayed.[6] By assigning such a price, we can determine an "optimal" level of price and quality, which minimizes total trip cost for

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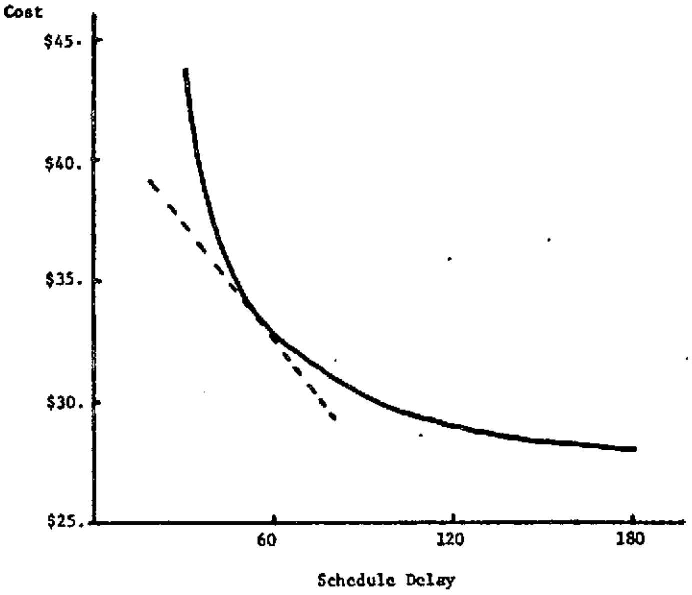
[5] Conceivably, the stochastic delays could be priced and thereby differentiated among customers by the sale of "priorities." Frequency delay, however, could not be reasonably differentiated among customers.

[6] This approach, while used persuasively in valuing some delays in transportation, such as congestion delays, should be approached cautiously here. The time lost through congestion is irretrievably lost, whereas schedule delays may have alternative uses. Ideally, we would like to discover the tradeoff of demand $\left.\frac{\partial T}{\partial P}\right|_{N = \text{const.}}$

Cost as Related to Schedule Delay



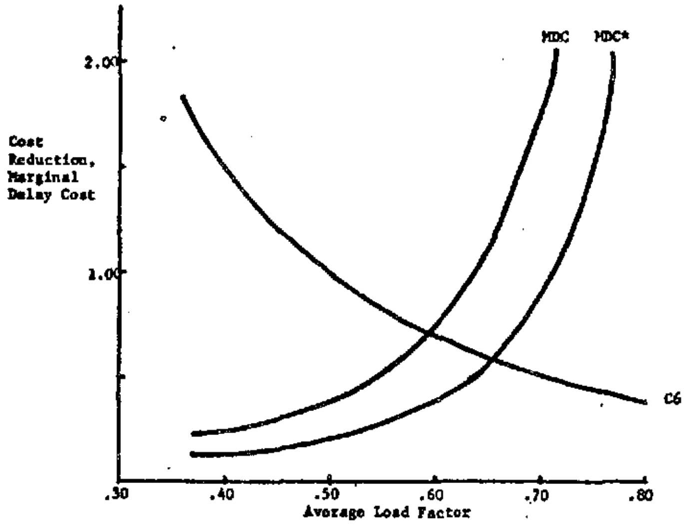
Hypothetical Route:
Distance = 600 miles
Mean Demand = 800 passengers daily
Aircraft = Three Engine Turbo-Fan

FIGURE 3

that "typical" traveler, inclusive of the value of delay times. In figure 3 we indicate that optimal level where the slope of the technical tradeoff between cost and delays equals the assumed value of time. Alternatively, we may represent the minimization problem with a marginal analysis, such as contained in figure 4. Here we indicate with the curve labeled "C6," the reduction in cost per passenger (fare) of a 2% increase in the average load factor, as a function of the load factor. We also indicate with the curves labeled MDC, the implicit value of the additional delay caused by a 2% increase in the average load factor, with time valued at $5.00 and $10.00 per hour. Cost minimization occurs at that ALF where the fare reduction caused by the increase of the ALF by 2% just equals the marginal delay cost (MDC); in this market between .59 and .66.

As pointed out above, the technical tradeoff between price and service quality varies with changes in the distance, size and dispersion of demand. This has the effect, then, of changing the optimal ALF chosen for markets with different characteristics. We should expect, for example, that the optimal load factor should be greater, *ceteris paribus,* for a long flight than a short one. The delay for either route is related to the average load factor of the system, or the relative number of empty seats flown, on the average. Thus,

Least Trip Cost Analysis



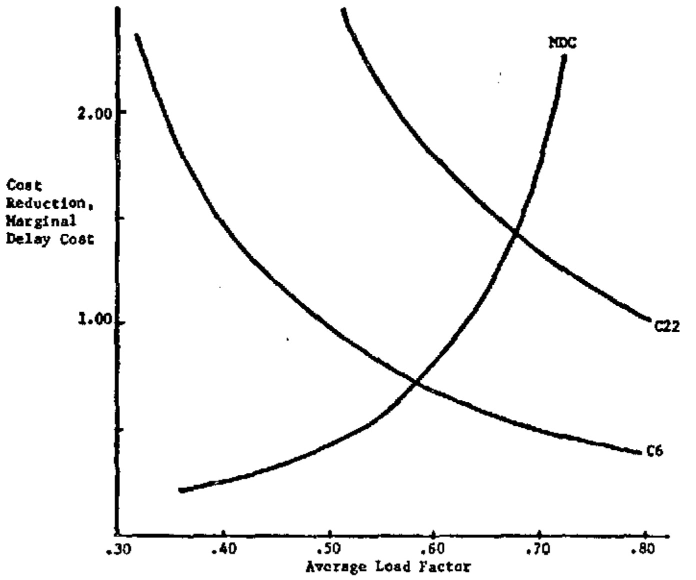
Curve C6 = Cost reduction of 2% increase in average load factor
Curve MDC = Marginal delay cost from 2% increase in average load factor; time valued at $10.00/hr.
Curve MDC* = Marginal delay cost; time valued at $5.00/hr.

FIGURE 4

while the delay associated with any given load factor is equal for both routes, *ceteris paribus,* the cost reduction (in dollars) per passenger, of a slight increase in the average load factor is much greater for the long route than the short one. In figure 5 we demonstrate this effect graphically. The curve C22 represents the cost reductions for a trip of 2200 miles, from an increase in the ALF of 2%. As can be seen, the least trip cost occurs at an ALF of .59 for the 600 mile trip, and at approximately .68 for the 2200 mile trip. On figure 6, we portray the range of "optimal" ALF's for a market of a given size, as the distance is increased.

We should also expect that the market size should affect the optimal average load factor. The stochastic delays are derived by first computing the probabilities of being delayed one, two, three or more flight intervals; and then multiplying each by the average interval between flights. In comparing a large and small market, with all other characteristics being identical, we find that the *probabilities* of being delayed are similar for operations at a given average load factor in either market. However, the expected *delays* are less in the larger market, as the flight frequencies would be greater, and the average interval between flights would be shorter, for any given ALF. Hence, we would expect that the optimal average load factor in the larger market would be greater than that in the smaller market. On figure 7, we describe the analysis graphically. In this case, the marginal cost reduction

**Least Cost Average Load Factor Analysis
as Distance is Varied**



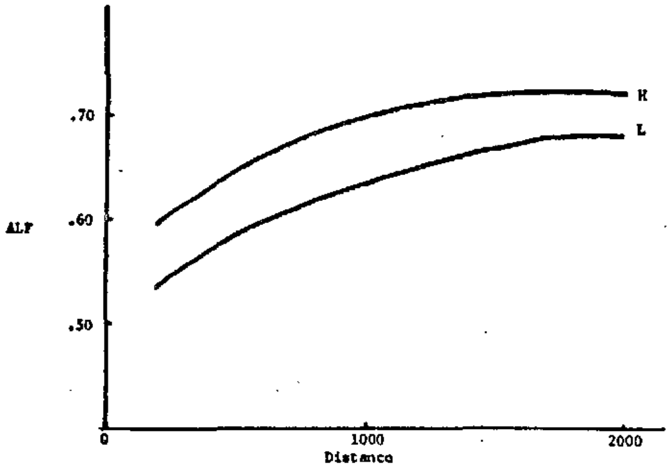
Curve C6 = Cost reduction of 2% increase in ALF for trip length of 600 miles
C22 = Cost reduction of 2% increase in ALF for trip length of 2200 miles
MDC = Marginal delay cost

FIGURE 5

curve, C6, is identical for both markets. The marginal delay costs associated with a market of mean demand of 3200 (labelled MDC32) lie below those associated with a mean demand of 800 (labelled MDC8). Hence, we find that the optimal ALF for the smaller market is approximately .60, while that of the larger market is approximately .64. Figure 8 describes the optimal average load factors continuously against market size, as measured by mean daily demand.

The delay model by which the relationship between the cost and the level of service delays were estimated contains a number of assumptions and approximations from limited data of the characteristics of the stochastic demand distributions. Hence, the relationship should be considered tentative in the quantitative sense. However, the model, when tested indirectly by comparing the forecast distributions of average load factors in specific markets with those observed, was found to be reasonably accurate. In any case the qualitative assumptions of the model (i.e., the signs of the partial derivatives) are reliable, and we are thus prepared to defend the qualitative conclusions; i.e., that load factors on long hauls should be higher than on short hauls, *ceteris paribus*, and higher in dense markets than in thin markets. The measure of the delay, re-

Range of Optimal Average Load Factors as Related to Distance; mean daily demand = 800.



Curve H represents optimal load factors consistent with time valued at $5.00/hr.
Curve L represents optimal load factors with time valued at $10.00/hr.

FIGURE 6

lationship could be refined with more extensive data on the demands for individual flights over a wide variety of city pairs.

IV. CHARACTERISTICS OF THE EXISTING STRUCTURE OF AVERAGE LOAD FACTORS

It is interesting to compare the pattern of average load factors that has developed in the industry, with the pattern we have suggested. In one instance, the relationship of fares and the average load factor to length of haul (distance), the industry's pattern has been mildly perverse.

One well known characteristic of airline costs is that the average cost of capacity per mile declines significantly with increases in distance. On figure 9 we describe the average cost per passenger mile at various distances, assuming that load factors are held constant. The source of this nonlinearity is the rather substantial fixed or "terminal" cost per flight, which does not vary with distance. The C.A.B. has, from time to time, investigated the cost and fare "taper," to see if they were in close correspondence. *The Domestic Air Fare Study* of 1967, confused the issue, however, by principally computing the cost "taper" with load factors that varied with distance.[7] Although actual load factor relationships with distance were not exhibited in this study,

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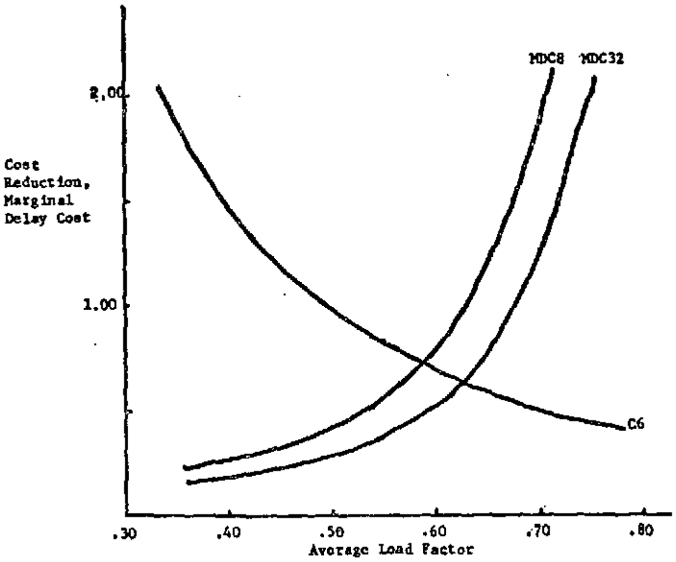
[7] The principal analyses and discussions centered on a cost taper derived with load factors varying from .585 at 200 miles to .64 at 1000 miles to .46 at 2,500 miles. See Domestic Air Fares: A Study, Civil Aeronautics Board, Jan. 1968.

Least Cost Average Load Factor Analysis as Market Size is Varied

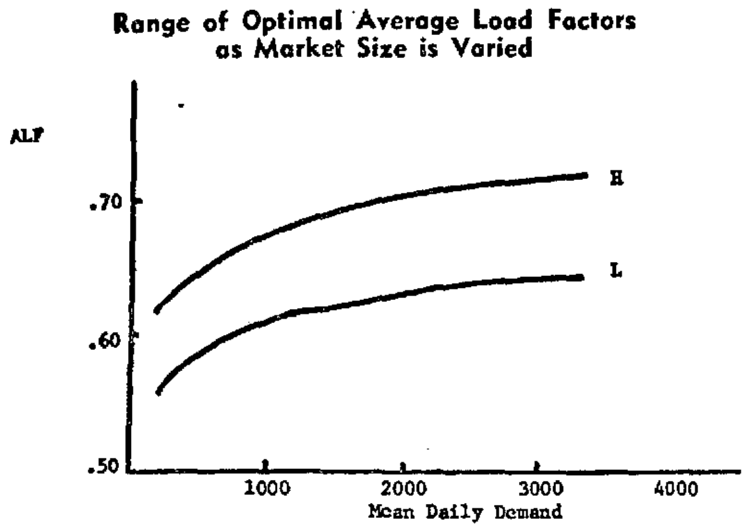


MDC 8 = Marginal delay cost; mean daily demand = 800
MDC 32 = Marginal delay cost; mean daily demand = 3200
C6 = Cost reduction of 2% increase in ALF

FIGURE 7

one can only assume that the varying load factors chosen were typical of the existing pattern. The determination of the study was that the fare (actually the weighted "yield") taper was not as steep as the cost taper; if this were so it would explain why the load factors were lower for long hauls. Following that study, a number of fare adjustments have been made to increase the fare taper, presumably to be consistent with a cost taper with constant load factors.

The only data currently available to the public concerning the ALF's in the various markets, is that generated by the current *General Fare Investigation*. From this, we have data on capacity and traffic on each of 353 non-stop routes, by all certificated carriers during selected months of 1969. We are thus able to analyze the relationship of average load factors to the market's characteristics with cross section regression analysis. This analysis indicates that the average load factor is most strongly influenced by the level of competition, e.g., the number of carriers serving the market. The load factors tend to be higher in large markets than in small markets, but even after adjusting for these effects, there yet remained (in 1969) an inverse relation between the average load factor and distance. The results of these regressions are summarized in table 2.



Distance = 600 miles
Curve labelled H represents optimal ALF's with time valued at $5.00/hr;
Curve labelled L represents optimal ALF's with time valued at $10.00/hr.

FIGURE 8

V. CONCLUSIONS

We have demonstrated that the price level and structures set by the C.A.B. tends to determine the average load factor of the air transport system. Moreover, the level of service quality and the average costs of the system are closely related to the average load factor. By qualitative analysis with simple assumptions concerning the relationship, one can conclude that average load factors should be higher in long haul markets than in short haul markets, and higher in dense markets than in thin markets. The actual specification of desirable load factor standards depends on the quantitative description of the technical tradeoff between price (cost) and service quality, and a measure of the traveler's preference (tradeoff) between price and service quality. With the limited data currently available, delay models were constructed to approximate these tradeoffs, and from these a range of "optimal" average load factors were computed.

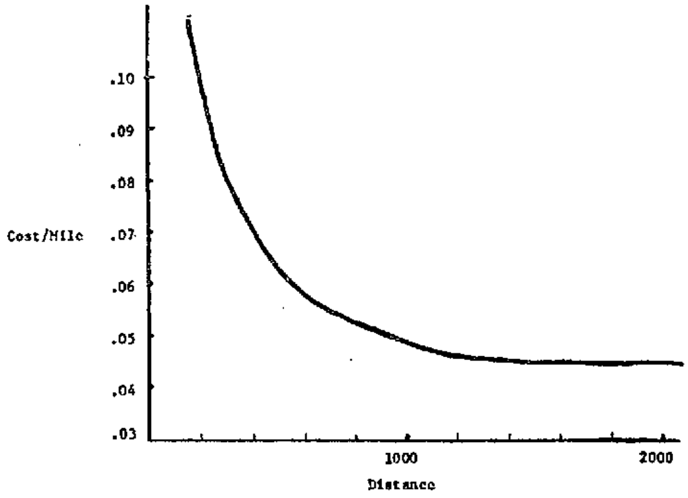
APPENDIX

THE ESTIMATION OF SCHEDULE DELAYS

Schedule delay arises from two sources:

(a) That a traveler's desired departure time does not coincide with a scheduled flight ("frequency delay"), and

· Cost Taper with Constant Average Load Factor



Cost measured per passenger mile; ALF = .56 at all distances.

FIGURE 9

(b) That the desired flight is filled, and the traveler must take another flight (stochastic delay).

Frequency delay (type "(a)") was estimated by simulation. The daily pattern of demand (Figure 2) of a typical route was transformed into a discrete frequency distribution. A procedure was used to schedule "F" flights during the day, such that each flight faced demand of equal size. The difference between each traveler's desired departure time and the nearest scheduled flight was computed, and their absolute values summed for all travelers. The mean, or average delay for each traveler was computed. The procedure was repeated for F+ 1, F + 2, etc., thus generating the average or "expected" value of frequency delays as a function of the daily flight frequency. These observations were fitted to the function

(1) $T_f = 92F^{-.456}$

where T_f is the expected frequency delay, per passenger (measured in minutes) and F is the daily flight frequency.

To estimate stochastic delay, we characterized the problem as a queuing phenomenon, and described it as a Markov process. To do this, we assumed that each flight faces a random demand with mean N_f and standard deviation σ_F. We describe the state of the system by a variable "Q," defined as the number of passengers desiring space on a given flight. Assuming that the distribution of demand is normal, we can then assign probabilities to a one step transition matrix. An example of such a one step transition matrix is

CROSS-SECTION ANALYSIS BY MARKET OF AVERAGE LOAD FACTORS

"t"-Statistics in Parentheses

All Markets:

1. $ALF = .588 - \underset{(1.4)}{.2\times10^{-4}} \times DISTANCE + \underset{(9.1)}{.8\times10^{-6}} \times PAX - \underset{(6.5)}{.07}\ NO\ CARRIERS \quad R^2 = .213$

2. $ALF = .244 - \underset{(1.8)}{.018}\ LOG\ DIST + \underset{(7.1)}{.073}\ LOG\ PAX - \underset{(5.5)}{.146}\ LOG\ C \quad R^2 = .144$

One Carrier Markets:

3. $ALF = .494 - \underset{(1.6)}{.3\times10^{-4}}\ DISTANCE + \underset{(4.1)}{1.4\times10^{-6}}\ PAX \quad R^2 = .128$

4. $ALF = .303 - \underset{(1.25)}{.016}\ LOG\ DIST + \underset{(6.4)}{.059}\ LOG\ PAX \quad R^2 = .238$

Two Carrier Markets:

5. $ALF = .349 - \underset{(0.1)}{.3\times10^{-4}}\ DISTANCE + \underset{(16.10)}{1.9\times10^{-6}}\ PAX \quad R^2 = .572$

6. $ALF = .153 - \underset{(0.8)}{.019}\ LOG\ DIST + \underset{(4.5)}{.121}\ LOG\ PAX \quad R^2 = .145$

Three Carrier Markets:

7. $ALF = .495 - \underset{(0.8)}{.2\times10^{-4}}\ DISTANCE + \underset{(0.8)}{.1\times10^{-6}}\ PAX \quad R^2 = .024$

8. $ALF = .371 - \underset{(1.42)}{.017}\ LOG\ DIST + \underset{(2.2)}{.031}\ LOG\ PAX \quad R^2 = .105$

Four Carrier Markets:

9. $ALF = .464 + \underset{(1.0)}{.5\times10^{-4}}\ DISTANCE + \underset{(2.8)}{.1\times10^{-6}}\ PAX \quad R^2 = .62$

10. $ALF = .107 + \underset{(0.5)}{.013}\ LOG\ DIST + \underset{(2.2)}{.045}\ LOG\ PAX \quad R^2 = .495$

TABLE 2

given in Table A1. The row and column headings identify the state of the system, or the number of travelers desiring a seat on the flight. The row headings indicate the possible states of the system at any time T_o, while the column headings indicate the possible states of the system at time $T_o + 1$. The entries in the matrix are the conditional probabilities. For example, if the state (number of passengers) at time T_o were .4 of the mean demand, the probability that at time $T_o + 1$ there would be a demand of $.4N_f$ is .1; that there would be a demand of $1.2N_f$ is .187, etc. If at time T_o, the demand exceeded the capacity, then of course the demand at time $T_o + 1$ must reflect this "overflow." Hence, the conditional probabilities would change, as indicated in the matrix. These probabilities are defined with respect to a given capacity, measured in units of "X" where

$$(2)\quad X = \frac{S - N_f}{\sigma_f}$$

where S = aircraft capacity.

The "steady state" of the Markov process defines the probabilities that Q is of any given size. Comparing these probabilities with the aircraft capacity, we can estimate the probability of being delayed by one, two, three or more flights. By multiplying these probabilities by the average headway interval, we can estimate the expected delay associated with any relative capacity, "X." By computing many values of delays, as X is changed, we then fitted the function:

$$(3) \quad T_s = .455\left(\frac{N}{\sigma}\right)^{-.645}\left(\frac{S-N}{\sigma}\right)^{-1.790} \times \text{(headway interval).}$$

One Step Transition Matrix X = .575

State (queue length) at $T_o + 1$

State	.133N	.40N	.67N	.93N	1.2N	1.47N	1.73N	2.0N	2.27N	2.53N	3.07N
at T_0 .133N	.049	.100	.158	.194	.187	.141	.084	.039	.014	.004	.028
.40N	.049	.100	.158	.194	.187	.141	.084	.039	.014	.004	.028
.67N	.049	.100	.158	.194	.187	.141	.084	.039	.014	.004	.028
.93N	.049	.100	.158	.194	.187	.141	.084	.039	.014	.004	.028
1.2N	.049	.100	.158	.194	.187	.141	.084	.039	.014	.004	.028
1.47N	0	.049	.100	.158	.194	.187	.141	.084	.039	.014	.032
1.73N	0	0	.049	.100	.158	.194	.187	.141	.084	.039	.046
2.00N	0	0	0	.049	.100	.158	.194	.187	.141	.084	.085
2.27N	0	0	0	0	.049	.100	.158	.194	.187	.141	.169
2.53N	0	0	0	0	0	.049	.100	.158	.194	.187	.210
3.07N	0	0	0	0	0	0	.049	.100	.158	.194	.397

Note: Matrix condensed for expository purposes; computations were made using 33 × 33 matrix.

N represents the mean demand per flight period.

TABLE A1

THE ROLE OF THE MANUFACTURER IN AIR TRANSPORTATION PLANNING

by James MacKenzie

Douglas Aircraft

July 12, 1972

Abstract

This lecture deals with the role of the aircraft manufacturer in the airline industry. The process will be illustrated by using a fictitious airline as an example--that is, a case study approach with "Mid-Coast Airways" serving as the example. Both in slide form and with supporting papers, a brief history of the airline, a description of its route structure and a forecast based on econometric analysis are presented. Once the forecast rationale is explained, information will outline the requirements for additional aircraft and the application of new aircraft across the system using alternative fleet plan options. The fleet plan will be translated into financial summaries which will indicate the relative merit of alternative aircraft types, or operating plans.

I'm going to talk about the role of the manufacturer in the aviation and commercial field with particular emphasis on the marketing aspects of commercial aviation.

The last time I looked, our advanced research and systems group had several proposals in various states of preparation or submission to NASA relating to a broad spectrum of projects. These included retrofit programs for the JT3D/JT8D engine, two segment approach programs and studies, experimental STOL vehicular development proposals, composite materials for STOL aircraft and a whole host of wide ranging projects. Now, this relationship has been going on for some time but it's primarily been handled by this group which has previously been part of our military organization. We recently reorganized and brought into an overall marketing structure of what was formally our military sales group and is now called government marketing and I think the emphasis or the shift in NASA's approach to truly commercial problems signals a change in our company where we now, and I represent the commercial side strictly, will be dealing more and more in these kinds of problems. We are presently supplying people to a task organization to conduct a funded STOL system study and I'll talk a little more about that later. But, I think the shift of NASA's interest into commercial programs of large scope signals or represents growing awareness on the part of the Federal Government through sociological and economic problems and I think that this interest is needed and certainly welcomed by the manufacturers and a discussion I had some time ago with a representative of the Port of New York Authority, he mentioned that the area encompassed by their jurisdiction crosses over some 1500 different political and labor entities and so I think that if we are about to achieve an effective STOL system we certainly need policies and institutions of the highest level for the federal government to cut across these jurisdictions and interests to establish an effective, viable, system where we can have land as required where we can develop safe control techniques or systems. I think that it is particularly important, however, that we recognize that if we are to achieve true sociological and technical advances that it has to be done recognizing the economic constraints that are applied to both the aircraft builder and the manufacturer. We're talking now about programs where the development costs exceed the net worth of the companies that are asked to develop the vehicles. The inability of private institutions to financing these entirely such as the programs of the SST and I am sure that this will apply to any future major system development, demands that we get better ways of financing funding programs of this type. The second thing in these economic constraints applied to the users of the airplanes and if you look at the foundering of the SST program with the prolonged delays and high speed rail development in this country there is a doubtful future of aircraft like the Concord and I think you can relate more to the fact that those systems have yet to prove their economic merit than you can to ecological considerations although the ecologists may take credit for torpedoing the SST program. I wonder what the outcome would have been if that aircraft really had the economic promise that more conventional aircraft have.

I think that it also is important to remember that whatever the Government does in terms of establishing policies and institutions to assist the industry we have to remember that it will be accomplished through private enterprise, that's the builder and the airline and the banking institutions.

Q. Are you stating that the Congress was aware that the SST did not have the economic problems?

A. I think that there are many people that seriously questioned the economic viability of the SST. They certainly knew the Concord was not as economically attractive as the U.S. SST, but the cost of the airplane and the technical unknowns about its terms of maintenance and reliability I know had the airlines concerned. I think that that is a big part of the problems involved. If the airlines had aggressively stated the case and I think that this was part of the problem of the entire SST presentation that really wasn't marketed very well. My hunch is that is was because the economic benefits were very difficult to prove.

Q. Are you suggesting that there might have been some kind of a consensus that it was not economically viable.

A. That may be too strong a statement, but in discussions that I had with various representatives of airlines the common theme was concern, doubt as to whether it was really going to be a money problem. That kind of question as far as operating costs, seat mile cost, etc., were never in question with the 747 or the rest of the subsonic airlines and you see now in the Concord to a much higher degree and it's a much smaller airplane, rising price tag.

Q. Of course, that was not a secret that -

A. That's right, but I think the focus was on ecological aspects and the noise factor.

Q. I think that it was also a question on timing, too. Maybe the airlines would have been ready for something like that.

A. Well, that's right, they were saddled with a tremendous investment for 747's and DC10's and L-1011's all at the same time or just preceding it. And then, you throw on that an economic recession starting in '69 when all airlines were all in trouble anyway. All I'm suggesting is that when your technology enables you to propose certain kinds of vehicles, I think that it's essential that those vehicles offer some sort of economic incentive to the user otherwise you might find that the operating costs are so high that they are not marketable.

Q. We followed the vote very closely from the Aeronautic Space Council Staff's point of view on the SST and several votes throughout its history and my observation was that the final vote was more of an economic vote than an ecology vote. The Congressman who had initially voted in previous years against it on ecological grounds was now convinced that the threat was well enough defined to vote against it,but on the other hand, and it wasn't necessarily concensus, but there was a big uncertainty and they just didn't have the right answers from the manufacturers or the Government on the economics of the aircraft.

A. Although that didn't get us many headlines.

Q. Oh, no, the papers picked up the ecology issue.

A. That's correct. Since 1920 when the Douglas Aircraft Company was founded, we've watched the phenomenon of commercial aviation grow from an experiment to a national necessity of the first priority and because of this growth there has been a great many entrants into the manufacturing field, very few of them have survived. There are three manufacturers today in the United States competing for commercial markets: Boeing, Lockheed and McDonnell-Douglas. Each of those companies has the productive capacity to satisfy close to the total demand. So we have an industry that is characterized by over capacity. This means that the competition between builders is intense. It's resulted in very spotty earnings records through the years, not only for the three that survived, but for previous entrants. It means that there's tremendous competition between them for product differentiation. Each one strives for higher speeds, more passenger service features, larger capacities, all those things that drive development costs upward, at the same time price competition working to keep the margin between costs and sale price very narrow. It also drives the break even point of the aircraft much higher than the builders would like to see it and this competition is passed on to the airlines because as a regulated industry where they are regulated in respect to what they can charge for a seat to the public they too seek product differentiation and they seek advantages that they can advertise in order to maximize their share of the market. So we have a combination of high development, high competition between both builders and users and it might be argued that what the industry really needs is either fewer competitors or more regulation within the industry. But, I would argue that given those as problems we can still say that the 707 and DC8 are better airplanes because of that competition and that the 737 and the DC9 are better airplanes because of the competition and that the L10-11 and the DC10 are better because of competition. So, I'm submitting that there is a great deal of merit in the basic structure where you have a highly competitive situation in terms of the quality of the end product. I think that one factor overrides the easy way out which would be to control capacity or to regulate it in such a way as to minimize the problems attendant to both the airlines and the builder. One other thing about this competition was the carrier seek or or the builder seek product differentiation as to the carriers. This means that the airlines are going into re-equipment cycles before their existing aircraft are fully depreciated or obsolete. What I think we need are Government policies which sustain competition, which are aimed at protecting the economic health of both the aircraft manufacturers and the airline.

I mentioned that I am going to focus today on marketing and this is merely the beginning as to where it all started as far as how you go about developing an aircraft. I think that marketing is appropriate here because it is in the marketing area where all the social, technical, economic barriers are brought to focus. It is there that the success or failure of a given idea is going to be achieved. Marketing is also the principal line of communication between the builder and the airline. At Douglas we have a fairly conventional marketing organization. Sales is the most visible group, it's the principal agency of contact with the airline and they are the spokesman to the outside world, but the sales group represent less than 15% of the total marketing organization. The rest is composed of engineers, economists, financial analysts, schedulers, a whole host of specialists that develop and support a case for the aircraft. To this you can add the entire resources of our engineering organization, our legal and contract group and the products support groups for after sales support. The marketing process encompasses a very large number of men. If we look at the sub groups within our marketing organization we can first talk about our advanced transportation concept groups. Now, this organization is charged with the responsibility of relating technical possibilities downstream against what they see of the environmental needs to be out into the future and they are going out today to about the year 2000. Their purpose is to keep Douglas Aircraft in the mainstream of air transportation and it's easy to get off track as you can see by the number of companies that have been in the field and have somewhere failed to come up with the right product at the right time. We have a similar group relating the cargo development where they're studying the emerging infra structure of inter-modal transport of containerized cargo and their emphasis is todetermine how and when the very large cargo airplane will make economic and technical sense for both this nation and other nations throughout the world. At this point, maybe if we can turn the projector on ....

The advanced transportation concepts group prepared this forecast of world traffic and they've done this in a factor technique where if you say we're at about an index of one here by the year 2000 we're going to be up past 20, which means that there is a great tremendous growth potential worldwide for air travel. These two lines represent out to this point, the low band and the high band in our market research forecast through the year 1980. Beyond they've taken a number of techniques to extrapolate out into the year 2000. They've used delphi techniques and a lot of intuitive judgement. The band out here as you can see is quite wide so there is, the further out you go in the time the vaguer it gets and grayer it gets, but, even if you assume that the low band is the more reasonable, we're still talking about the factor of 8 times the growth by the year 2000.

There will be a definite break in the period around 1985. I don't know why they did that. It could be that they're saying that at that point of time they can't tell any more but they think that there is a maturing of world markets. The group that I'm responsible for is presently going out to 1981 and these fellows simply take it beyond there.

Another interesting part of this growth pattern though, is what they see as how that travel is going to be accomplished and this is the greatest pointer that I've ever seen. It's very appropriate. What they're saying is that really the classic modes are going to persist clear out into the year 2000 with short range aircraft accounting for about 13% of the total, medium range 19% and transcontinental 13%, interconti-actually coming down, SST is now becoming a very big factor by that time, long range represents aircraft going some 5000 miles or beyond, equivalent to the 747 or the long range DC10's and STOL now is beginning to emerge as a real factor. I should point out that this is in terms of RPM's. Now you say that 8% of the total may not seem like very much, but it terms of people it could be a great deal. One man traveling from here to London accounts for 6000 RPM's, excuse me, say from Los Angeles to London, and that's the equivalent of say, 20 people going from Los Angles to San Francisco. So we could be talking about a very large number of people but yet generating a few RPM's out of the total.

I think what we're saying here is that STOL and Feeder Aircraft do not necessarily, they're doing the same service but they're not the same airplane. It's a mix.

Q. Is this the world market or is this the domestic market?

A. That's world.

Q. Do you see any VTOL by 2000?

A. No. That did include helicopters.

Q. How do you differentiate the long range and trans-con?

A. Transcontinental is, let's say, 2500 miles.

Q. Is that somewhere in long, short or medium range?

A. This we're talking about 727 type range capability. Out to trans-con 2500 miles, inter-continental is 3500 and long range is beyond that. The Tel/Aviv/New York type are going above 5000 miles.

Q. If I perceive correctly,you're present short range are in three segments; STOL, short range and medium range on both of the diagrams. Are you saying that the medium to short range are going to be unchanged?

A. But the mix between STOL and DC9 and 737 and the kind of equipment that we are shifting towards. STOL

Q. Does this include charter service?

A. I believe that this is scheduled. Well,no, I take that back. I think it does include charters.

Q. I think a way to look at that is that the STOL Feeder business might be as much as 80% of the day's total.

A. I'm sure it is. You'll see later that I have some forecast of aircraft numbers by type and I think that we're saying that by 1980 that there are some 480 STOL aircraft.

Our Market Research Group is charged with more near term responsibilities and I mentioned earlier that we are working on a funded NASA study STOL system and we have actually assigned or loaned people to a task-oriented group and they're presently going through exhaustive analysis of a major potential STOL system as to what the capture would be within the market. What the trade-offs are in terms of range against surface desireability on the part of the consumer and what the economics of the aircraft would have to be the make of the craft. It's a rather interesting study and a rather complex one. We went through the same kind of analysis several years ago when we were trying to decide whether to build the DC10 and it all started with an analysis of the potential economics of an aircraft and big discussions with airlines as to what kind of operating costs levels they were seeking, what comfort standards were they after, what kind of improvements in systems in terms of all-weather capabilities and a whole host of trade studies in which you try to determine what kind of an airplane truly makes sense in the market for the period you are designing the building to. Our goal was to develop an airplane that would have as broad an appeal as possible and you achieve this through what we call operational flexibility. This involves a number of considerations, the effective range of the aircraft, its takeoff and landing performance to enable it to work out of a host of airports, the all-weather flexibility, there are a number of keys that we focused on. The total market estimate was very critical to this decision because we knew we were going to invest over a billion dollars in developing the aircraft and that exceeded our net worth, so you have to get to some pretty reasonable estimates of how many of these airplanes you can sell or you are really facing a disaster. When you think of the experience with the 10-11 and the engine problem you find out how critical this can become. You may recall that at the time we were offering the airplane we said we'd build it if we had a total of 50 firm orders from at least two major airplane manufacturers. We got American Airlines to commit to 25 firm and 25 options. Following that Lockheed, who was also in the race got a spate of orders from TWA and Eastern, Northeast, Delta, and Air Canada, and at that point our program was really on the ropes. United then committed to the DC10 and with that we had our quota. (They bought 30 firm and 30 options). With that we had sufficient orders to commit to a firm program and we started building the airplane. Because of the lead that Lockheed had jumped into we wanted to overcome this and broaden our customer business. We were fortunate in that we had committed to the General Electric Company for our engine development and that they had early in the game come up with a growth version of the CF6 engine. We were able to convert this additional thrust into higher design weights in order to achieve greater range. We now have four models and as you can see, the basic airplane, series 10, which American, United and National are operating today, is powered by a 40,000 lb. thrust engine. It's maximum takeoff weight is 430,000 lbs. and its range is about 3670 nautical miles. When we go to the long range version, the CF6-50C our thrust is gone up to 51,000 lbs.

We can then go to higher design weights, greater fuel capacities and increase the range up to 5300 nautical miles. We also had Pratt Whitney in the competition with their derivitive engine of the JT9-D which produces 50,000 lbs. of thrust and again the same design weights, the airplane is slightly heavier than the GE version so the range is not quite as great but it is actually the next one that will be certified and that will happen this fall. We also went to convertible freighter versions and we've sold those in CF powered versions. They can carry 158,000 lbs. payload for 3150 nautical miles so in the passenger version the range is about equal or in the passenger mode is about equal with the standard passenger airplane, so that's given us additional flexibility and because of this we have now broadened our customer base to 25 airlines. Seven carriers have bought the series 10 airplane: American, Continental, Delta, Lakair is the next one (it's a charter carrier based in London), National has bought the basic airplane, United and Western. Northwest bought the series 20 with Pratt Whitney engines primarily because they believe very strongly in engine commonality. They're a large 747 operator and they felt that the common overhaul line would justify that going to an airplane with slightly lower performance levels. The convertible aircraft has been bought by Martin Air Charter which is an operator based in Holland, O & A, Sabena, and TIA and the long range GE power aircraft has been ordered by El Mexico, Air Afrique, Air New Zealand, Alitalia, Atlantus, Fin Air, Iberia, KLM, Luftansa, National bought the long range version for their Miami/London flights and finally SAS, Swiss Air, UTA and Viasa. Now there are a number of carriers that have yet to come into either the 747, the L10-11 or DC10. The competition is very keen for those remaining operators and now we have the A300B, the French-British product, coming into the scene actively marketing in the United States throughout the world within a twin powered wide cabined aircraft.

Q. Do you know the total rack up of the three airplanes?

A. We sold, including options, 240 airplanes. I think the 747 is about 210. I'm not sure on the count.

I might mention here that despite Lockheed's problems, they're tough competitors. I think that their airplanes are going to work fine. They've been hurt because of the engine delays because we've broadened our customer base. But the future looks very bright for them in Great Britain and there are still a lot of people out there who haven't bought them.

Q. As I recall, Lockheed preceded you people in this type of aircraft. Can you elaborate a little bit on that and your view of the 747 and this type of aircraft and why you felt you should go into this type of aircraft as opposed to perhaps some other area. You knew that you were going to get high competition. It seems to me that when two or three companies are all competing for the same market perhaps they would do better if they would kind of divide their market upsurge. That's an over-simplified way of putting it, but I'd like it if you would elaborate a little bit more.

A. I think there are a number of reasons. One, our growth estimate told us that there was healthy growth despite the immediate problems that were facing us. The 747, we believe, was going to have tremendous passenger appeal and here we were building stretched DC8's that we saw just could not compete around the major routes of the world against the wide cabin airplane, so our choice then was whether to enter it or abandon the field and I think at this point that emotion creeps into it. We just hate to give up without a fight. Secondly, we felt the 747 was oversized for the 1970's. It represented about a tripling in capacity from the standard DC8/707's and this jump and there were reasons why the 747 was the size that it was. A lot of developments on that airplane had been accomplished through the C5 competition. We felt that there was logical gap in size between standard body forms in jets and the 747 that would serve as a better vehicle for less dense routes and that's a compliment to 747 service on off time, off day service and I think we proved right. I think that the airplane is going to be quite successfu

We started out with twin engine air bus and American Airlines had written us back for a twin engine air bus, but when we went around to the other airlines we couldn't find any one else that wanted that airplane. They all wanted more range, more takeoff flexibility. They wanted to be able to operate out of Denver and Mexico City. You just can't do it with two engines and go anywhere so the trade study said that it had to be a three engine airplane. If you go to three engines when you've got the takeoff performance and the enroute cruise performance to go to transcontinental and of course when we got the growth engine we could go a long way.

Q. I have been told that the market analysis groups of both Lockheed and Douglas predicted more than break even sales for both companies building essentially the same airplane. Is that true?

A. Yes, that is true. And I think that the total market is there if we assume that everybody gets an equal share. I think they will. While we've done all this product differentiating we haven't done that without a price either. We might break even here.

Q. What are the numbers up to 500/600?

A. I can't answer that question for two reasons. It's a very closely kept number but at the time of the congressional

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was to reduce their price and they were very successful and sold five of the airlines practically within a week. We met that price and made a comparable reduction and passed that back to American and the competitive factors keep both cards pretty neat. The bankers get involved where they look at your estimates,do they believe the costs estimates of manufacturing. And then in turn do they believe that you are going to be successful. They do have a lot to say about whan an aircraft company can do if it's heavily committed to a long term gap, as to new programs, derivitive programs, developmental programs.

Q. What would happen if you had gotten to a point where you would never break even. What would the banks have to do then?

A. I can't answer that, but I think that it's a pretty fundamental thing, unless you make some money somewhere along the way, you're going to cease to exist. In 1966, Douglas was selling aircraft faster when our bankers forced us into a merger simply because the cost of the manufacturer was exceeding the sales price of the aircraft. Now, what McDonald brought to the Douglas company was a lot of money and there was a lot of restraint on his part as to how to get Douglas Aircraft out of trouble. We elected to middle management and we felt that we had a sound engineering group and a sound basic middle management and they left us pretty much alone with some key people coming in with manufacturers wondering what they could look at and what we were having some problems with, but within a couple of years we have turned around and we/ve been fairly profitable since and, by industry standards, profitable.

Q. Were you not experiencing a very difficult training period?

A. Oh, yes. We had, I can't remember, I think there was something like 3/4 of the people in production that had been there less than a year.

Q. There was a high turnover as I recall and many people who you were training would work for a couple of weeks and then leave.

A. Turnover was high and experience was low, coupled with some vendor delays of engines and landing gears.

There was a kind of a remarkable recovery but to come back to another question, why did we get in, here is a more current forecast of where we see us going from today up until 1980. It's a healthy growth rate close to 12% per year for total services with a growing in non-scheduled areas as we go up toward 1980. That means that in order to supply that there are going to be a lot of new airplanes built and here are estimates as to what is going to happen to the world fleet composition through the year 1980. There will be a phase out of the conventional props and turbo props, they'll be down to about 700 by the end of the decade. The DC9, 737, Caravelle, BAC111 still had some growth left in them primarily because operating airlines are still reordering and it looks like we're estimating that the fleet will grow to a maximum of about 1560 by 1976 and at about that time we see those lines closing down and then a gradual decay as we go out into time. 727 -- there is a lot of life left in the 727 and Boeing has done a remarkable job of modernizing that airplane and stretching and increasing its range, making the interior more attractive and it's showing up in the past few months in rather remarkable sales. The older DC8's, 720's, 990's we see phasing out and they've already started going out and will be down quite low by 1980 and the conventional 8's and 707's also starting downhill about now getting down to the low 900's by 1980. To replace that and to accomodate the growth that we have shown on the previous chart, we'll see a remarkable growth in numbers of short and medium range wide cabin aircraft that includes now the A300B, the DC10 twin if there is one or any other competitive twin in the U. S. plus L10-11's and DC10's. Long range aircraft are composed primarily of 747, long range DC10's and long range 10-11's and you can see that there is a lot of aircraft to be built in the next ten years. STOL just emerging will be growing by 1980 to 470 units, supersonic aircraft primarily. Now the Concord coming in 1976 and we are saying 87 units by 1980.

Q. Would you comment on the USSR?

A. That excludes the USSR. I don't know much about them except that they're beginning to aggressively market in neutral and satellite countries and in some of the countries in Western Europe and they have a pretty good family of conventional aircraft jets. They've got the Illutian family of aircraft, the tri-jets, four engine jets, long range airplanes, YAK-40's. They've got a lot of airplanes and they're trying to sell them. I think they've got some very difficult problems in marketing the Western countries because they have a very bad track record at home and among their satellite nations as far as product support goes. The SST is anybody's guess.

Q. How about Communist China?

A. That's an interesting area; for Boeing, as you know, has had a sales team there and the going export license was granted last week and I think that somebody will sell them some airplanes and we have people in contact with them as well. How much is there and how soon is a difficult question. The country is under-developed in all modes of transport as far as rail and highway systems and it could be argued that maybe air would be the cheapest and the fastest way to get a travel system and a domestic transport building in China although I don't know their labor costs are bound to be low and maybe building highways would be cheaper, but for foreign international travel they've indicated that they are interested in going into other countries and I think we'll see some action. In the long range the potential is huge, with 800 million people.

Q. What are your estimates as to the passenger capabilities on the STOL feeder jets?

A. That's in the trade study area now, and the last I heard they were talking about 100 seaters. It's very tough to get very good economics with 100 seat STOL aircraft. I think in the long run it might be bigger but then if you do that you cut down on the size of the network so I don't think it's any better now than to just guess from my point of view.

Q. Why did Douglas close the DC8 while Boeing kept open the 707?

A. We just couldn't sell any more DC8's.

Q. I thought that it had the lowest operating costs in the country.

A. It is, the DC8-60. But the problem you run into is one of who are your customers, your established customers? The DC8-61 is not a long range aircraft and I think Boeing production is pretty much limited to their 320B's which is the intercontinental aircraft. Now they're kind of struggling as well and I don't see so much more in the way of sales for their company.

Q. Will the continued production of the DC8 steal from the DC10?

A. Yes, but if we had had our way we would have delayed the DC10 because we have a very good airplane and a very low cost airplane and we built a lot of them and we're making money on them. Everything argues the delay except the competitive factor with the 747.

Q. You made a reference to the economics of a 100 passenger airplane as pretty poor. Is this an implication that its technology that has to be developed in this area or is this an implication that manufacturing structures are so hard, or have they gotten so big? Has this created a problem, or is it something that just relates to a 100 passenger airplane?

A. I base that on what I understood the study price to be and I think it was somewhere around $12 million. Now you're getting a lot for this, you're getting STOL capability, but with a hundred seats and $12 million the cost per seat mile ran very high so unless you can increase the capacity and once you've got a basic airplane you can stretch it once you've got 50 more seats as this would just improve the seat cost tremendously.

Q. Is the cost of the technology STOL performance as great in the transcontinental area?

A. Sound is one thing, smoke, all weather are all part of the performance. There are a lot of variables and you can compare the costs against all these things and you'll find that you just can't get them for nothing, and eventually it's tested in the market place.

Q. When you say STOL, what band of runway lengths do you mean? Does that include up to 4000 feet (RTOL)?

A. Yes, but we'll say down at 1500, 2000, 2500, 3000 and for each one you've got a different price level and a different engine problem and different augmentor systems. Now let's assume that from our own internal purposes we've got an airplane that needs some real requirements for the future and we're going to go ahead with it but the problem then is to convince the airlines that they really ought to buy it against competitive aircraft being marketed. We see our development sales case as a two faceted problem and the first being performance. We have a large sales engineering group that looks at the aircraft being offered to the airline in terms of the airlines operating environment. We're blessed at Douglas and the same is true of the other manufacturers with very extensive computer facilities that are there primarily because of design and manufacturing requirements but since we do have them we can use them for other things and a lot of our marketing efforts depend on computer support.

When we look at performance of an airplane, we have flight simulation models, which will fly the aircraft over every route that we anticipate the airline using the aircraft and these models compute the allowable takeoff weights, taking into account runway obstacles, temperatures, elevation, wind, they compute fuel burns for the route taking into account any airline ground rules that are in imposed such as enroute, navigational tolerances, delays, reserve requirements of destination, fly through capabilities, it's a very flexible program and it also computes costs for the flight according to the ground rules specified by the airline. So, when we are done with the performance analysis we can go to the customer and with some confidence say yes, the airplane will satisfy every mission which you would ask of it or it will do them all except one, two or how many routes there are or perhaps because of runway lane, all up loading limits on the airfield or routes that exceed exchange capabilities, but anyway the airline then knows what the aircraft will do. But, it's not enough that the airplane can do the job that it has to do in an economic fashion.

That just says that a DC10-10 when compared against a DC8 or 707 has a much lower break even load factor and a much greater profit potential primarily because the seat costs are 25% less. Now it is true that it takes more passengers to break even but if you put in routes where the traffic is indicated to be reaching levels that will generate some good profits for the airline. This is based on a 140 seat airplane against a 270 seat airplane and assuming a yield of 6¢ per passenger mile and it assumes the transcontinental flight.

Q. Do you mean costs, not profit?

A. That's the fare divided by the number of miles and diluted to account for non-revenue passengers, discounts, etc.

Q. What's the primary reason for the DC10's being more sufficient than the standard jet?

A. It's just a lot bigger and a lot more efficient engine and when you break it down in terms of costs per seat, cost per mile and cost per seat mile, it's just a more efficient airplane and that's the productivity game of the jumbo jets or wide cabin jets are bringing (economy of scale).

Q. Isn't the thesis being advanced that the 727 even with 20% higher SFC that you can have more seats because it costs 30% less per seat comes out to the seat mile operating cost total and that's the interest?

A. Well, what we're showing here is profit based on total operating costs where we're taking into account all the depreciation charges and later on in the financial step I'll show you how interest can effect this total. The original type aircraft we mentioned is.

Q. The 727. It seems that its been hitting the DC10 and a couple of others head on because of its lower cost per seat encourages 30% lower and because of the economy of scale in the lower SFC of the DC10 and all its tradeoffs don't make it look like its always an economic advantage.

A. Well, we say we'll beat the 727's.

Q. What we're trading off here seems that the airplane costs per chairs is lower on the DC10 but what you're trying to do does not require the larger airplane than the effective seats that you're utilizing have a higher cost than the DC10 and so it's essential that you can't put a big airplane on a low demand market and it's the market that needs replacing.

A. The most critical decision that the airline has is to put the right sized airplanes on routes where traffic will support it in two ways; in capacity we have to have a reasonable load factor and you have to be able to provide a competitive level of frequency. It's a nice balance. Well, so we've proved that the airplane is economic and can make money;there are other ways to improve your competitive posture and one is by offering more comfort and this cross section shows the kind of things we're working with when you're comparing a wide cabin airplane with a standard jet. You get out of the tube, you've got the 8 feet high ceilings, the broad aisles, broader seats, the flexibility that comes under the deck with lower galley arrangements, the containerized cargo possibilities, it's just a much more appealing airplane and the passenger benefits from both of these factors. The airplane can operate under a much lower fare structure than it would otherwise because it has more productive aircraft. The airplanes are more comfortable and are more reliable and have more passenger service features and there are two way benefits. But, even given all this,and I'm coming back to your question, it's a great airplane, it's got a lot of passenger field and still can mean a financial disaster if it isn't matched to the market. What happened to the airlines in 1970 is that they had a tremendous amount of 747's, pre-delivered payments on the DC10's and 10-11's and at the same time a recession occurred and load factors fall out and highly competitive system and there just wasn't enough revenue to cover all the costs that kept recurring. The result was that the industry lost something like 100 million dollars. So, we spend a lot of time at Douglas trying to develop better ways to forecast traffic. Increasingly, as far as forecast in the United States goes, we are relying on econometric techniques and basically we're saying that revenue passenger miles are a function of personal consumption expenditures with the velocity of many being simply the GNP being divided by the money supply. The yield that the airlines charge and the passenger trip length which is the major service standards. It grows and grows because more and more non-stops services are being provided between cities so that what use to be a 2 or 3 segment flight may now be a non-stop and so that your average passenger trip length is one. Now when we do this, and I'm talking here about forecasting U.S. traffic in total. You're forecasting a lot of other variables instead of the depending variable. We go to the Wharton School in Pennsylvania for estimates of the various economic indices such as gross national product and personal consumption expenditures and then we plug that back in to this variable. The one that has given us the most trouble is yield because its tough to know where yields are going, and I'd defer getting into that for just a few slides because I think that I have a chapter that explains it a little better. But, when we compare what we estimate in the econometric models and this one happens to be a model of the U.S. scheduled service against historic performance where we plug in the achieved explanatory variables we get almost a perfect correlation of the past traffic growth, which says that if you forecast the variables that we are putting into your format accurately you're going to get a very accurate traffic course.

Q. What's the number of years before the actual estimate is made?

A. It doesn't matter when its made. We could make this chart today. All we have to know is what the PC yields, the passenger trip lengths, etc.

Q. Can the estimate be made before the actual or is it a result of correlation of the actual?

A. The task of whether your model is good is whether it can reproduce history. Now the future will only be as good as our estimate of both variables that go into the formula. I should say that those variables are more stable and more subject to analysis than the dependent variable which is RPM's.

Q. So the estimate really reflects the information taken from historical data.

A. The validity of the model depends on testing it against actually what happened in the test. So, using that we can then say that this is a forecast of U.S. domestic traffic and we're coming up with a total of 11.2% for scheduled service within the U.S. These are the eleven trunks. This is the local service plus intrahawaiin and intra-alaskan trunk. Now, we also have models that will forecast actual airline traffic using the same econometric techniques. Now here you get some differences in variables such as what's the historic share of the market, of the carrier within the total industry. But, I've gone here to ficticious airlines because once we get into real airline forecast we're talking about proprietary information. Now, moving on knowing the forecast, knowing what the airlines are planning to do about its existence, knowing what it has on hand and on order, we can generate a seat mile demand and what current aircraft on hand and on order will supply and this then represents the gap that must be filled by adding on an aircraft and so you can see what Mid Coast, which is a very large airlines, operating both internationally and domestically. We're forecasting a tremendous growth on the DC10 equipments, wide body twin equip, to satisfy the seat mile gap which I had shown earlier. But even this is not enough for an airline to make a decision as they have to have city fare forecasts so that they can relate aircraft schedules to expectant passenger travel. So, we then look at each city pair within the airlines networks and we take into account a host of demographic and social factors, political considerations, competitive factors on their systems and taking historic data to establish a time series. We then project taking into account these influences to come up with a city pair forecast. Once we've done this then we can show how many weekly passengers are expected between each city pair on their system. Given this we can then go to our airline planning group which has got a scheduled planning group which has got a scheduled planning and evaluation level which will flow that traffic over the airline system and develop successive aircraft fleet schedules out as far as we care to go and this schematic simply says that on Flight 10 originating in San Antonio and ending Chicago we have 967 passengers in an average week joined by 6 on line connecting passengers from Portland and Seattle, 5 from Mexico City, 23 from Corpus Christi. Those totals then flew to Houston where 695 got off, 1310 originated, 25 connected from Corpus and we got 1647 ending up in Chicago, and we do that for the entire airline system. In short, what we do is develop a liable flight plan and a viable schedule which takes many years of forecasting. Now the model allocates on the basis of looking at each routing and comparing against the total service offered on that route. The variables if it is a daily service, bi-weekly or five a day or whatever it is. The air traffic capacity and the customer attributes of the aircraft, what are the departure and arrival times, etc. Once you develop a rating for that particular flight you can compare it against all the flights being offered in that market and assign it a percentage of the total traffic and that's the way the model flows the traffic. So, given a reasonable estimate of the traffic this is also a reasonable estimate of how that traffic will flow. Once we've developed an operating plan we can then translate that plan into the financial forecast for the carriers and here we're showing an income statement generated in successive years '72, '73 and '74 for Mid-Coast Airlines where we take into account all the revenues, all the expenses, develop operating income levels and finally net income levels in successive years. This also is computerized and can be generated over night in a very timely fashion. We develop sources and applications of fund statements which show the airlines where the money can be expected to come from and where it will be applied and we can plot then the relationship between costs and revenue over a time frame. This is fairly typical of historic performance by most trunks where they were enjoying very profitable years because of this spread in the middle 1960's and then the tremendous squeeze that was put on them in 1970 and then we're forecasting a return to normal now. I mentioned that the yield is a problem. This reduction in cost per ton mile through the 1960's was achieved primarily because of transition from props to jets. Although we've had larger, more efficient airplanes coming in now in the terms of wide cabin equipment, the productivity gains are not enough to offset inflationary trends so we're seeing 1971 as a kind of water shed year where we're looking at rising costs in the rest of this decade, and we're making a further assumption that the CAB and the airlines through prudent and intelligent fare structure management will recognize this rise in costs and adjust fares upward to account for it. If that should occur, then I think we'll see airlines returning to a condition relatively good economic health through this decade.

This shows the picture of the airline and with the event of these new aircraft coming in, how their debt structure is rising to over a billion dollars, but because they're growing tremendously and they're generating profits, their debt equity levels are holding fairly low, just quite a bit lower than they were a few years ago.

Net income. It looks like a pretty impressive gain in net income. Again, the airline is tripling in size, so this kind of level is not terribly out of line and as you'll see on the next chart where we plotted the expected return on investment in the airline where they were down here at practically no return, now rising up by about 10% by the end of the decade. The CAB guide line for a reasonable rate of return from the airlines 12%, so I think what we're saying there is that things are going to get better, but not excessively.

Q. Has the consideration of a four day week entered into any of your discussions?

A. No, sir.

Q. Do you think that might occur?

A. Yes, it sure could.

Q. Are you doing a twin jet?

A. We're talking very seriously about building it, but we don't have it proven, but we are discussing it with many airlines.

Q. If you built your usual quality, twin wide body,do you think you could crack the European market or do you think that they would buy they're own? Will they be forced to buy their own?

A. I might say that some of them would be forced to buy their own and that the preference factor for a European airline for an A300B would be in the order of maybe 15%. Other things being equal you could split the market and I think you would have to bias in favor of a European manufacturer because of the 15%. I think that the reverse would be true in the United States.

Q. Do you think the Civil Aviation Production and Finance Act has solved all, some or none of their financial problems?

A. I'm not familiar with the details of the act.

Q. What is the stopping order of the DC10 twin. Is it the Chairman of the Board; is it a bank not lending the money?

A. It's airline interest.

Q. You can't get 2 or 3 airline orders?

A. I'm not saying we can't, I'm saying we haven't yet, but think if we had the orders we'd build the airplane.

Q. Do you have an idea as to how many firm orders it would take?

A. Yes, and that varies. The Chairman said he would like to have a hundred of them.

Q. How long would it take if you decided to go ahead with this?

A. About two years. We're talking now if we committed this summer. We'd be delivering in late '74, so slightly over 2 years.

Q. Are we going to have 3 companies building them again, do you think?

A. I really doubt it. I think that if we enter it I doubt if Boeing would. Although Boeing might come along with an airplane with a super critical wing or an advanced 727 type or something like that.

Q. You don't believe in a 747 twin?

A. I don't know enough about it. I think that they have to cut the weights tremendously to make an effective airplane with the engine thrust that's available. If you can get the thrust up to say 55,000 lbs., it might be a pretty good airplane.

Q. One more question. Your projections of the passenger miles were that you pretty well assumed that that was all going to be in the long haul of the large jet and that the difference between the characteristics between the large jet and the smaller type airplane the sensitivities are such that one less larger aircraft means several less smaller aircraft so there's a great deal of leverage there and with a slower less sensitivity (this is one thing that I'm interested in) and the other thing that makes me ask this question is that it looks like a great market in the future are the non-U.S. domestic and non-European domestic but the rest of the world and it seems to me that the market there is for smaller airplanes. Have you looked at these sensitivities and what that means to the profits of the manufacturer? Are the profits low for a smaller airplane?

A. Well, let's tackle the first part first. I assume you're relating to the forecast for MidCoast Airways with the increase of fleet?

Q. No, your general forecast. How many long haul, large jumbo jets are going to be sold and then how many smaller aircraft are going to be sold, etc.

A. We're assuming there that the bulk of that growth and that you're talking about the U.S. forecast is really going to be in the 11 domestic trunk carriers. They represent about 90% of the total productivity of the airlines structure in the U.S. The local service carriers are growing and have grown at a slightly faster rate than the trunks in the last couple of years, but they've got an awful long way to go to really penetrate or to alter drastically those relationships. Now in that area I would see perhaps quite a shift in the STOL type aircraft, but I guess what we're saying is that conventional aircraft is still going to be doing the lion's share of the work for the next ten years or so.

Q. You didn't say what the future wide bodies are going to be for third generation.

A. I don't really know. I think that there will be super critical wing airplanes, cruising close to Mach 1 and composites, but we're also talking about slow supersonics that swing with a pivotal wing.

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CONSUMER MARKETING AND THE AIRLINE INDUSTRY

by William R. Roy
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July 18, 1972

Abstract

A brief discussion on the fundamentals of consumer marketing as applied to the airline industry. An attempt will be made to boil down the mystique and jargon which frequently surround the subject of marketing. Topics to be covered include: (1) What is "the marketing concept"? (2) How do we find out what consumers want from an airline? (3) Once we know their wants, how do we plan "marketing strategy"? (4) What are the roles of advertising, sales, and middlemen in the process?

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Consumer Marketing In The Airline Industry

I am going to try to give you some perspective into key elements of consumer marketing. What it means, how it works, the consumer value it creates.

Third point, frequently one of controversy, today it's popular as part of surge of consumer advocacy to knock marketing's role in the economy, to accuse marketing of creating waste and foisting unwanted goods on to an unsuspecting public.

Sometimes I wish that marketing techniques had the powers that the Nader's Raiders sooth sayers of gloom and doom attribute to it. Unfortunately or fortunately, depending on your perspective, it does not.

Defining marketing is a little like defining sex. It's intuitively understood by the participants but damn hard to put into words. The best definition I came up with trying to synthesize a number of various veiwpoints is to say: "The business process by which goods and services move from the producer to the user."

As the economists say, "marketing creates place, time and possession utility." In English, that means the marketing processing enables a customer to find the kind of goods he wants when he wants them and ideally at the price he is willing to pay.

In the airline industry this concept of time utility becomes very important because of the perishable nature of our product. The skill with which we pursue the consumer marketing process in our industry makes the difference between seats going out empty or full. When that plane is sitting on the apron, if we can't fill it, those seats are going out empty and as a result we have lost our opportunity to sell that particular component of our product.

Once we define what marketing is - moving goods from the producer - we realize there are two ways of looking at the process - from the producer's side or the consumer's side.

If we go at it from the producer's side, in other words, how we are going to convince people to buy the product we have available, we don't really have a complete marketing process. We end up trying to get the customer to want the goods or service we are selling.

The real marketing approach takes the consumer's viewpoint and tries to figure what his wants and needs are. Then determine how our product can fill those needs.

This is called the marketing concept - try to understand what the consumer wants. This is a concept which is easy to pay lip service to and hard to put into actual practice.

In my opinion, airline industry has not done a very good job in this respect.

Because of airline scheduling, crew and equipment logistics, it's often easier to fit the customer to our products than fit our products to the customer. It's a little like Henry Ford's well-remembered statement that the customers could have any color car they wanted so long as it was black. We have had a bit too much tendency to do that in the airline industry.

A good example of an enlightened marketing concept approach, whether it was intentional or not, was the introduction of the coach lounge. It gave the consumer a chance to get up out of his seat, a rather confined space, walk to another area of the plane, sit down, relax and move around the plane. So as I say, whether it was intentional or not, this was a good example of the marketing concept in action. There was knowledge on the part of various airlines that the consumer wanted more options on the plane and the idea of developing the coach lounge gave more of these options.

Here are the ways I'd describe what it takes to get the marketing concept juices flowing. I see it as a five-part process. There's nothing sacred about five. I am sure other marketing practitioners could combine or subdivide the components differently and make it a four-step or ten-step processing depending on their bent. These are the five steps.

Beginning with marketing research and analysis, we must find out what the customers' real needs and wants are. Most people don't buy a garbage can for the aesthetic impact but so they have someplace to put the garbage.

Neither do most customers get on an airplane for the sheer ecstacy of flying through the air. As Carl Ally, Chairman of Pan Am's Ad Agency once put it: How may people would pay 250 bucks just to get in a 747 for seven hours to have dinner and watch a movie while circling over beautiful downtown Newark? You get in a plane to go someplace. Getting from point A to point B has value as far as the consumer's concerned. It's that destination impact that is imperative if you use a marketing concept in the airline industry.

Next, we've got to find out how well our product fills those needs and how we stack up against the competition and their ability to fill the same customers' needs.

Finally, a market analysis is needed to determine what our chances of success are. There very likely may be cases in certain product areas, and I keep referring to product areas because I think of the aeronautical business as a product. It is generally referred to as a service but I think you can justify calling it a product. It competes for discretionary income just as other products compete for discretionary income.

If certain customer needs are being filled infinitely better by the competition, it's best to look around for some other needs which our product can fill or to consider making some changes in the product.

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One caveat on research - as a former airline research director, I can take certain liberties in knocking research - the best research is often that which confirms intuitive convictions. People close to their industry generally have some idea of what customers think. Beware of startling research results. All you might really have is a piece of poorly executed or badly interpreted research.

I would put limited stock in Freudian-type research where an airline would go out and administer a series of Rohrscharch tests to customers and, based on that, determine what really makes people fly. When the 747 first came out there was a tendency in this direction. People said they were afraid of the 747. Some Freudian-type researchers came up with the idea that people thought of the airplane as womb. That people were afraid of the 747 because it was unlike the intimacy of the 707 womb is a lot of bull. They were afraid it couldn't stay up in the air and said so. If you ask people directly and with some depth probes, most people will tell you what they are thinking. Don't let anyone ever let you believe that there isn't a fear of flying which some surprisingly frequent travellers will tell you. We have had large numbers of travellers who make up to 15 international and 40-50 domestic trips per year who will tell you that they still have a fairly fearful approach to flying. Many people feel that if man were meant to fly the Lord would have given them wings and they are a little uneasy about it.

So, in establishing marketing objectives, once we know the customer needs, our own product strengths and weaknesses and competitive potential, we begin the formal marketing planning process.

First we establish marketing objectives - these are the basis on which we build our action plan. Some examples would be: in the case of Pan Am or TWA, to increase the share of the New York to London Market by 15%. This is a competitive strategy. It is trying to get a bigger chunk of the market at the expense of the competition. Another kind of objective is one that stimulates primary demand. For example, to get 10% more wives to travel with husbands on NYC-LAX Transcon. The sort of thing United has been promoting. This is trying to get people who are hardly in the market into the market. So we have two kinds of marketing objectives.

Objectives need to be realistic. One of the problems that airline industry and all industries face is this whole question of making the objective realistic. If we were to say that Pan Am should get a 35% increase in the share of the NY/London market, that would not be realistic. If an objective is unmeetable we should not come up with it.

They also need to be reasonably specific. An objective that is too vague, for example wanting to increase our share by 10%, that's too vague to have much meaning.

It is expedient that marketing objectives are consistent with corporate objectives. That may sound silly but frequently a semantic problem exists and all top management are not committed to the same objectives.

In the airline industry, as with other industries where regulation plays an important role, it is important that regulatory policy is clear or serious conflicts will develop which ultimately impact the company's ability to meet the customer's needs.

What's a strategy? It's a plan for meeting the marketing objective. There are four basic types of strategy. Let's take an example of getting more wives to fly Transcon and follow that through the strategy building process. First we use research to determine what needs are present and what kind of product will best fill those needs. Realistically, the airline seat is not the product. Trying to sell the trip to California on the basis of the great airplane ride is like trying to sell a new car on the basis of its great tires.

Price is, of course, a factor and we need to understand it.

Distribution means getting the product into the hands of the user.

Promotion covers all those things we do to tell people about the product.

The basic idea behind developing a product strategy is to figure out how to make your product stand out from the competition. This in trade jargon, is called product differentiation.

There are two components to product differentiation:

> The first is the ease or complexity with which we can develop unique product features.
>
> The second is the importance the customer places on that feature in his decision-making process.

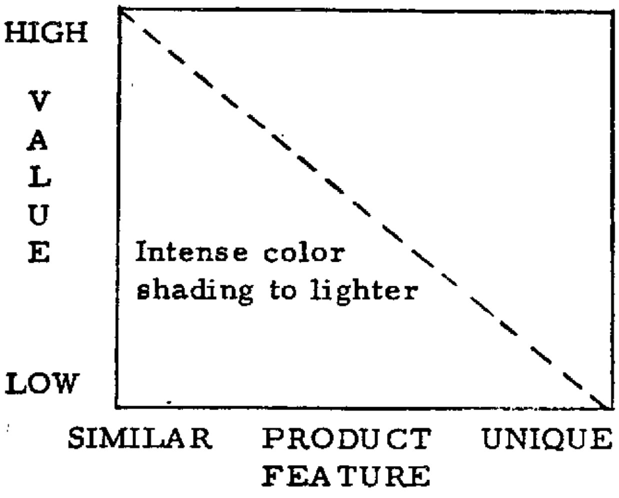
The chart shows the consumer value on vertical axis and ease of developing unique product features on the horizontal. Note the color shading -- assume this represents all the product features available to consumers.

It's realtively easy to come up with the low-value unique features like the kinds of costumes the stewardesses wear.

It's also easy to come up with the high-value items like a 747 -- but if one or two competitors also offer 747's, you hardly have a unique feature.

What to strive for is that nugget of a product feature that has a high-value in the consumer's mind and is also clearly unique to our product.

DIFFERENTIATING THE PRODUCT



As a general rule the life cycle for new ideas is fairly short. Particularly in the case of many of the things we will come up with which are not patentable so the competition will emulate it very quickly. The idea is to try to come up with unique features that the competition will not be able to emulate.

For example, at Pan Am we stress the experience concept. We know that it has one of the highest values in the consumer's decision-making process. We also know that Pan Am enjoys a unique position in this respect since no competitor can offer a product based on as much international experience as Pan Am. This is one example of the sort of things that are hard for anybody else to take away from you. If the consumer begins to feel everyone is experienced and no one stands out we have lost the edge that we had. This is one of the reasons in the last couple of years for the basis of the world's most experienced airline theme.

If we return to the example of getting wives to travel Transcom, maybe not in-flight at all but at destination can be used as part of a unique ground package featuring items of high value to wives like a free visit to Elizabeth Arden's in LA. Something they won't get from anyone else. It is enough to make the difference in their decision making process. What I am leading up to here is, maybe the decision-making process is not based exclusively on the in-flight or airline experience. It is basic to the total travel experience.

It is tied into this idea of the person's going to a destination. He thinks about destination and is concerned in that respect more than being concerned about what is going to happen in-flight.

Looking into your agenda, you have already had a lot on the subject of pricing so what I would like to do is position it as a marketing concept rather than going into details.

Under marketing concept, price is a function of what the user will pay and whether the producer can recover his costs, including a reasonable return on investment.

At the same time the consumer-oriented seller will be sufficiently sensitive to market elasticity to determine what impact a change in price will have on customer demand and this goes back to the idea of the whole travel experience.

In the travel industry price in the consumer's mind is different from price in an airline's mind.

The consumer is concerned about what the total trip will cost - only to the extent that changes in air fares affect the total cost is the customer going to be influenced. From the time he leaves his door until he gets back - parking, meals, etc., pricing strategy has to take the whole picture into account.

If the consumer perceives that there is a major cut such as the winter 8-day GIT'S we had this past year in the Atlantic which result in much lower total cost to him then price can impact his decision-making process.

QUESTION: Why do you think the airline consumer is smarter than the automobile consumer who historically doesn't perceive the cost of operating an automobile?

ANSWER: He isn't.

QUESTION: Why do you always talk about total costs in the airline markets but not in the automobile?

ANSWER: I am not really talking about total costs in that respect. I am talking in terms of a guy envisioning he is going to get something, he is going to get a travel experience just like he is buying a new car. He is willing to invest $X in that new car. He is also willing to invest $X in that travel experience. The costs of operating that car are not perceived because it is at smaller amounts over a long period of time. If a guy is going to take an international trip and has to lay out, let's say, $1500 that becomes very real to him. If it is $1500 or $2000 he can discern the difference between them. Again I am talking about differences in total expense - not 40 or 50 dollars, but 20% or more change in the product he is buying. One of the things we should light on here is to determine the level of visibility. This is part of the pricing strategy. Where does a company want to be in terms of pricing visibility. Do we want to be one of the pricing leaders, taking the role of giving some impetus to the industry in the way pricing should go. Do we want to be part of the pack or do we want to drag our heels. This is very important in terms of the role a company is willing to play within its industry and really needs a basic strategy to position that effectively.

When we talk about distribution startegy or how we move the product from the producer to the user, we first need an understanding of the various steps that are involved in the process. While airlines perform a service, for all intents and purposes, we can think of the airline ticket as a salable product moving through a distribution channel just as color TV sets, refrigerators, or fashion clothing would move through a distribution network.

In the airline industry the channels of distribution are fairly complex. We can sell an airplane ticket direct in our own sales offices. Have it sold by another airline in one of their ticket offices, have it incorporated as part of a wholesaler's package tour, sell it through a travel agent or via commercial account.

As we can see from the following chart, frequently two or three steps are involved in the distribution of the product. In the case of a commercial account sale it might be either direct to the airline or through a travel agent or it might even be to a travel agent who then goes to another airline, who actually writes the ticket selling our product.

One problem fairly unique to the airline business is the vast number of outlets through which a relatively high priced product is sold. For example, in Pan Am's case, worldwide there are roughly 17,000 travel agencies and 12,000 ticket offices belonging to other carriers, all of which can write a ticket on Pan Am.

These numbers make this distribution system fairly unique to the airline industry. I was trying to think the other night of what other large big ticket items like automobiles, color TVs, etc., the traditional sorts of things have distribution systems where as many different outlets are involved in selling a product and it is very hard to come up with anything. In most cases the big ticket producers have franchised operation where only their product is sold. In the case of GM cars - only GM cars will be sold through a dealership. In the case of major appliances a dealer may carry 2 or 3 other competing brands but there really aren't any situations where, as there are in the airline industry, the retailer carries a multitude of competing brands. For instance, in International air travel, the travel agent will carry over twenty different transatlantic carriers' tickets available. In other words, he can write a consumer's ticket on any of those 23 some odd carriers. He also has the ability to write on any of the domestic carriers. So he is handling a multitude of different products.

I think Pan Am is fairly representative. We may be on the low side. Someone like United who has more domestic offices than we do might very well have more outlets for the sale of their product.

In the United States alone, there are probably an excess of 15,000 travel agent and airline ticket offices where you can buy an airline ticket.

As a result, it's extremely difficult to control the sale of the product the way producers of other big ticket items like TV's, home appliances, or automobiles are able to operate through, in many cases, franchised dealerships who feature either no competing products or only one or two competing products.

In the airline's case, almost every travel agent can sell not only all the competing domestic carriers' tickets, but also all the competing international carriers' tickets. This makes it extremely rough to develop any form of exclusivity with the middlemen who sell your product to the ultimate user.

Back to the example of the wives to L.A. Assume we develop a tour package with unique features -- How do we get the work to possibly 60,000 sales people in 15,000 retail points, especially when our product is one of maybe 250 others we offer and maybe 2,000 offered all together by us and our competitors?

Our distribution strategy must be able to cope with the kind of situation which results when Mrs. Smith goes into her friendly travel agent and asks about our special wives package.

This takes us to the fourth strategy which is promotion. Because of the limits in the air travel distribution system, promotion becomes a key ingredient in the attempt to make potential customers aware of your product and its features.

Essentially, there are four kinds of promotions:

> Advertising, which includes radio, TV, newspapers, magazines and trade publications.
>
> Sales promotion, which includes everything from direct mail to letters to folder racks, to motion pictures of travel destinations, to window displays.
>
> Sales development is a form of missionary sales activity in which we use our headquarters and local sales people to work with key travel agents, travel agency associations, commercial accounts and the like to keep them aware of our product's capabilities.
>
> Finally, word of mouth is an important form of promotion. A satisfied customer is one of the best forms of advertising or promotion an airline could have. From research we found that first-time travelers frequently depend on recommendations from friends, relatives, doctors, or dentists in making a decision on where to go, where to stay, and what airline to use.

Let me spend a few minutes on what promotion can or cannot do. Promotion vehicles, like advertising, sales promotion, etc., can be used for either a push or pull effect. What does this mean? Pull type advertising and promotion means developing awareness, interest or preference for our product in the mind of the consumer so that he in fact goes into a retailer and asks for our product. In effect, we are using promotion to pull our product through the distribution channel.

Push promotion, on the other hand, is the kind of promotion aimed at getting the middleman to promote the virtues of our product to the end user.

Trade advertising, direct mail to middlemen, and the missionary sales development activity are three of key ways in which we build enthusiasm for the product among middlemen. A fourth method which is frequently used in other industries and is known as push money, or special incentives to sell a certain product, is illegal insofar as air transportation is concerned. Many tour wholesalers selling package tours do, however, give retailers a special override commission on the land package for selling large quantitites of their tours.

One word on advertising -- advertising has been one of the most maligned of the promotional vehicles available for use. No question that advertising has in the past occasionally been used to mislead the consumer. However, when one reviews the various theories on consumer buying behavior, he finds that a key to the consumer's ability to make a buying decision is the information which he can obtain on the product and its features.
Advertising is, in the final analysis, one of the least expensive ways of providing product information to the consumer.

The idea that advertising can, through subliminal means, force the consumer into buying products he doesn't want or need is pure garbage. The most advertising can do is make a customer more aware of the ability of a given product or service to fill the customer's needs. Now, in all fairness, let's admit that these needs may be somewhat latent and advertising a product feature may help to bring them to the surface. But advertising per se cannot create the basic need.

Maybe this wife who is going out to the West Coast really wasn't chafing at the bit until she saw the ad that said now you can go and experience this glorious time with Elizabeth Arden and your husband will now accept you, and you can do it at a low cost. That's basically appealing to her latent desire to get out someplace - to make herself look different so her husband will think of her as newly married. It is not building a need within her, it's simply bringing that need a little more to the surface.

Once we have developed our four strategies -- product, price, distribution, and promotion -- we're ready to bring them together into the overall marketing mix.

By marketing mix, I mean the way we combine the various marketing tools to move the product or service. For example, in some cases, we might use more advertising and less missionary or developmental sales effort.

We might depend more on low price to sell the product or we might concentrate on unique product features.

Frequently, if the porduct doesn't move very well, we make adjustments in the mix like a little more advertising or other forms of promotion.

Since departure time, in the airline industry, is a product feature, we might decide to make minor changes in this area. However, whenever, major changes in the mix appear to be needed, it is appropriate to pause and review the marketing objectives and strategies to determine whether a more fundamental rethink is necessary.

Measuring the Results:

This is the area most frequently overlooked. It is important as part of the planning process to establish measurement criteria. How are we going to measure success? What level of success means we have a hit? How bad do we let things get before we declare a miss?

After the fact decisions on what constitutes success are also dangerous since they frequently result in lowering our standards for success or failure. Once we are three months down the road and we see some of the problems that exist we are not quite so apt to say we need $X million before declaring this a success. This is unfortunate because the thinking that went into the process originally is the thing that should be used to measure that.

Without-pre-established measuremnt criteria it's also hard to determine whether minor modifications in the marketing mix can have the proper effect.

That sums it up. I congratulate you on wading through this exercise with me. As I recall, one of the fundamentals of learning theory says if an indvidual can remember 10% of what he hears, he is doing quite well.

The 10% of our visit together here today that I hope you remember is:

marketing begins with the customer:

consistent sucess depends on finding a product or service that fills his needs:

start with research and analysis to determine what the consumer wants, how the product is positioned in the market place and how we have to modify our product, if necessary to meet those consumer wants:

establish realistic marketing objectives, things we are striving for in that process:

develop strategies on: products, price, distrbution and promotion:

Based on these strategies create a mix of marketing elements, activate the marketing process, hopefully to achieve success but also to establish, ahead of the game, the measurement criteria that we are going to use in measuring the success. It seems to me that the airline industry has a long way to go compared to other big ticket item products which implemented the marketing concept in a big way a number of years ago. That sounds a little pessimistic. On the optimistic side in the last few years I have seen what I consider to be quite an increase of marketing interest in the airline industry. I predict that we will see in the next decade a real growth in the marketing concept in the airline industry as it becomes more consumer oriented. In my next talk later on this morning with Dan Colussy, I will explore that in more depth.

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FUTURE DIRECTION IN AIRLINE MARKETING

by Dan A. Colussy
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July 18, 1972

Abstract

The rapid growth and broadening of the air travel market, coupled with a more sophisticated consumer, will dramatically change airline marketing over the next decade. Mr. Colussy discusses the direction this change is likely to take and its implications for companies within the industry. New conceptualization approaches will be required if the full potential of this expanding market is to be fully realized. Marketing strategies need to be developed that will enable various elements of the travel industry to compete not only against each other but also with other products that are competing for the consumer's discretionary income.

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Airline marketing will change dramatically over the next decade. There will be the potential for a rapid growth and broadening of the air travel market, but new conceptual marketing approaches will be required to fully develop this new business potential.

Airline marketing management will face the challenge of re-evaluating and restructuring its activities to be consistent with an environment quite different from the 1950's and 1960's. Even the definition of the airlines' role in the travel industry and the product they provide will be subject to significant change.

Let's take a look at some of these changes in the marketing environment which the airlines will face in the next 10 years. There are five key elements of the marketing environment: 1) Total market growth, 2) Consumer expectations, 3) Competition, 4) Regulation, and 5) Technology.

Within the past 10 years we have seen leisure travel grow from about 1/3 of total airline traffic to approximately 50%. Over the next 10 years pleasure or vacation travel could well reach 2/3 of total airline volume. In fact, at Pan Am leisure travel already represents about 2/3 of our total passenger traffic. This does not reflect an anticipated reduction in business travel, which should continue to grow moderately, but rather a more rapid growth in leisure travel. This is the area of greatest potential for the airlines during the coming years.

The growth of pleasure travel will reflect an accelerated change in several key socio-economic factors. These factors should, in fact, contribute to a greater growth in leisure travel than has been experienced during the past 10 years. These factors include:

1. GREATER DISCRETIONARY INCOME THROUGHOUT ALL STRATA OF THE POPULATION. While perhaps difficult to be optimistic about our general economy based on our experience during the past two years, most economists are in general agreement that the next decade will present unique opportunities for a broader distribution of our country's wealth and greater per capita discretionary income at all levels.

2. WE WILL FIND OVER THE NEXT 10 YEARS THAT PEOPLE WILL HAVE CONSIDERABLY MORE FREE TIME. This will result primarily from the trend toward longer vacations. In a recent behavior science corporation study conducted for Pan Am, 37% of the respondents who earned over $15,000 a year, had 4 or more weeks of vacation. Of the total sample, almost 60% stated that they split their vacations. The combination of longer vacations and a splitting of the vacations creates new potential for multiple air travel each year.

I might note that we recognize there is some traffic potential created by the movement to shorter work weeks, as a result of 4 day weeks and 3 day weekends with the new holiday schedule. However, the market growth resulting from this movement may be smaller and slower than many in the industry now anticipate at least in the international travel markets.

3. THERE IS AN OBVIOUS CHANGE IN LIFE STYLE, REFLECTING A TREND TOWARD GREATER EMPHASIS ON PERSONAL ENRICHMENT. In the past, travel has had some difficult in competing with tangible durable goods because it was not an item with a "useful life" that could be utilized over a period of time. However, it now appears that travel is being perceived more as a personal investment and this will lead to further growth in travel. The extended 3 to 4 week trip is becoming more important in the international market. A recent Stanford Research Institute study reveals that self-expression and individualism are becoming more important value trends while status achievement and conformity are receiving less emphasis. In the 30's and 40's a trip to Europe was made for status. Today's younger generation make the trip for personal enrichment. This reduced emphasis on "materialism" is also shown in the Behavior Science Study. When asked how they would spend a windfall gift of $1,000, foreign travel was rated number 2 just behind home improvements but ahead of domestic travel or a new automobile. New automobile placing behind travel is a significant change in the typical American's attitude.

To summarize, leisure travel has become an integral element of the life style of a greater number of people than ever before. Over the next 10 years it will become a key element of the life style of millions of new people not previously in the market if, of course, the travel industry does a proper marketing job.

The business and marketing significance of this can be best illustrated by reviewing what we believe to be the 3 key consumer market segments:

1. The Experienced Traveler - The "heavy user" of leisure travel, through multiple annual trips, will grow substantially in absolute numbers and relative importance. Primarily composed of people who have grown up in the '60's and '70's accepting air travel as a commonplace event, this segment of consumers has no reservations about flying and indeed look upon travel as a rewarding and desirable experience.

2. The First Time Traveler - Airlines, in our preoccupation with battles for share of market, have perhaps lost our perspective on the fact that only a small proportion of our population flies in a given year. There is ample evidence, however, that each year millions of people discover for the first time that air travel is easier and more affordable than they thought possible. Less than 10% of the U.S. population has ever left the North American continent. And once they try it, they like it. They're hooked. Participation in just one charter or a group of local friends is all it takes to introduce these people to air travel. This market segment, (the great middle America) because of its absolute size, represents truly substantial business potential.

The motivations which bring these people into the travel market are diverse. They include special interest activities such as sport related, religious, and study groups. Additionally, strong cultural ties and increased pride of identity among the various ethnic groups in our country represent a key motivation for international travel. There is a real tendency for second generation Americans to go back to their homeland for a visit.

3. The Youth Market - This is a market segment which has perhaps been overworked and over-emphasized in other industries. But in the travel industry, the youth market, because it is traveling more frequently and at earlier ages, will continue to represent a key source of traffic.

The second key element shaping the marketing environment over the next decade will be the nature of consumer expectations. In general, the air traveler will be smarter and more knowledgable. This will be partially a reflection of the increased number of consumers with accumulated travel experience which is far beyond that which characterizes today's consumer. People coming back and talking about their trips improves the whole security thing. This accumulated travel experience will cause and permit the consumer to be more discriminating in terms of his travel decisions relating to choice of destination and selection of airline. The current wave of consumerism, sharpened by the consumer's own travel experience, will lead to a new emphasis on travel value. This value consciousness will be the key factor influencing the consumer's travel decisions.

The consumer will be offered more diverse travel options, and he will be more skillful and discriminatory in his selection of travel products. As a result, he will not be motivated by the types of promotional techniques currently employed by many airlines.

The third key element of the marketing environment will be the competitive situation which individual airlines will face. This competition will exist at 4 levels. First, there will be competition between the various scheduled airlines. Secondly, there will be competition between the scheduled airlines and the supplemental airlines. Thirdly, there will be competition between the airlines and other modes of transportation. Fourth and probably most important, there will be competition between travel and other applications of the consumer's discretionary income.

Competition between the scheduled carriers will no doubt continue undiminished as each tries to capture its fair share of the market. Depending on each airline's route structure, the competition will be for both the business and leisure travel markets. The focus of competitive efforts directed to the business market will be on special services and schedules. Competition for the leisure market will focus on destinations and service features.

The competition that now exists between scheduled airlines and the supplemental will be considerably blurred as more scheduled carriers offer a product comparable to the supplementals. Through their own charter activities, the scheduled carriers will eliminate the price advantage previously maintained by the supplementals. Market share in the charter business will then become a function of effectiveness in product structuring and promotion. At PAA, we feel there has been no major mass marketing effort directed at general leisure market to develop charter traffic. This is changing today.

Competition between the airlines and other modes of transportation will be primarily limited to the automobile. Steam ships have adopted a marketing strategy of positioning themselves less as a mode of transportation, and more as a destination. As a result, combination fly/cruise programs should be expected to expand, making the two industries complementary rather than competitive.

The automobile will be a more important factor in the domestic market place, where it competes both as a substitute and as an alternative to air travel. However, it also represents competition to international travel, since a consumer must choose between a traditional family vacation by auto and a vacation by air to a more exotic or unfamiliar location. The consumer may prefer to have a summer home in N. H. than spend $4,000 to $6,000 on an international trip.

Competition between travel and other applications of the of the consumer's discretionary income will become even more intense. New products for the home, such as entertainment and household appliances now on the drawing board, will be expensive and capture a substantial portion of the consumer's discretionary dollars. Perhaps even more importantly, the trend toward purchase of second homes, campers, boats, and other high cost leisure products can be expected to cause significant competition for the consumer's discretionary income. This competition will exist both in terms of the initial financial investment and in the subsequent income and leisure time spent in utilizing the purchase.

The fourth element of the marketing environment involves the area of industry regulation. Trends toward both U.S. and foreign governments action to stimulate air traffic, particularly through bulk travel concepts, are accelerating. In particular, we can expect relaxation of the limitations on the number of off line charters permitted entry overseas, particularly at Pacific destinations. Second, we can anticipate relaxation of qualification requirements for affinity and ITC charters. Additionally, we can expect continued downward pressure on air fares, both for scheduled and supplemental services. Pan Am advocates part charters.

The fifth element of the future marketing environment relates to technological changes within the industry. Supersonic aircraft, beyond the Concord, with more favorable economics and true intercontinental range capabilities may be expected in the early 1980's. However, in the upcoming decade they will impact principally in the high priority business travel market, where time is the critical factor. Their impact on leisure markets will be limited to high income consumers willing to pay a premium for travel to more distant locations in shorter time periods.

As far as large subsonic transport aircraft are concerned, in the next decade we will see only evolutionary growth in existing models of aircraft with no major technological breakthroughs. The DC 10 and L-1011 will probably be stretched in both size and range capability. The maximum capacity for an intercontinental aircraft will probably be limited to approximately 600 seats for an all economy 747. Improved comfort features for narrow-body equipment will assure maintenance of their value for use in less dense markets or those with high frequency requirements.

Other advances may be expected to improve reliability, utilization and all-weather capabilities. All these factors which should contribute to better cost efficiency of existing aircraft and will hopefully permit airlines to begin to realize an adequate return on the massive investments we have made in these aircraft.

At present, our passenger handling systems on the ground are very labor intensive. Without advancement of these systems, the expected traffic growth would result in poorer standards of service and/or spiraling costs. Automated check-in and seat selection should be a reality within the next 10 years. An alternative to the present high cost reservations system, for at least some routes, should be a possibility.

In general, technological change within the airline industry will not be dramatic. Advancements should enable us to keep pace with traffic growth but not contribute to it, as did the introduction of the jets. Additionally, we might expect cost efficiencies to keep requirements for fare increases at rates lower than for most other goods and services.

Outside the airline industry there will be requirements for other elements of the travel industry to introduce technological advancements. Hotel handling of passengers at check-in and check-out, tour operations, and surface transport to and from airports must all be upgraded to accommodate efficiently the growth in traffic. At this time there is limited coordination among the airlines and these other elements of the travel industry in terms of advance planning. I expect the airlines will take a more active role in assuring that all elements of the travel industry are better integrated and prepared for handling passenger growth. This is a real change in direction for airline intent and interest.

Having identified these 5 elements of the marketing environment -- specifically, total market growth, consumer expectations, competition, regulation, and technological changes--what are the implications for the airline's marketing management.

I believe these implications can be summarized in 3 key areas.

First, the airline industry faces a period offering greater business growth potential than we have ever known before. This will result from continued growth in business travel and a boom in leisure travel stimulated by greater discretionary income, more free time and multiple vacations, plus a change in life style emphasizing personal enrichment. The primary consumer segments accounting for the leisure travel growth will be the experienced, frequent flyer, the first time travelers, and the youth market. The major obstacle to exploiting this growth potential will be the alternative uses for the consumer's discretionary income.

Secondly, the transportation element of travel will become less important in the consumer's travel decision. Instead, more consumers will be interested in buying a total travel experience. Essentially, he will expect to purchase a package of services that will facilitate his movements virtually from his door to his destination and back home. The leisure traveler will expect much more help in planning his trips and assistance during his trip. The business traveler will expect a similar total travel service, with of course, a different package of features more suited to the nature of his travel.

The airlines are the logical element of the travel industry to assume the responsibility of providing the consumer with a satisfactory total travel service. More than any other element of the industry, the airlines are perceived as already having this responsibility as far as the consumer is concerned. It is the airlines that give the greatest promotional support to the stimulation of travel and it is the airlines who are best able, in terms of resources and potential gain, to assume this responsibility.

Concurrent with this consumer emphasis on a total travel experience, the airlines must become more involved with quality control for the total trip and pricing of the total trip. Pricing, in particular, will be a key element of competition both in pricing of the air transportation as well as the land portion of the trip.

Finally, the growth in the travel market will support and require even greater market segmentation through product diversity. The travel industry will be similar to the automobile industry, where total market growth has permitted virtually unlimited model and option offerings. Because travel and the objectives for travel are so strongly related to differing personal interests, experience levels, and personality characteristics, the trend to market segmentation in our industry through product diversity can be expected to accelerate rapidly. This is giving the customer more options, even in a mass travel market situation. This product diversity will be required to develop frequency of travel. It will be made possible by a total market so large that there will be adequate volume to support very specialized travel products. The growth in international air travel is very high. The product line will range from charters sold only as basic, economy transportation to special ground and inflight service packages for first class travelers and from large, standardized group tours to individualized special interest travel itineraries.

Before defining what I believe to be the future direction of airline marketing strategies, I would like to review quickly the key elements of the changing marketing environment and their implications for airline marketing management.

Within the marketing environment the airlines face changes in total market growth, consumer expectations, the nature and degree of competition, regulation, and technological advancement. These changes will result in significant new business potential; a consumer emphasis on the total travel experience, with a resulting priority on quality control and pricing of the total trip; and increased market segmentation through product diversity. To meet these challenges, I believe the industry will move toward new marketing strategies in 6 key areas.

First, the airline industry can be expected to expand its diversification activities both vertically and horizontally. Many airlines, including Pan Am, have hotel subsidiaries. Others, including Pan Am, market their own brand name tours, for which they control pricing and quality. Some airlines, including TWA and Pan Am, have recently announced new emphasis on charter travel. And Pan Am has just announced its entry into an auto rental program in Europe. Pan Am's network of 650 locations in Europe is as large as Avis or Hertz in Europe. Recognizing the potential and the obligation for assuming the responsibility for the consumer's total travel experience, the airlines will move much faster into all key elements of the travel industry.

The second element of the new marketing strategies to be employed by the airline industry involves consumer priorities. During the past decade we have seen the airlines shift their priorities between frequent business travelers and new or inexperienced pleasure travelers. Within the next 10 years, a further change will lead to new consumer target priorities. The three primary targets will be the frequent business traveler who is primarily traveling first class; the "frequent" leisure traveler, who will make two or more trips per year; and the first time traveler. Each of these groups offer significant leverage for increased business and all product and promotional strategies will be heavily directed toward these consumers.

Thirdly, the airlines' definition of their product will change to be consistent with their new role as the supplier of a total travel experience. The present emphasis on inflight amenities, such as coach lounges, decor, meals, and movies will be pushed into the background and the airlines will be more concerned with structuring and providing a pleasant trip.

There will be significant increases in the variety and number of tour packages available to the consumer. This is not to imply that the market will be characterized by increased escorted group travel. Quite the contrary is true. While people may travel in groups for the air transportation, their land packages will differ considerably from one traveler to the next.

The airlines will have incentive to become even more involved in the development of the tourist infra-structure at the destinations along their route system. This will include such activities as sightseeing, hotels, car rentals, transfer services, and support industries.

This involvement by the airlines will result from the emphasis on quality control and the need for competitive pricing. The demand for new destinations and new travel experiences by the experienced traveler will also stimulate participation by the airlines in developing new vacation markets.

There is going to be a consolidation into a smaller number of total travel conglomerates. The airlines are in a strong position to head these up. Alternatively, someone like American Express could gain aircraft capability.

Finally, the product distinctions between scheduled airline's service and that of the supplements should be significantly diminished if not completely eliminated. A good percentage of the pleasure travel will be based on movements of people in large groups on either plane load or part charters, using both affinity and non-affinity concepts.

The fourth key element of marketing strategy relates to pricing. In general, there will be an effort to simplify air fares in order to facilitate sales activities, consumer understanding and acceptance, and a profitable balance between fares for both business and pleasure markets. Most people in the industry realize that the fare situation is very complex and difficult from a sales standpoint. Developmental fares will be utilized to increase frequency of pleasure travel and to bring new consumers into the market. These pricing incentives, to the extent practical must, however, also be directed at offsetting seasonal and day of week traffic imbalances. This will tend to maintain some degree of complexity in fare structure, but this will be necessary if airlines, hotels, and other elements of the travel mix are to maintain traffic flow at some stable levels. The basic economics of our industry dictate that our resources must be effectively utilized on a year round basis. If this can be accomplished the comsumer will ultimately benefit in that we can be offered the lowest price possible and the widest number of travel options to meet his own unique set of values and needs. Pricing strategy then will play a vital role in developing new business as well as ensuring fair and equitable prices to those consumers already in the travel market. All of this must be accomplished and still permit the airlines to maintain a reasonable rate of return and stable financial condition.

There will continue to be fare differentials, but they will be more like 10-20% rather than the 40-50% differentials we see today. The dumping of seats will not continue, but differences in overall service will be charged different fares.

The fifth key element of future marketing strategies involves the channels of distribution. At present, the airlines have limited control over their channels of distribution. This must change if we are to ensure the quality of the travel products being offered. Consumers are expected to demand better and more informed travel counseling. This requirement for more extensive travel counseling and the airlines desire and incentive to gain greater influence over the sales outlets which sell our products should lead to a more selective appointment procedure of retail travel agents. Retail travel agents will continue to play a vital role in the selling of air transportation essentially for airlines like Pan Am who do not have a large number of their own retail outlets throughout the U.S. In the area of packaged tours, distribution changes are also likely as airlines strive for better quality control and better brand identification in an effort to develop stronger consumer interest and confidence in new tour products. This should result in a consolidation in the number of current packaged tour wholesalers and a closer working relationship between airlines and wholesalers in an effort to provide a more attractive and higher value consumer product.

The sixth and final element of marketing strategy involves the advertising and promotion activities of the airlines. First, there will be an increased priority on promotional efforts directed toward the stimulation of primary demand. This will reflect the objective of increasing the frequency of pleasure travel and the positioning of travel as an alternative to other applications of the consumer's discretionary income. Competitive advertising between airlines will focus more on the greater appeal of one carrier's destinations versus those of its competition. The primary emphasis, however, of airline advertising and promotion will be on the appeal, value, and quality of the total travel experiences which it can offer. This emphasis on the airline's ability to provide a total travel experience will be an important part of its promotional efforts.

Continued focus on inflight amenities concerned principally with the air portion of the total travel experience will have to be de-emphasized if our promotional resources are to be most effectively utilized in developing and capitalizing on the future traffic potential. Heavy promotion on special lounges will not properly compete for the consumer's discretionary dollar given the wide variety of non-travel options he has for these expenditures. It's our belief that airline marketing has matured to a point where more sophisticated techniques will be brought to bear on our total marketing problem.

I have tried to outline the challenges and opportunities that face the airline industry, and in particular its marketing management. I have described what I believe to be the direction that the airlines will pursue in six areas of marketing strategy. To recap these areas, they are: Increased vertical and horizontal diversification in the travel industry, the placement of priority on the "heavy user" of pleasure travel, an emphasis on structuring and providing a total travel experience, the development of new pricing concepts for air transportation and travel packages, a restructuring of the channels of distribution, and a promotional effort that is consistent with the airline's definition of its product and target consumer. During the past 15 years, the airline industry has experienced both feast and famine several times. The lessons learned during this period and the total business potential resulting from the social and economic changes that can be expected provide the basis for being more optimistic about our industry than we have ever been before.