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The U.S. Aviation System to the Year 2000

Raymond A. Ausrotas

Flight Transportation Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

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1. INTRODUCTION

1.1 The Future of the Aviation System

It is nothing if not presumptuous to look ahead twenty years in any phase of human activity. This seems particularly true in civil aviation where the certificated airlines are in the throes of transition from economic regulation to a free market system. Furthermore, while in the past forecasters could count on the number of players in the game remaining constant (subject to elimination by merger), currently new airlines are born every day, at least on paper. The friendly old aviation gang has broken up, with the rules of the game constantly changing. Thus at first glance an attempt now to predict what will happen in the future appears whimsical, if not downright foolish.

However, this inquiry concerns not just the airlines, but aviation. Here that much-misused and maligned word, system, is justified. Airlines depend on many other parts: manufacturers build their aircraft, airports provide space to land them, and the air traffic control system keeps them apart. Then there is general aviation, by some measures the largest part of the system. The flying farmer in Kansas views the big jets which occasionally appear high overhead as simply faster and more expensive Greyhounds; looking at clear and empty skies over his homestead, talk about the aviation system straining at capacity appears ludicrous.

One possible approach to the future is to dissect the system and look at the components. The objection to this tack is the interrelationship of the parts -- if one part moves, then it affects most, if not all, of the other parts. The problem is equivalent to solving a set of simultaneous equations (with possibly time-varying coefficients). For example, if some airports reach saturation, the effects on the system will appear in both the short term and the long term. In the short term, traffic may shift to other (nearby) airports; general aviation aircraft may be banned; larger aircraft may replace smaller aircraft, keeping operations almost constant while providing extra lift; or operations may simply remain at the saturation level. In the long term, more or longer runways may be added to the airports; larger and more sophisticated aircraft may be designed by the manufacturers; technological improvements in the ATC system may provide more airport and airway capacity.

Furthermore, the outside world is interacting with the system and affecting its behavior. A slump in the economy leads to a downturn in travel, as fewer businessmen fly as well as fewer vacationers -- even the deepest discounts cannot attract the public when consumer confidence is down. And in the long run, changes in lifestyles, population make-up, telecommunications, etc., alter travel patterns as well.

Since the aviation system has reacted to internal and external forces over time, a plausible approach to the future is to look back and search for potential cause-effect relationships. Then, if long term trends exist inside and outside the system and links between them are identified, pictures of the future can be drawn. These certainly will not be predictions, but rather possible evolutions of the system. Many alternative futures are possible, depending on the action taken by different persons both inside and outside the aviation system. With some luck the futures that will be presented here will seem credible, even if not highly probable, given the nature of the task. At the least, they are intended to stimulate thought about the likelihood of the outcomes they portray. Consequently, to planners concerned with aviation, they may provide guidelines for possible initiatives in research and technology.*

*The author would like to acknowledge the guidance and assistance of the contract monitors, Messrs Robert Letchworth and Matt Winston of NASA Langley Research Center.

1.2 The Aviation System: Definitions and Measures

The aviation system is sufficiently complex so that no single statistic can provide a comprehensive overview. However, there are measures of activity which indicate how fast the system is changing and some key variables which explain how the system functions. There are also constraints (or potential constraints) on the system (or various subsystems), and linkages between constraints and key variables. These constraints may or may not be quantifiable, such as regulatory changes, aircraft noise limitations, and airport curfews.

It is possible to classify the subsystems of aviation in many ways -- the exact designation is not important if no major components are lost. Most simply, the system can be split into the users of the system and the providers of the service. The users are general aviation and public-for-hire carriers (scheduled and unscheduled, a distinction which is gradually being blurred). The suppliers of the service are airports, airways, the ATC system, and the aerospace industry which builds the vehicles which flow over the system. More detail is provided in Figure 1.1.

Different classifications are possible. One used often (Schriever and Seifert, 1967) splits the system into air vehicle; air traffic control; and airports and terminals. Another widely used breakdown (FAA, 1967) is into air carriers, GA, fuel consumption, aircraft technology, air cargo, aviation safety and complementary and competing modes. Yet another way (CARD, 1971) is to look at the system from a mission point of view (commercial passenger service, air cargo, GA) and a system element point of view (air vehicles, ATC, airports, complementary surface transportation). It is apparent that classifications and their concomitant emphases depend to a large degree on who is looking at the system and for what reason.

Figure 1.1 shows the complete system. Some parts of it will receive little analysis in this study: military components (since the emphasis is on civil aviation) and non-transportation-related GA activity. Table 1.1 shows the key measures of activity which will be used throughout the study.

Figure 1.1

The Aviation System

A. User Subsystems

1. Public Service
   - Passenger
     - Scheduled
       - Trunks, Regionals, etc (jet equipment)
       - Commuters (propeller equipment)
     - Charters
       - Supplemental (large aircraft)
       - Air Taxi (small aircraft)
   - Cargo
2. General Aviation
   - Transportation
     - Corporate
     - Private
   - Recreational
   - Industrial (Agricultural, etc)
3. Military

B. Supply Subsystems

1. Airport
   - Large hubs
   - Other hubs
   - Commuter
   - GA
   - Military/joint use
2. Airways and ATC System
   - Surveillance and Data Acquisition
   - Navigation
   - Communication
   - Landing Aids
3. Aerospace Manufacturers
   - Airframe
   - Engine
   - Avionics
4. Fuel

Table 1.1

Key Measures of Activity
of the Aviation System

A. User Subsystems	Measures
1. Public Service	
1a. Passenger	
Scheduled	
Trunk, etc	Revenue passenger miles, aircraft revenue hours, average stage length
	Airborne speed, available seats/aircraft, number of aircraft
	Yield (¢/RPM), net profit, DOC, IOC
Commuter	RPM, average stage length
Charters	
Supplemental	RPM
Air Taxi	Number of operations
1b. Cargo	
2. General Aviation	
2a. Transportation	
Corporate	Number of operations (IFR/VFR), number of aircraft, hours flown
Private	Number of operations (IFR/VFR), number of aircraft, hours flown
2b. Recreational	Number of operations, number of aircraft
2c. Industrial	Number of operations, number of aircraft
3. Military	Number of operations

Table 1.1

continued

B. Supply Subsystems	Measures
1. Airports	Total number, enplaned passengers, number of operations
1a. Large Hubs	Enplaned passengers, number of operations (scheduled/GA)
1b. Other Hubs	Enplaned passengers, number of operations (scheduled/GA)
1c. Commuter	Number of operations
1d. GA	Number of operations, number of airports
1e. Military/Joint Use	Number of operations
2. Airways and ATC System	Number of IFR operations, (airports, ARTCC), total number of operations, number of towered airports, flight service operations, delay measures
3. Aerospace Manufacturers	
4, Fuel	Fuel consumption (jet and avgas gallons/year)

1.3 1960 Revisited

In 1960 there was an exciting presidential campaign in the United States as Richard Nixon and Jack Kennedy debated on television and radio. Kennedy won the debates (although this was disputed by some listeners) and the election (although some questions were raised about the decisive ballots in Chicago). The value of manned space exploration was being heatedly discussed, even as NASA (the National Aeronautics and Space Administration , which itself had only been established in 1958, replacing NACA, the National Advisory Committee for Aeronautics) tentatively selected 1970 as the year for a manned lunar landing.

In the air transport system, it had been over a year since the first turbo jet had been introduced in domestic service (B707-12C, December 10, 1958), followed quickly by two other turbine-powered aircraft, the turboprop Electra (January 23, 1959) and the DC-8 (September 18, 1959). The transition to the jet age was well under way. By the end of 1960 the domestic airlines had in their inventory 470 turbine-powered aircraft (246 turboprops and 224 turbojets) out of a total of 1980 aircraft. The total investment by the domestic passenger carriers reached $1.66 billion. For the first time DC-3's carried less than half of local service airline traffic.

The airlines had not yet passed the combined bus-railroad intercity common carrier passenger mile total (38.8 billion RPM, 49.3% of the total RPMs). In fact, in domestic travel passenger miles flown in coach were still fewer than in first-class (47.2% compared to 52.8%), but, increasingly, faster trips as well as 25% discounts were making coach ever more attractive. However, the new era was not without its problems. In 1960, there were 0.93 fatalities per 100 million rpm in domestic passenger service, notably the second in-flight Electra crash (which led to severe speed restrictions on the aircraft, but no grounding) and the mid-air collision between a TWA Super Constellation and a UAL DC-8 over Brooklyn, New York. 1960 was the worst year for accidents since 1951.

As a result, questions were raised about the efficiency of the FAA (Federal Aviation Agency), which had been established in 1958, almost coincidentally with the introduction of the jets. The higher speeds of the turbine-powered aircraft required faster reaction times from the ATC system if safety was not to be compromised. Additionally, flight delays, diversions, and weather cancellations were estimated to have cost the airlines $25-50 million for the year.

In the economic regulation area, 1960 saw the conclusion of the four-year-old General Passenger Fare Investigation (GPFI), in which the CAB (Civil Aeronautics Board) decided that a 10.5% return on investment would be proper for the trunks. However, a 5% fare increase granted in June 1960 did not help the industry achieve this profit; rather, for the year profit shrank to $4 million (a 3.4% return), although gross revenues rose to $2 billion. Air cargo reached 920 million ton-miles, up from 350 million in 1950.

While the air transport industry and general aviation were undergoing tremendous growth by practically any operational measure, complaints and apparent problems were abundant. In fact, President Kennedy established a task force ("Project Horizon") to "redefine and affirm" national aviation goals for the 1960's. Alan Boyd, then the new Chairman of the CAB, was well aware of one of the objectives of the Board - to nurture the industry - when he reflected on the findings of the GPFI (which had noted that, while revenue growth proceeded unimpeded, profits trended downward since mid-1955 and that the "transition to jet equipment which the industry is now undergoing has presented financial and other problems of a magnitude never before faced." [ATA 1961])

> "Today's low (airline) earnings focus attention on another of our immediate problems. Mach 3 (supersonic) is staring us in the face ... Carrier earnings are the only hope for a substantial private enterprise contribution to supersonic development -- and the nation must develop one. Carrier earnings in the years immediately ahead are the only hope that a private enterprise air transport system can absorb the next equipment transition."

SST's, the need for improved earnings, and modernization of the ATC System aside, observers of the airline industry noted these additional problems facing air transportation in 1960:

1. Overcapacity and the concomitant need for traffic to fill the seats;
2. Rising cost levels, in particular high wage costs which took up 42% of total expenses, compared to 23% for materials and services, 12% for fuel and oil, and 11% for amortization and depreciation;
3. Nascent noise problems;
4. Rising subsidy needs by local service carriers (from $15 million in 1950 to $37 million).

Given all these difficulties, how did the industry survive?

2. 1980: The State of Affairs

2.1 How Did We Get Here?

By 1980 many things had changed in the air transportation world, but low profits and the need for financing new equipment were still primary problems for the airlines. Twenty years after the introduction of jets (and ten years after widebodies), the airlines were still in turmoil, wringing their collective hands about excess capacity, ATC problems, and excessive cost levels. Even as passengers enplaned have grown by a factor of five and RPMs by seven, only the spectre of the SST has seemingly moved off. (In the meantime GA aircraft have grown by a factor of three as well.) What happened to cause the airlines to seemingly return to ground zero after a wild rollercoaster ride through the previous twenty years?

2.1.1 Population and Income

On the surface, a growing population would suggest increased travel. However, what is really needed is an increase in those portions of the population which: (1) are likely to travel (being old enough, for example); and (2) can afford it (for business or personal reasons). A large population by itself means little as far as air travel is concerned (for example, India, China), nor does a baby boom portend packed airplanes, at least not for a generation. More correctly stated, an increase in the number of families or single individuals with "above average" income could indicate a potential demand for air travel, *ceteris paribus*. This increase can come about because of a general increase in income, an increase in the number of families, or both. Table 2.1 shows the growth in the number and money income of families (and unrelated individuals) from 1960 to 1980.

The cause of the higher income family was two-fold: an increase in the salary of the main wage earner, complemented by a secondary income. The number of working women whose husbands were also employed rose from 12.3 million in 1960 to 23.8 million in 1979.

As the number of families with incomes above $25,000 has risen from 6.1 million in 1960 to 20.2 million in 1979 (and the number of higher-income individuals has risen from 0.8 million to 5.3 million), the number of people who have ever traveled by air has also increased from 36 million to 94 million (Table 2.2).

Table 2.2 shows a decrease in the rate of growth of first-time travelers in the last decade, compared to the 1960's. To maintain the level of travel that is going on in the U.S., the airlines will increasingly depend on the frequent traveler rather than newcomers to the jet set. Twenty percent of the adult population took an air trip in 1980 (29 million), averaging three round trips each. (In 1969 the Port Authority of New York and New Jersey surveys indicated that 5% of all passengers took 40% of all trips, indicating that this group of people was flying every week.)

Not only has the population grown, but it has become better educated (or at least has had more schooling). Table 2.3 shows that the number of annual college graduates (about evenly divided between male and female) has increased from 392,000 in 1960 to 921,000 in 1978. This number, however, has been on a plateau since about 1974, reflecting the decreasing growth of persons in this age group (Table 2.4), since the family size from 1960 to 1980 has undergone a major shift. The average family of 1960 had 3.7 children. In 1965, it was 2.9 children; by 1972, 2.0; and from 1975 to 1978 the total fertility rate stabilized around 1.8. Lifetime birth expectations of wives across all ages, races, education levels and labor force statuses indicate that the two-child family remains highly appealing.

What caused this massive shift to the two-child family? Sociologists have produced (heavy) volumes on this subject. Fingers have been pointed at greater and longer participation in the work force by women, the equal rights movement, better education, higher abortion rates, and more childless (and unmarried) couples. All these (and many more) factors no doubt contributed. But the fact is that the fertility rate has been dropping steadily since 1800 (7.0). The baby boom years from 1940 (2.3) to 1957 (3.8) can be considered as an aberration -- the rate in the last twenty years has simply resumed its two-century-old downward pattern. Where the birth rate will stabilize makes for interesting discussions among demographers.

In addition to births, the population has been swelled by immigration (legal and illegal). As the birth rate has declined, legal immigrants (400,000 annually) have taken a larger proportion of annual growth, currently about 25%. (The Immigration and Naturalization Service (INS) also estimates that there are 800,000 annual illegal aliens entering the United States.)

Thus, from 1960 to 1980, most demographic indicators were pointing to increased air travel: the higher education levels, the return to small-family formations, and the growth in higher income families. In fact, for the first decade of this era, economic growth in the United States was explosive.

TABLE 2.1

Money Income (1979 Dollars)

Year	Total Number of Families (Millions)	Families with Incomes $25,000 and Over (Number in Millions)	(%)	Total Number Unrelated Individuals (Millions)	Individuals With Incomes $15,000 and Over (Number in Millions)	(%)
1960	45.5	6.1	13.4	11.1	0.8	7.2
1965	48.5	9.7	20.1	12.2	1.5	12.2
1970	52.2	15.0	28.7	15.5	2.5	16.2
1975	56.2	17.0	30.4	20.2	3.4	16.9
1979	58.4	20.2	34.7	25.6	5.3	20.5

SOURCE: Statistical Abstract of the United States, 1980.

Table 2.2

Percent of Population that has Traveled by Passenger Airline

	1981	1972	1962
National Results	65%	54%	33%
Sex			
Men	68	58	37
Women	62	51	30
Occupation			
Professional & Business	82	75	57
Clerical and Sales	75	64	45
Manual Workers	58	45	26
Non-Labor Force	55	45	31
Size of Community			
1,000,000 and over	73	65	1/
500,000 - 999,999	74	67	42
50,000 - 499,999	70	58	41
2,500 - 49,999	60	43	32
Under 2,500	52	44	n.a.
Region of Country			
East	66	57	39
Midwest	61	51	29
South	56	45	22
West	81	70	50

1/ 500,000 and over.

Note: Data for 1972 and 1981 based on population 18 years and over, 1962 based on 21 years and over.

ATA Chart

Table 2.3

High School and College Graduates
(thousands)

Year of Graduation	High School Graduates: Number	High School Graduates: % of Persons 18 Years Old	College Graduates: Bachelor's Degrees: Number	College Graduates: Bachelor's Degrees: Per 100 H.S. 4 Yrs Earlier	College Graduates: Master's & Doctor's Degrees	College Graduates: Total Number of Degrees
1960	1,864	72.4	392	28	84	476
1965	2,665	70.8	501	25	162	663
1970	2,896	77.1	792	30	274	1,066
1975	3,140	74.3	923	31	382	1,305
1978	3,147	74.8	921	30	410	1,331

SOURCE: Statistical Abstract of the United States, 1980.

TABLE 2.4

U.S. Population by Age Groups (Millions)

(1960 - 2000)

Year	Total	Under 17	(%)	18-21	(%)	22-64	(%)	65 and over	(%)
1960	180.7	64.5	(35.7)	9.6	(5.3)	89.9	(49.8)	16.7	(9.2)
1970	204.9	69.6	(34)	14.7	(7.2)	100.4	(49)	20.1	(9.8)
1975	213.6	66.3	(31)	16.5	(7.7)	108.4	(50.7)	22.4	(10.5)
1979	220.6	62.5	(28.3)	17.1	(7.8)	116.2	(52.7)	24.7	(11.2)
Series II Projections (replacement level fertility (2.1) + 400,000 net immigration)									
1985	233	62.3	(26.7)	15.4	(6.6)	127.9	(54.9)	27.3	(11.7)
1990	245	64.8	(26.4)	14.5	(5.9)	134.4	(54.9)	29.8	(12.2)
2000	260	69.0	(26.5)	15.0	(5.8)	144.7	(55.7)	31.8	(12.2)

SOURCE: Statistical Abstract of the United States, 1980.

2.2 The Economy and the Aviation System

One of the more established correlations in air transportation is between fluctuations in the economy at large and passenger travel (Figure 2.1). To be sure, GNP does not explain all of the variations. In fact, a case can be made that whatever causation exists is in the other direction, i.e. it is travel (and its subsidiary industries) which causes waves (at least ripples) throughout the economy. The high growth industries, such as aviation, push the GNP above a steady-state level, since by definition, mature industries move at the same pace as the overall GNP. To put matters into perspective, in 1980 aerospace manufacturing and air transportation made up 2% of the US GNP (about 1% each). However, aerospace exports ($15 billion) constitute over 10% of total U.S. manufactured exports.

Generalizing, over the past two centuries the increase in Gross World Product can be attributed to growth of technological knowledge, new forms of transportation, and control over energy (Macrae, 1976). During the last seventy years, aviation has done its share to raise living standards (expectations, certainly) around the world.

Closer to home, correlation also exists between U.S. GNP and general aviation, as exemplified by the number of domestic aircraft shipments (Table 2.5). Where this correlation is not perfect, special circumstances exist. Sales held up remarkably well in 1974-1975 despite doubling of gasoline prices and the concurrent recession; unlike the 1970 slowdown, investment tax credits for companies buying capital equipment were available to mitigate the slump. (Business aircraft manufacturers also patted themselves on the back for having developed more sophisticated and aggressive sales techniques.)

For historical purposes, it is sufficient to note these correlations without becoming involved in more elaborate analyses. Aviation, as all sectors of the economy, was booming in the 1960's until, fueled by the government-printing-press-financed Vietnam war, inflation started running amok in the U.S. This inflation carried over to the 1970's and, compounded by instantaneous and massive increases in oil prices, produced the unknown economic condition of stagflation. The aviation system was able to survive the vicissitudes of these twenty years better than many other industries because it was simultaneously undergoing vast technological changes.

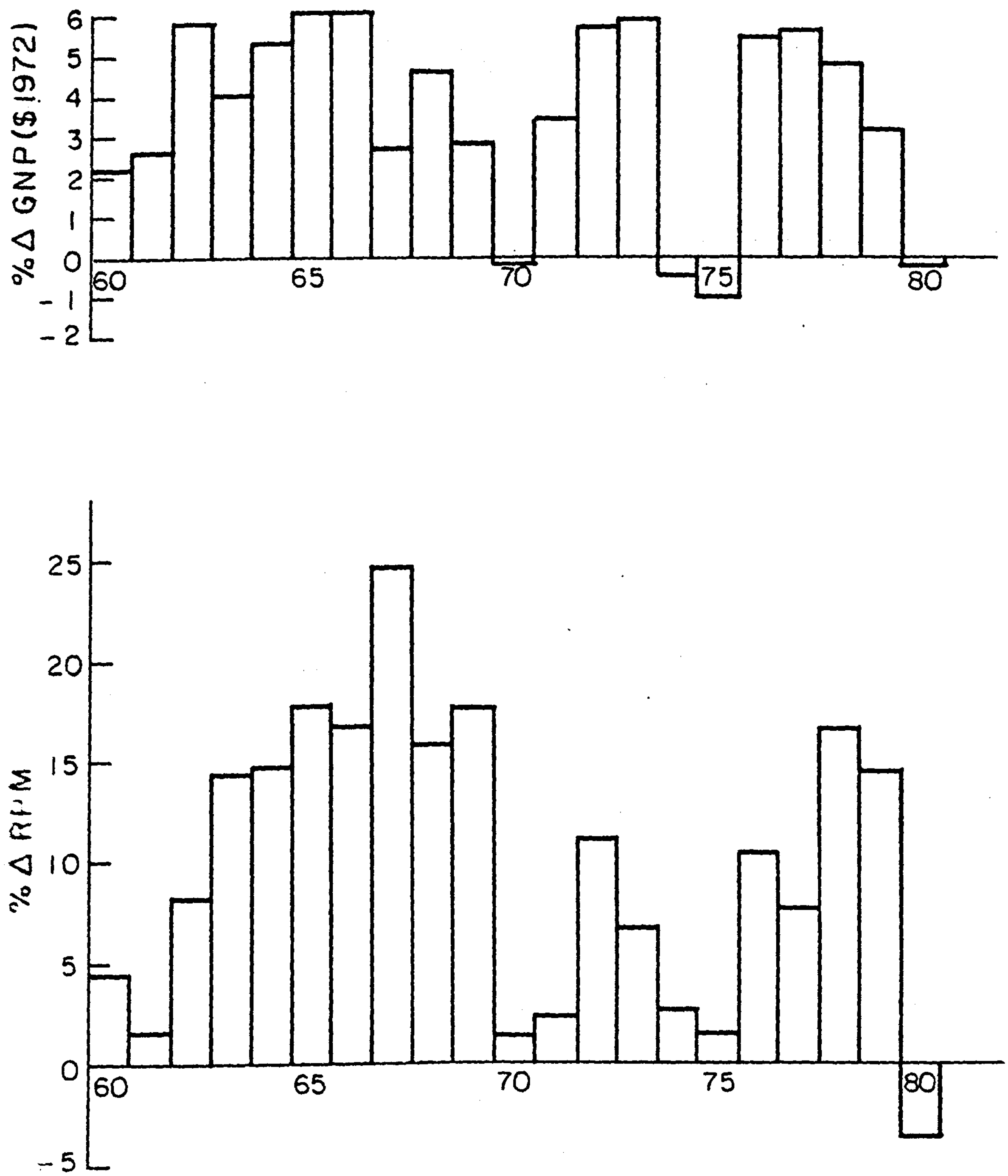


FIGURE 2.1 PERCENTAGE CHANGES IN GNP AND RPM
(SCHEDULED, CERTIFICATED)

Table 2.5

GA Aircraft

Dec 31, (Year)	Number of Active GA Aircraft (000)	($1972%) ΔGNP	Number of Units (000) Shipped (USA only)	cumulative	Billings (10^6)	Price ($1972) (000)
1960	77	2.2	6.3(E)		128(E)	28.0(E)
1	81	2.6	5.7(E)	12.0	105(E)	25.8(E)
2	84	5.8	5.6(E)	17.6	113(E)	28.5(E)
3	85	4.0	6.2(E)	23.8	125(E)	28.5(E)
4	89	5.3	7.8	31.6	154	28.0
65	95	6.0	9.5	41.1	257	36.3
6	105	6.0	14.8	55.9	370	32.5
7	114	2.7	10.5	66.4	283	33.9
8	124	4.6	10.9	77.3	334	37.2
9	131	2.8	10.0	87.3	532	61.4
1970	132	-0.2	5.3	92.6	265	54.6
1	131	3.4	5.6	98.2	217	40.3
2	145	5.7	7.5	105.7	419	55.8
3	154	5.8	10.1	115.8	598	54.9
4	162	-0.6	10.0	125.8	621	54.1
1975	168	-1.1	10.6	136.4	724	54.2
6	178	5.4	12.0	148.4	895	56.5
7	184	5.5	13.3	161.7	1,134	60.9
8	184	4.8	14.2	175.9	1,294	60.8
9	199	3.2	14.5	190.4	1,600	67.5
1980	208	-0.2	10.0	200.4	2,100	96.0

2.3 Internal Aviation System Dynamics

2.3.1 The Airlines

Beginning in 1958 and continuing through the 1970's, the U.S. airlines undertook a complete equipment overhaul. What in 1957 had been a $940 million investment in propeller-driven aircraft had turned by 1980 into $20 billion worth of jets. During this period, aircraft manufacturers produced a wide variety of airplanes, some of which have become economically obsolescent,although still flying in various parts of the world (i.e., Convair 880, 990; Sud Aviation Caravelle; Boeing 720) (Table 2.6). Some airplanes retained their name while spawning multiple offspring that in some cases were almost twice as big as the original designs (Douglas DC-9 series; Boeing 727 and 737 series). The wide-bodies entered service beginning in January,1970, (Boeing 747) followed shortly by the McDonnell Douglas DC-10 (August, 1971) and Lockheed L-1011 (May,1972) and, most recently, the Airbus Industrie A-300 (1977). A U.S. supersonic transport (SST) underwent serious design studies from 1963 (Boeing was selected to build a prototype in 1967) until the program died in the U.S. Congress in 1971 due to a combination of rational and irrational political, ecological, and economic causes.

Regardless of what was happening outside the aviation system, this massive equipment acquisition binge resulted in a four-fold increase in airline productivity (Table 2.7). Productivity was gained by increased speed, and, after the fleet had become all jet, by larger aircraft size. On the negative side, the jets led to more gallons of jet fuel being consumed per revenue-passenger mile, a consequence of little note when fuel was 10¢/gallon, but catastrophic at $1.00/gallon (Figure 2.2). The introduction of the widebodies reversed this trend; in addition, the airlines undertook many fuel conservation measures to improve fuel efficiency.

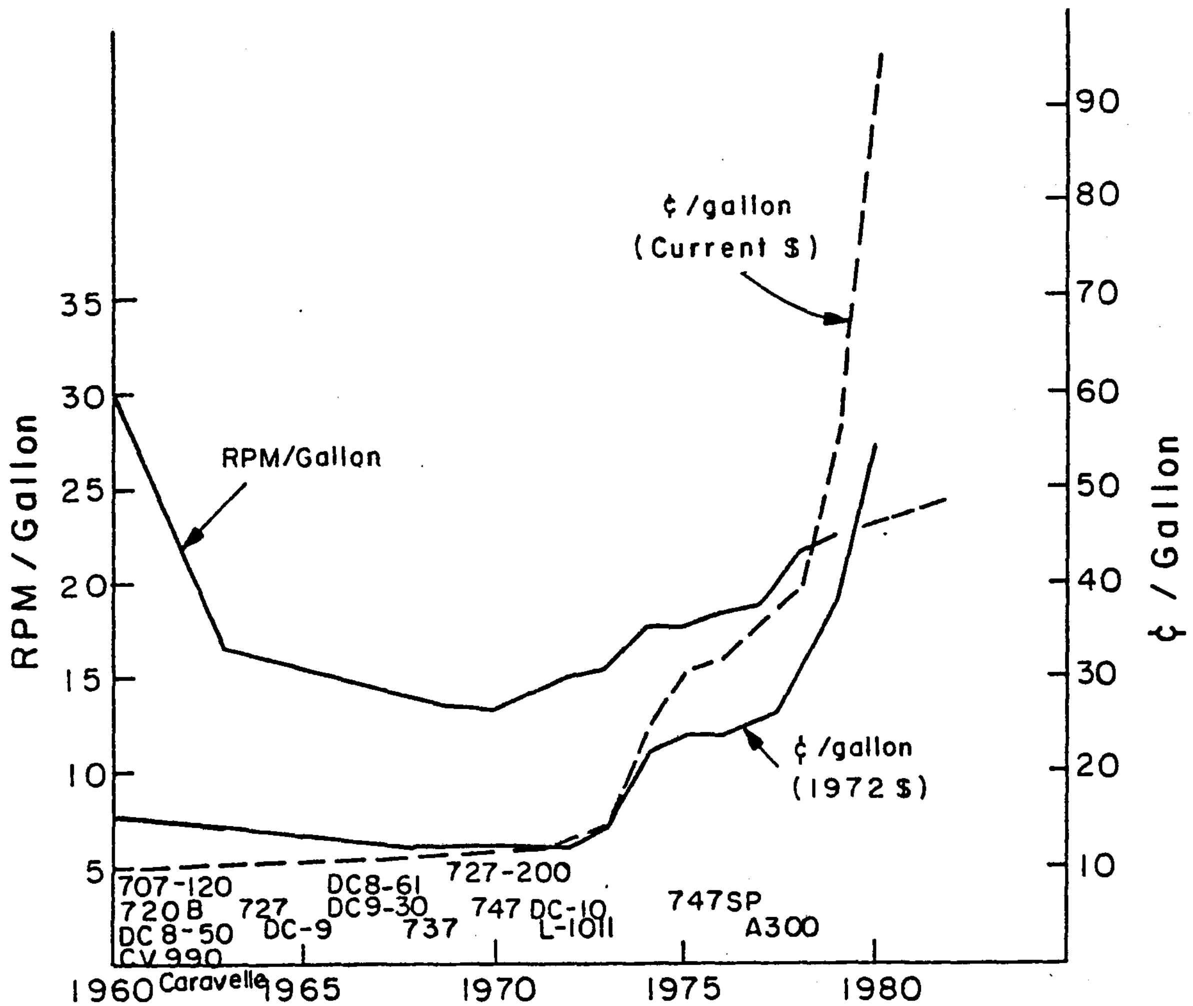
The primary beneficiary of this increased productivity was the airline passenger. The airlines passed the cost savings along to the consumer, as revenues followed costs downwards (in real terms) until the first of the energy price increases hit the airline industry in 1973 (Figure 2.3). This ability to fly more people (because of the speed and size of the new jets) at lower cost led to a phenomenal increase in passengers (from 56 to 273 million enplaned) and revenue passenger miles (30 billion to 210 billion).

The airlines' share of the intercity passenger travel on common carriers expanded from 45% to 86%, but only a small part of this growth was at the expense of the other modes -- it was mostly new traffic. In this period buses slightly expanded their ridership from 20 to 27 billion passenger miles, while railroads lost 11 billion (from 17 to 6 billion). Still, even now airlines have but a small (13%) portion of the total intercity travel market, which is dominated by the automobile. (Auto travel itself doubled between 1960 and 1980 to 1,260 billion passenger miles.)

Figure 2.3 shows that the airlines were largely operating just above break-even levels as revenues followed costs down, even before deregulation made its appearance as a politically attractive issue. Stockholders in airlines were certainly not the big winners as the common stock equity barely increased ($300 million versus $170 million) during this period despite multiplying passengers. Nor was their equity helped, in the early seventies, as the wide-bodies came rapidly on line and excessive capacity forced down load factors. This was followed by increased fuel costs which airlines were hard pressed to pass along due to CAB regulatory lag. The perceived attractiveness of deregulation was (and is) based on lower fares due to increased competition. However, since fares were already at or near cost levels, the only way fare relief could come about was through decreased costs.

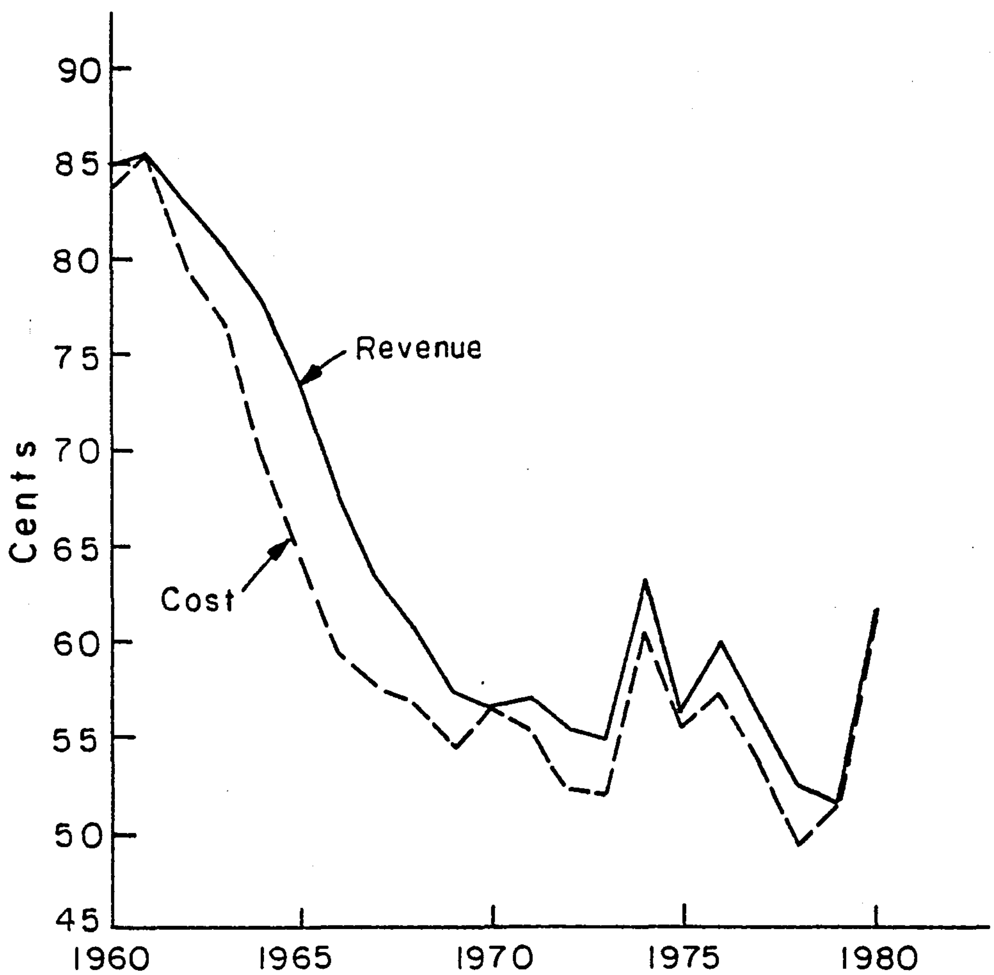
A look at airline operating expenses (Table 2.8) shows that while all costs have increased by 50% from 1968 to 1980 ($ 1972) the major culprit has been fuel which has gone from 14% (1968) to 31% (1980) of the total costs. Airline management has little control over fuel or capital costs; thus labor becomes the focus of any major cost decreases. This is indeed what happened following the Deregulation Act of 1978. Newly organized airlines did not have any advantages in capital or fuel costs, but used their edge in lower-cost labor to provide cheaper tickets.

To compete against these new entrants, the older airlines began to ask their employees to work for less (or at least to become more productive). Whether the major airlines, with their broad route structures and greater financial resources, should or should not match the lowest point-to-point fare offered by an upstart is a key decision for management. Should they choose "not to be undersold" (and gain concessions from their labor forces to make this a realistic threat), the plight of the largely undercapitalized new airlines will become the hot new topic of the security analysts' newsletters.



Source: CAB

FIGURE 2.2 JET FUEL CONSUMPTION AND COST



Source : CAB

FIGURE 2.3 REVENUE AND COST PER TON MILE (DOMESTIC SERVICE) 1972 $ (GNP IMPLICIT PRICE DEFLATOR)

Table 2.6

Commercial Aircraft -- Trends in Characteristics and Productivity

Type of Plane	Date of First Service	Full Payload Range (Miles)	Seats	Speed (mph)	Annual ASM's* (000)
Ford Tri-Motor	8/ 2/26	570	14	100	4,088
Douglas DC-3	6/25/36	500	28	180	14,717
Douglas DC-6	4/27/47	2,750	56	310	50,691
Lockheed Constellation	6/17/47	3,000	64	300	56,064
Douglas DC-7	11/29/53	2,800	99	360	104,069
Lockheed Super Constellation	4/ 1/55	4,620	99	335	96,842
Lockheed Electra	1/12/59	2,770	98	450	128,772
Boeing 707	10/28/58	3,000	181	600	317,112
Douglas DC-8	9/18/59	4,300	176	600	308,352
Boeing 727-200	12/14/67	1,750	189	600	331,128
Douglas DC-8-61	2/24/67	5,300	259	600	453,768
Douglas DC-10	8/ 5/71	2,760	380	600	665,766
Boeing 747	1/22/70	5,800	490	640	915,712
Concorde	1/21/76	3,800	100	1,300	380,000

* Assuming a constant utilization of eight hours per day -- this actually overstates the capacity of older models and understates most of the jets. The formula for annual capacity is: seats x hours per day x speed x 365. The numbers derived do not reflect actual productivity in commercial service because mixed class seating reduces the actual seats and actual cruising speeds are about 10% under the maximum.

SOURCE: Ausrotas (1981)

Table 2.7

U.S. Domestic Airline Statistics*

Year	Departure (000)	RPM (10^6)	Avg Stage Length	Enp (mil)	Yield (¢/RPM)	L.F.	Scheduled aircraft miles (10^6)	Seats /Aircraft	Speed	Productivity (Seats X MPH)	Enp/Dep
1960	3,619	30,556	227	56.4	6.09	58.5	820,756	65.4	235	15,369	15.5
1		31,062	225		6.28	55.4	795,169	72.9	253		
2	3,446	33,623	240	60.7	6.45	52.6	827,694	79.4	274	21,755	17.6
3		38,457	250		6.17	53.2	888,793	83.4	287		
4	3,693	44,141	259	79.1	6.12	54.8	957,575	86.1	297	25,485	21.3
1965		51,888	278		6.06	54.7	1,088,112	89.2	314		
6	4,070	60,590	289	105.8	5.83	57.9	1,178,458	91.2	331	30,096	25.8
7	4,624	75,487	316		5.64	56.5	1,462,240	94.4	354		
8	4,956	87,507	346	145.8	5.61	52.4	1,715,857	100.8	369	37,195	29.3
9	5,058	102,717	395		5.79	49.8	2,000,269	109.8	394		
1970	4,794	104,147	421	153.7	6.00	48.9	2,016,321	110.4	403	44,991	30.9
1	4,680	106,438	425		6.32	48.1	1,992,807	115.3	405		
2	4,726	118,138	420	172.4	6.40	52.1	1,986,759	118.1	404	47,712	36.4
3	4,806	126,317	425		6.63	51.9	2,041,000	119.9	404		
4	4,418	129,732	420	189.7	7.52	55.7	1,856,000	126.0	402	50,652	42.8
1975	4,443	131,656	427		7.68	54.8	1,896,000	127.3	403		
6	4,585	145,271	434	206.3	8.16	55.8	1,988,000	131.5	406	53,389	44.8
7	4,695	156,609	445	222.3	8.61	55.9	2,088,000	134.4	408	54,835	47.2
8	4,772	182,677	456	254.0	8.49	61.5	2,177,000	137.6	409	56,278	53.0
9	5,145	209,064	467	292.6	8.94	63.0	2,402,000	138.6	406	55,865	56.9
1980	5,130	201,198	478	273.3	11.58	59.0	2,435,000	141.4	405	57,267	53.3

* 48 states, 50 states after 1968.

Table 2.8

Principal Elements of Airline Operating Expenses

(Trunk and Local Service)

PERCENT OF OPERATING EXPENSES

ELEMENT	1968	1970	1975	1978	1979	1980
Labor	45.2	46.2	41.4	42.4	39.9	36.1
Capital	4.0	4.3	2.9	2.7	2.6	2.9
Fuel	13.8	12.7	19.1	20.1	24.8	30.5
Other	37.0	36.8	36.6	34.8	32.7	30.5
Composite Cost Index	104.5	120.0	188.7	242.5	280.2	334.4
100 = 1967						
Labor	108.0	134.7	208.6	283.8	305.6	332.0
Capital	105.5	119.8	133.4	152.5	155.8	188.5
Fuel	98.0	105.8	279.8	376.9	555.8	863.1
Implicit Price Deflator (100 = 1972)	82.5	91.5	125.6	150.5	162.8	177.5
Composite Cost Index	126.7	131.1	150.2	161.1	172.1	188.4
(Deflated)						
Labor	130.9	147.2	166.1	188.6	187.7	187.0
Capital	127.9	130.9	106.2	101.3	95.7	106.2
Fuel	118.8	115.6	222.8	250.4	341.4	486.3

* total operating expenses plus interest on long term debt less depreciation and amortization

2.3.2 The Airports and the ATC System

The boom in airline travel required a substantial investment in aviation infrastructure. A few large airports were built during this period (Dallas/Fort Worth, Dulles near Washington, D.C., Kansas City, Houston, Tampa), but most of the large city airports met demand by expanding their runway and terminal systems. They did this over rapidly increasing objections from airport neighborhoods, as in its wake the jet age brought increased pollution and noise to the areas surrounding the airports.

During this period community opposition, combined with protests from national environmental groups, caused a number of planned airports to be abandoned (notably Everglades in Miami and Palmdale in Los Angeles). New York City officials were similarly unable to find an acceptable site for a fourth major jetport. The rapid growth in operations at metropolitan airports up to 1969 (Table 2.9) created severe congestion problems. It was clear that no more activity could be tolerated at New York when in July,1968, on a clear day, 1,927 aircraft were delayed in taking off or landing -- some for up to three hours. Once aircraft were stacked up over New York's airports, others bound for New York were forced to remain on the ground until the effect caused stacks to develop all over the United States (Aaronson, 1980). To relieve the immediate pressure while looking for long-term solutions, the FAA created quotas at the busiest airports (New York's LaGuardia and JFK, Chicago's O'Hare, Washington's National). Gradually, the airports' congestion problem was mitigated by improved airport facilities, elimination of flights at peak periods, and, most importantly, by a larger number of passengers being accommodated by each aircraft operation (Figure 2.4). Elimination or dilution of GA operations at major airports also helped by diverting GA activity to reliever (satellite) airports. (There are 236 satellite airports in 75 metropolitan areas.) Even so, in 1980, 38% of all operations at large hubs were still made by GA aircraft and air taxis, while even at some of the busiest GA airports, air carriers coexisted with GA activity. GA aircraft were tolerated at most large hub airports since they used non-duty runways and utilized the airports at off-peak hours. As air carriers expanded their operations, GA activity generally decreased, particularly local traffic, as seen in Phoenix (Figure 2.5 and 2.6).

Large hubs aside, the infrastructure and smaller airports continued to grow from 1960 to 1980. (The overall status of U.S. airports is shown in Figure 2.7 .) While the total number of airports increased from 7,000 to 15,000, non-directional radio beacons grew from 200 to 1,000; airport traffic control towers from 150 to 500; and instrument landing systems from 200 to 800 (Table 2.10). A substantial part of this infrastructure improvement was in response to growth of general aviation.

As the jet fleet expanded (and following a number of mid-air collisions), the FAA, after the obligatory study (Project Beacon in 1961), began to undertake the recommended automation of the ATC system. By 1965 air route traffic control centers (ARTCC's) had radar coverage of airspace above 24,000 feet, where only aircraft equipped for Instrument Flight Rule (IFR) flights were permitted (20 ARTCC's existed in 1980). 1965 also saw the beginning of the Automated Radar Terminal Systems (ARTS) in Atlanta. The most advanced systems (ARTS III) now provide the tower controllers with aircraft identity and altitude information of beacon equipped aircraft and provide aid for routing and spacing of incoming aircraft. By 1975, 63 ARTS III systems were in place; in 1978 automatic potential conflict advisories appeared in ARTS III. In 1970 Terminal Control Areas (TCA's) were established whereby aircraft entering TCA's were required to have IFR equipment and beacons. Negatively, by 1975 wake vortex incidents forced the FAA to add an extra mile separation behind wide-body aircraft, reducing IFR operating capacity at airports.

In 1973, enroute automation took a large step forward when all ARTCC's switched to National Airspace System (NAS) Stage A. With Stage A software, the following major functions became automated:

a. receipt and updating of flight plans

b. radar and radar beacon tracking based on multiple radar input, and display of correlation of the actual track with the flight plan.

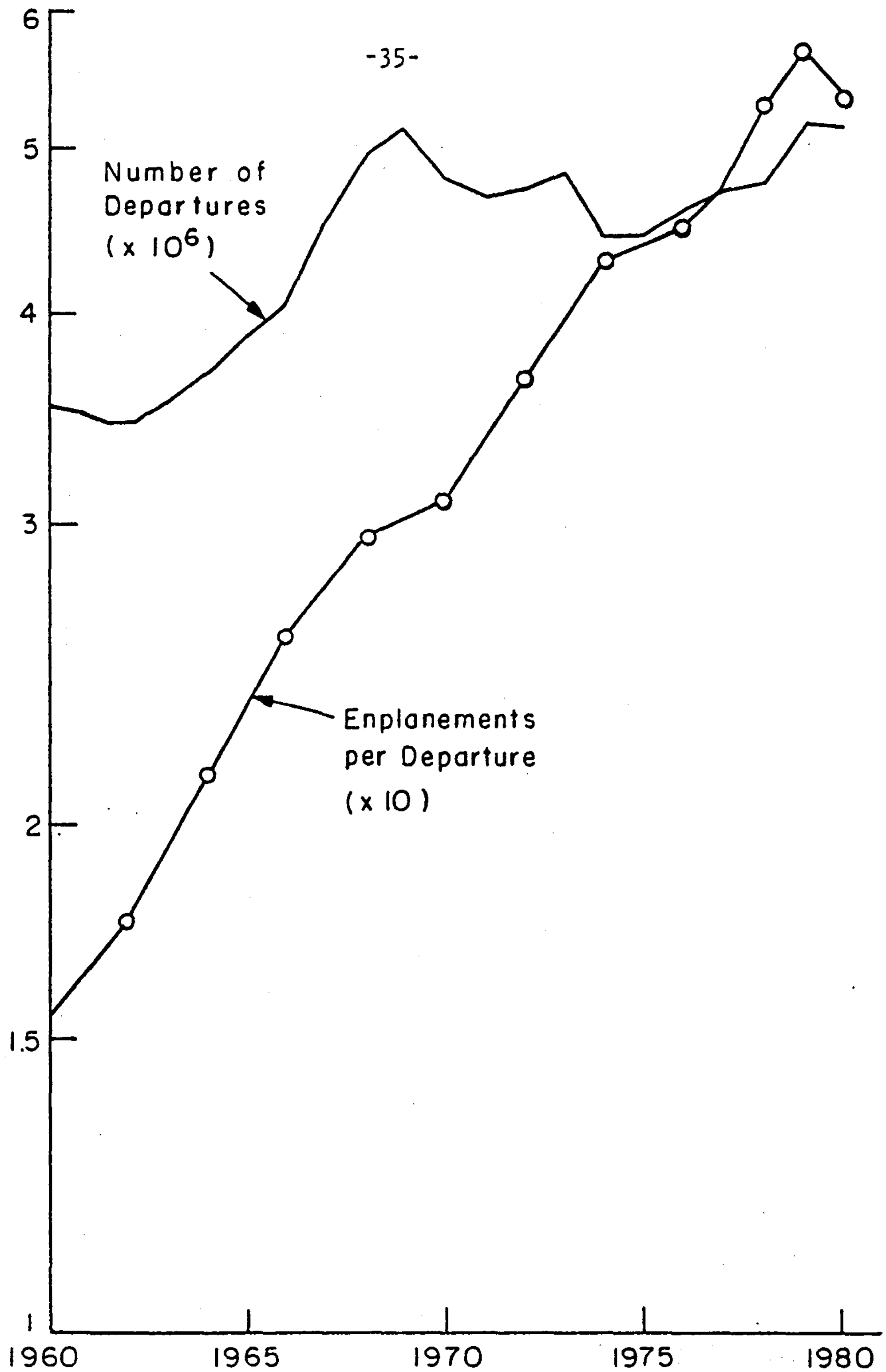
In 1972 the FAA linked up FAA headquarters, 20 ARTCC's and 19 high-density Air Traffic Control Towers. It was this linkage that allowed the FAA to implement its computerized "flow control" system housed in a computer in Jacksonville, Florida, that keeps track of the supply and demand for airspace at the nation's airports. For it is at the airports, ultimately, that the bottlenecks in the ATC system occur; no matter how smoothly the aircraft are controlled en route, eventually they must land.

Thus the FAA modernized the ATC system gradually over this period of time to meet the growing demand for ATC services. A good description of the historical development of the ATC system is found in Gilbert (1973). Even when the Professional Air Traffic Controllers' Organization (PATCO) strike came in August of 1981, enough automation had been built into the system to survive the walkout and subsequent firing of 12,500 (out of 17,000) controllers, although some capacity reductions at the largest

22 airports were put into place.

A particularly useful way to view the ATC system has been suggested by Odoni (1982) and is given in Table 2.11. This matrix format relates each ATC function (surveillance, navigation, etc.) to a particular phase of flight (airport, enroute, etc.). The "national" category was devised to accommodate elements of the ATC system that focus upon national rather than local roles, and are likely to become more important in the future. For example, central flow control is likely to be replaced by more sophisticated strategic plans when improved computer and communication technology is available.

Based upon this classification, the ATC system that has evolved to date is shown in Table 2.12. Brief descriptions of the key elements of the ATC system are shown in Table 2.13 (following Schriever and Seifert, 1968).



Source: CAB

FIGURE 2.4 NUMBER OF DEPARTURES AND ENPLANEMENTS PER DEPARTURE

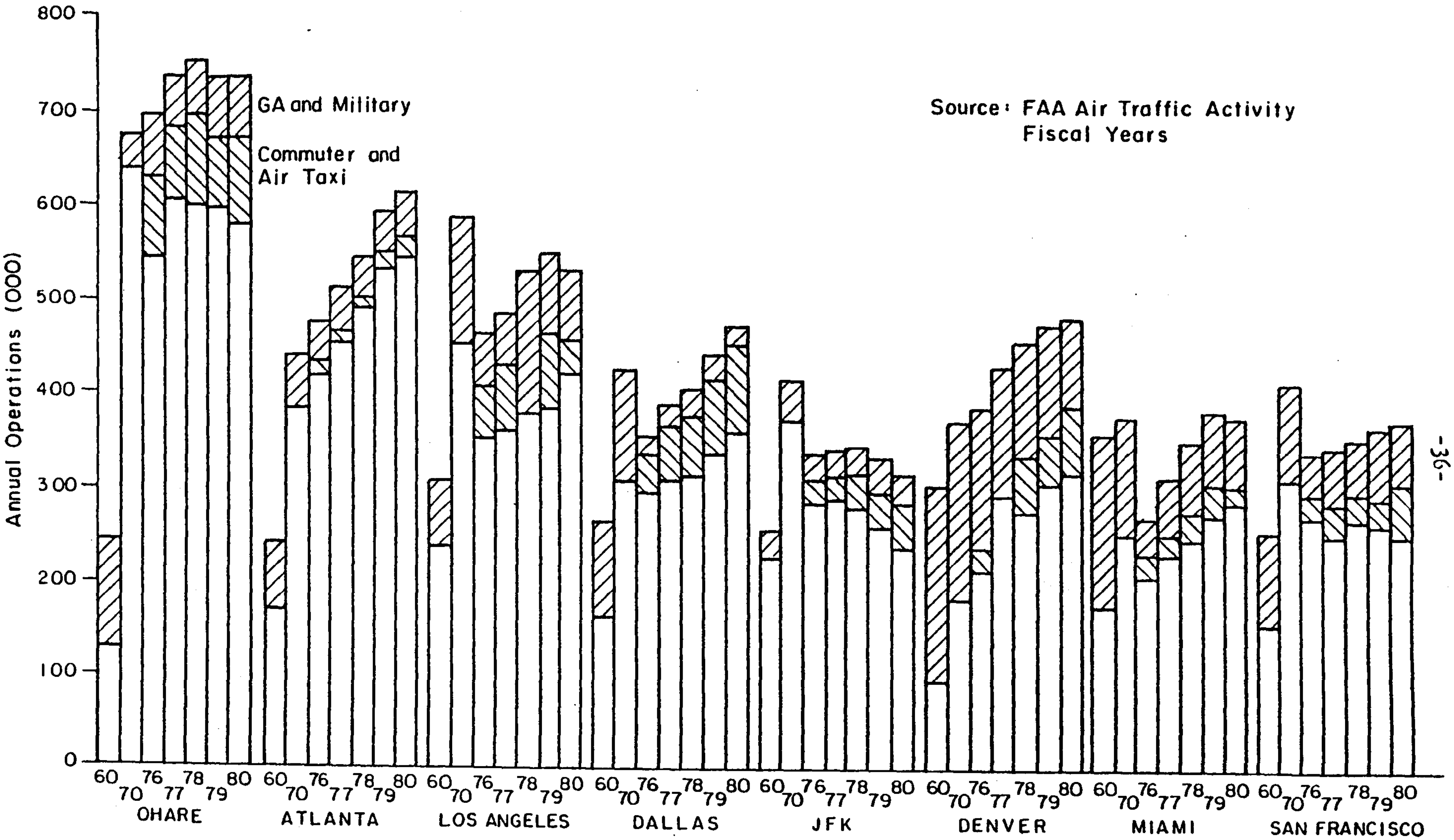


FIGURE 2.5 ANNUAL ITINERANT OPERATIONS AT MAJOR AIRPORTS (TOTAL 1960, 1970)

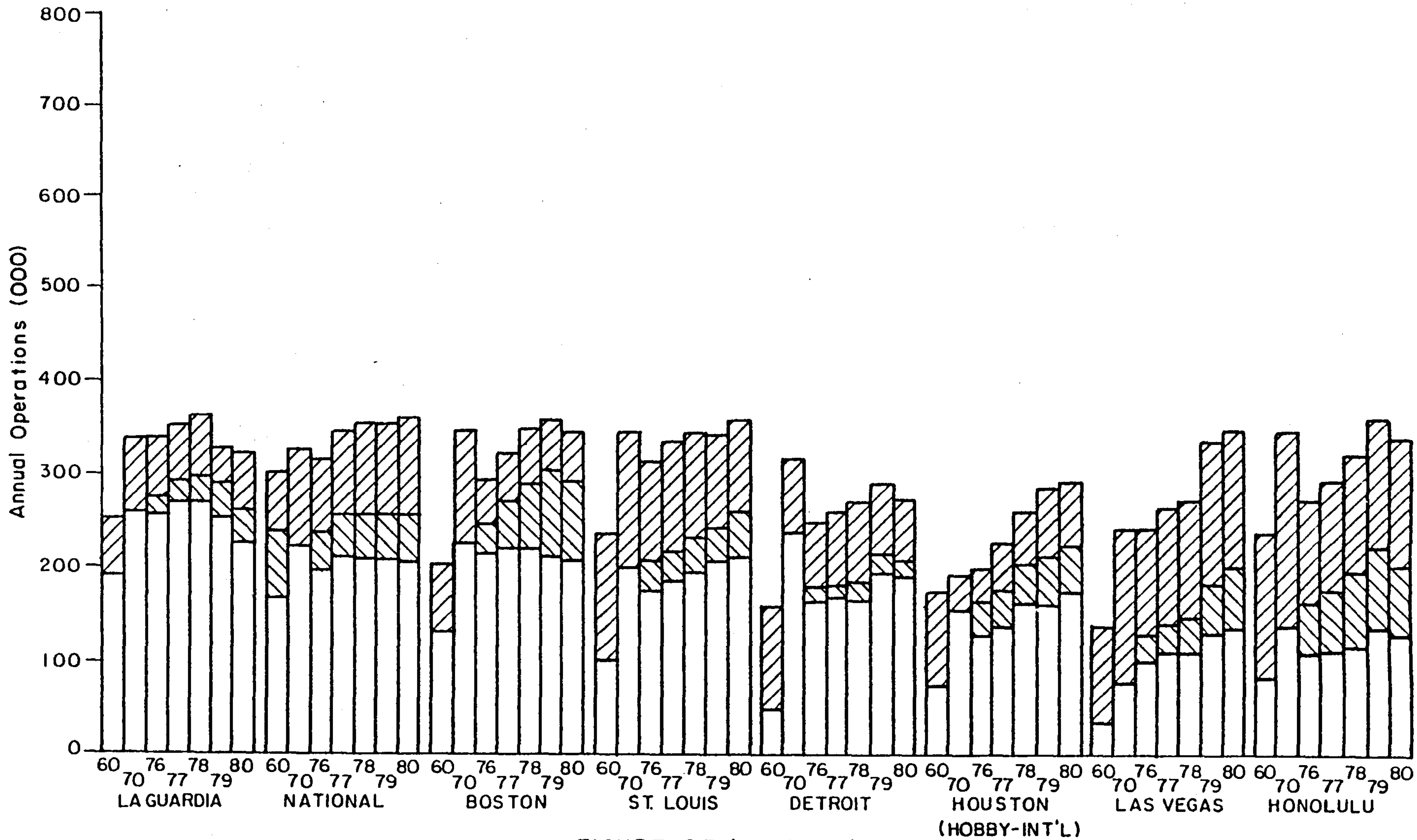


FIGURE 2.5 (continued)

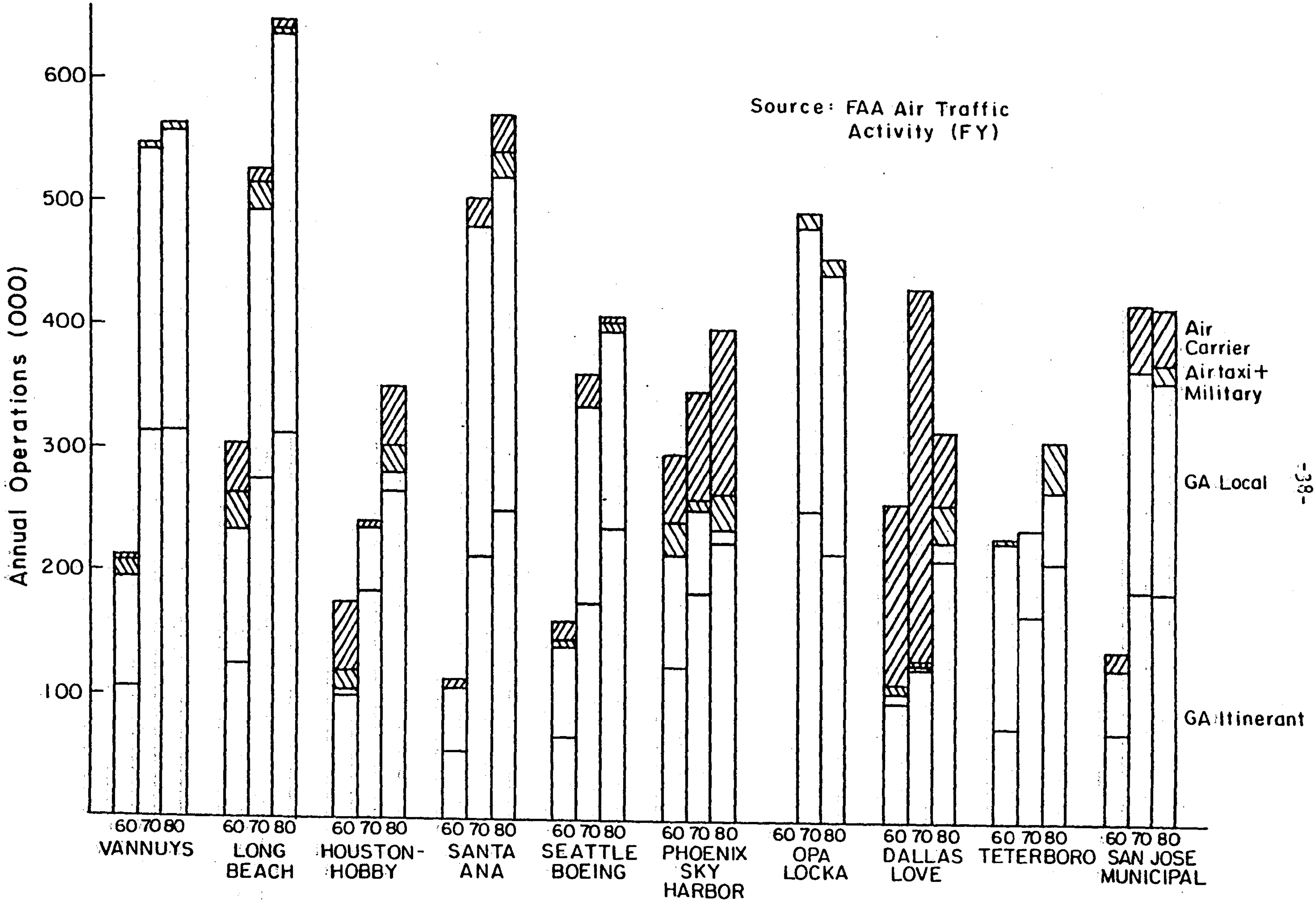
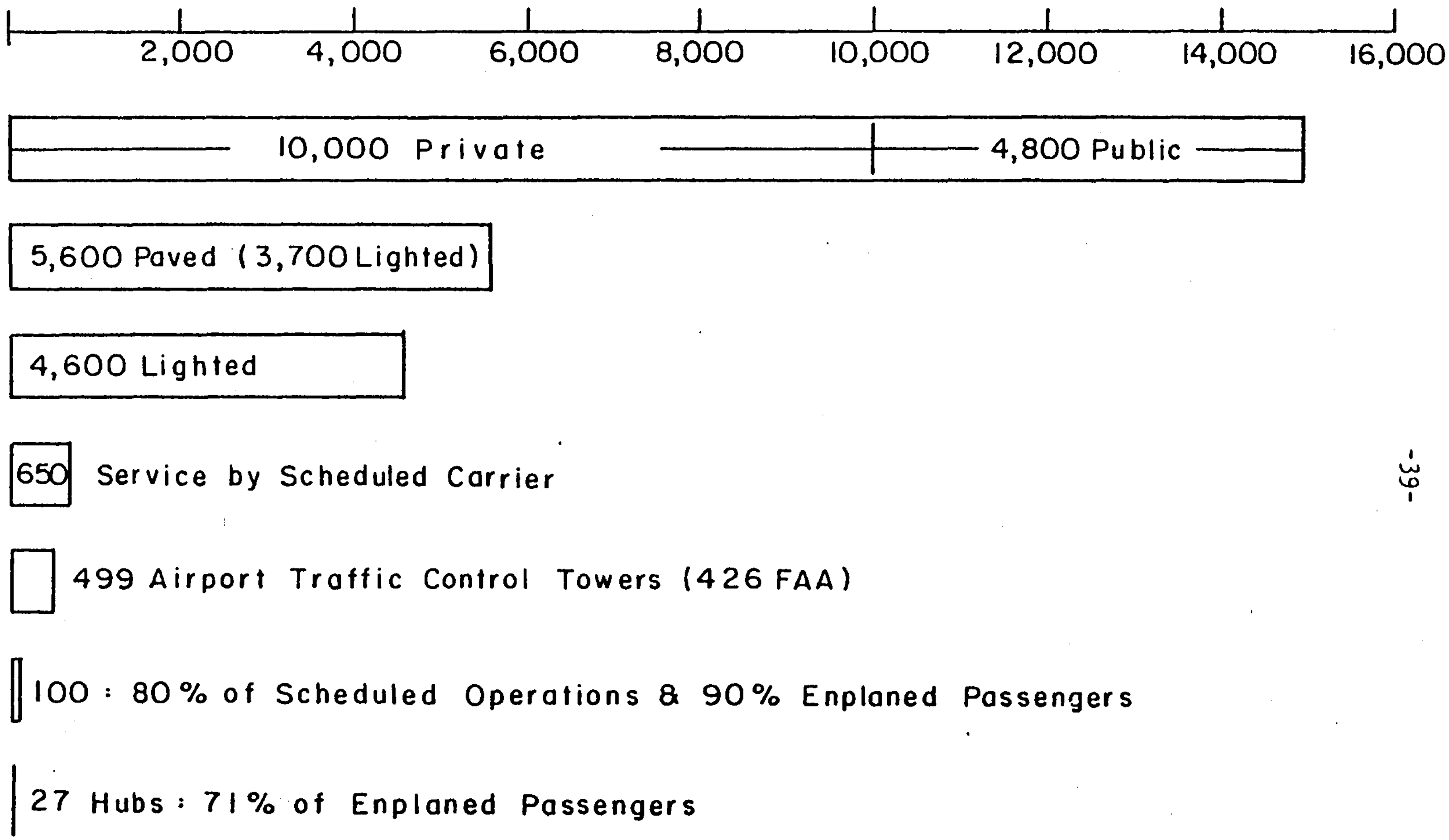


FIGURE 2.6 ANNUAL OPERATIONS AT TEN BUSIEST GA AIRPORTS



Source: FAA

FIGURE 2.7 THE US AIRPORT SYSTEM (JAN 1, 1980)

Table 2.9

LOCAL/ITINERANT AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL (000,000)

				GA			Military		
FY	Total	Air Carrier	Commuter	Itinerant	Local	Total	Itinerant	Local	Total
1960	26.4	7.3		8.7	6.3	15.0	2.1	2.0	4.1
1	25.6	7.0		9.1	5.8	14.9	1.8	1.9	3.7
2	27.4	7.1		9.9	6.6	16.5	1.8	2.0	3.8
3	29.2	7.1		10.9	7.5	18.4	1.7	2.0	3.7
4	32.9	7.4		12.4	9.2	21.6	1.8	2.0	3.8
65	35.6	7.5		13.6	10.8	24.4	1.7	1.9	3.6
6	41.2	8.2		16.2	13.5	29.7	1.6	1.7	3.3
7	47.6	8.6		19.0	16.7	35.7	1.5	1.8	3.3
8	53.0	9.9		21.0	18.8	39.8	1.5	1.8	3.3
9	55.9	10.7		22.3	19.5	41.8	1.5	1.8	3.3
1970	56.2	10.8		22.6	19.4	42.0	1.5	1.9	3.4
1	54.2	10.1		22.0	18.6	40.6	1.5	2.0	3.5
2	53.9	9.7		22.4	18.1	40.5	1.5	2.0	3.5
3	53.9	9.8		22.7	18.1	40.8	1.5	1.8	3.3
4	56.8	9.5	2.5	22.9	19.3	42.2	1.3	1.5	2.8
1975	59.0	9.4	2.7	24.2	20.0	44.2	1.3	1.4	2.7
6	62.5	9.3	2.9	26.2	21.4	47.6	1.3	1.4	2.7
7	66.7	9.8	3.3	28.1	22.9	51.0	1.3	1.4	2.7
8	67.2	10.1	3.8	28.5	22.3	50.8	1.2	1.3	2.5
9	69.0	10.4	4.4	29.4	22.3	51.7	1.2	1.3	2.5
1980	66.2	10.1	4.6	28.3	20.7	49.0	1.2	1.3	2.5

Table 2.10

FAA AIR ROUTE FACILITIES AND SERVICES: 1960-1979

Year Ending Dec. 31	VOR VORTAC	Non-Directional Radio Beacons	Air Route Traffic Control Centers	Airport Traffic Control Towers	Flight Service	Instrument Landing Systems	Airport Surveillance Radar
1960	752	190	35	153	335	191	52
1961	760	177	36	184	338	216	65
1962	777	222	35	202	336	228	70
1963	823	278	32	210	336	237	76
1964	855	275	29	212	331	247	74
1965	867	286	28	226	331	257	77
1966	972	477	28	238	331	268	91
1967	950	491	28	255	330	264	117
1968	952	538	27	271	329	279	111
1969	947	589	27	281	337	288	124
1970	964	640	27	288	332	310	120
1971	980	669	27	347	331	337	122
1972	991	706	27	355	324	403	125
1973	995	739	27	403	315	467	142
1974	1,000	793	27	417	320	490	156
1975	1,011	848	26	487	321	580	177
1976	1,020	920	25	488	321	640	175
1977	1,021	959	25	495	319	678	182
1978	1,020	988	25	494	319	698	185
1979	1,028	1,015	25	499	318	753	192

SOURCE: FAA

Table 2.11

ATC Classification Format

Location / Function	National	Oceanic	En Route	Terminal Area	
				Terminal Airspace	Airport/Final Approach
Navigation/ Landing Aids					
Communications (Air/Ground) (Ground/Ground)					
Surveillance					
Control Process/ Separation Assurance					
Weather Detection					
Flight Planning Assistance and Information					

Table 2.12

Baseline ATC System (1981)

Function \ Location	National	Oceanic	En Route	Terminal Area: Terminal Airspace	Terminal Area: Airport/Final Approach
Navigation/Landing Aids	• VOR/DME • VORTAC • VOR • RNAV • OMEGA • LORAN-C	• Inertial • OMEGA	(see National)	(see National)	• ILS • NDB • Lighting Facilities (Also see National)
Communications (Air/Ground) (Ground/Ground)	• VHF/HF Voice	• HF Voice	(see National)	(see National)	(see National)
Surveillance	• ATCRBS	• Pilot Reports	• ARSR (Also see National)	• ASR (Also see National)	• ASR • ASDE (Also see National)

Table 2.12

Baseline ATC System (1981), continued

Location / Function	National	Oceanic	En Route	Terminal Area	
				Terminal Airspace	Airport/Final Approach
Control Process/ Separation Assurance	• Central Flow Control • Contingency Command Post	• Procedural	• 9020 Computer • NAS Software • En Route Metering • En Route Conflict Alert • En Route MSAW (Also see National)	• UNIVAC Computer • ARTS IIIA/ARTS III/ARTS II Software • Terminal Conflict Alert • Terminal MSAW (Also see National)	• UNIVAC Computer • ARTS IIIA/ARTS III/ ARTS II Software • Terminal Conflict Alert • Terminal MSAW (Also see National)
Weather Detection	• National Weather Service • Pilot Reports • Flight Service Stations	• National Oceanic and Atmospheric Administration	(see National)	(see National)	• Airport Instrum'n • Low Level Wind Shear (Also see National)
Flight Planning Assistance/ Information	• Flight Service Stations • Central Flow Weather Service Unit	(see National)	• Central Altitude Reservation (Also see National)	(see National)	• Airport Reservation Office (Also see National)

Table 2.13

Summary of Radio Navigation Aids

Navigational Aid	Function	Unit Cost	System Accuracy	Range (Nautical Miles)	Remarks
Automatic Direction Finder (ADF)	Determines bearing to LF beacon stations and LF radio stations	$9,000	$\pm 2^{\circ}(2\sigma)$; very low frequency random error	50-200 nmi depending on signal strength and noise level	A general purpose aid
VHF Omnirange (VOR)	Determines magnetic bearing to VOR	11,000	$\pm 3^{\circ}(2\sigma)$; very low frequency random error	Line of sight $R \simeq 1.23\sqrt{h}$ h = altitude, kft	This unit is a combination VOR, localizer, and glide-slope navigation unit. For high altitude operations, mutual interference among VOR facilities may limit usefulness to critical areas; e.g. terminal area
Distance Measuring Equipment (DME)	Measures slant range to DME facility	8,000	± 0.2 nmi or 1% of range; very low frequency random error	0-192	As with the VOR, mutual interference among facilities at high altitudes may limit usefulness to a few critical areas, e.g., terminal area
Loran-C	Determines aircraft position	20,000	± 1500 ft(2σ); ground wave at extreme range not on baseline	Night $\sim$ 1000 Day $\sim$ 1300	This system operational. Velocity aiding essential on high performance aircraft from external sources such as air data and heading or an inertial sensor

Table 2.13 (continued)

Navigational Aid	Function	Unit Cost	System Accuracy	Range (Nautical Miles)	Remarks
Omega	Determines aircraft position	\$25,000	±2 nmi (2σ); night ±1 nmi (2σ); day low frequency random error	6000	This system is operational
Doppler Navigator	Determines vector distance traveled	40,000	±0.5% (2σ) of distance traveled or 1 nmi; very low frequency random error	200	Use for SST altitudes and speeds would require more transmitter power and a more directional antenna
Air Traffic Control transponder	Provides identification and altitude reporting to air traffic controllers	4,000		200	Altitude reporting in 100 ft increments up to 100 kft.
Instrument Landing System (glideslope and localizer) (ILS)	Provides directional information for poor weather landing	10,000	0.2° (2σ)	$\approx$ 20	Operational
Microwave Landing System	Same as ILS	15,000	0.1°(2σ)		Better protection from multipath relative to ILS

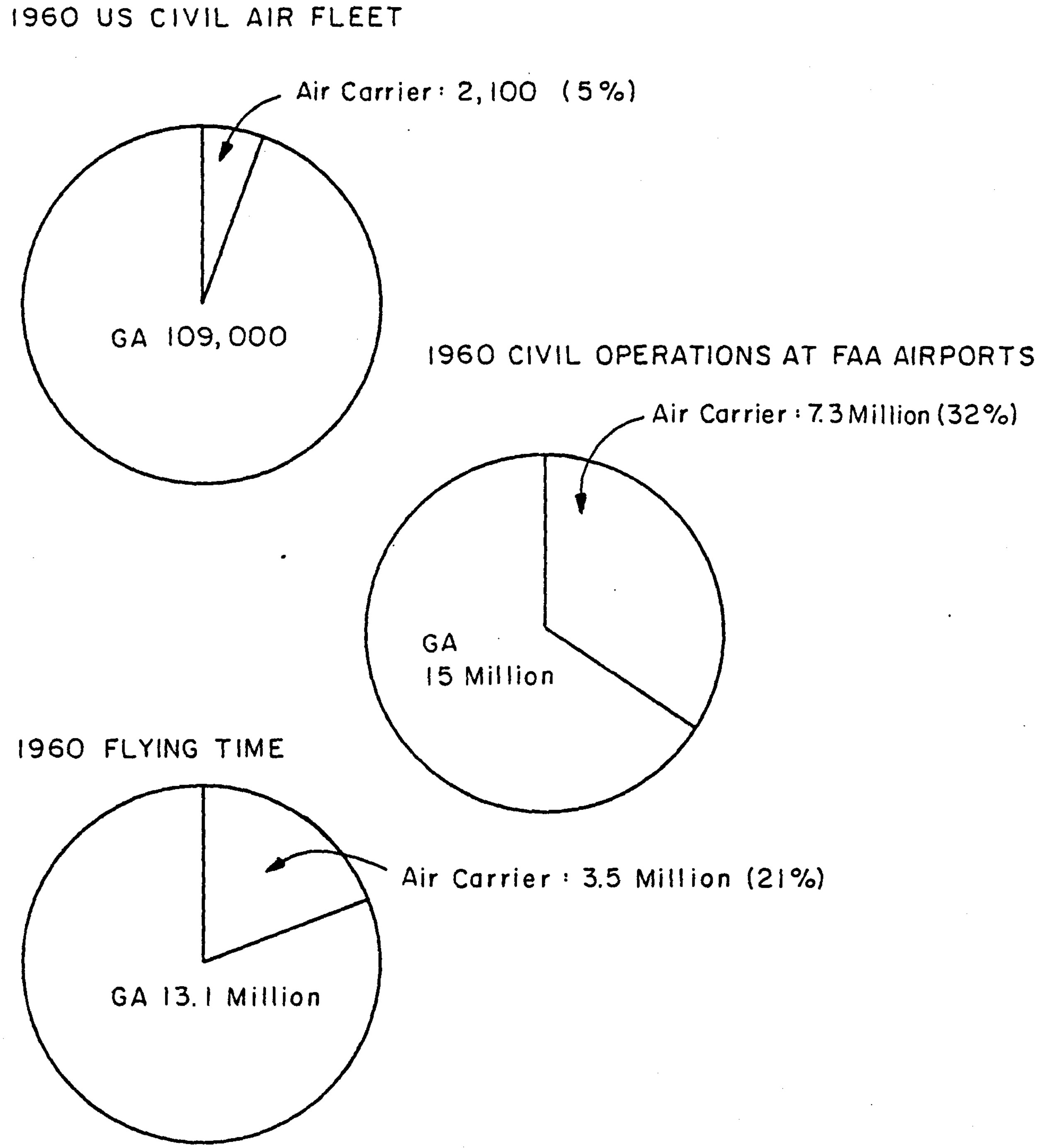
Table 2.13 (continued)

Navigational Aid	Function	Unit Cost	System Accuracy	Range (Nautical Miles)	Remarks
Marker beacon	Indicates to pilot distance to end of runway	700			
Navstar	Military Satellite Navigation System	$\sim$25,000	200m(2σ)		Capable of higher accuracy for military users

2.3.3 General Aviation

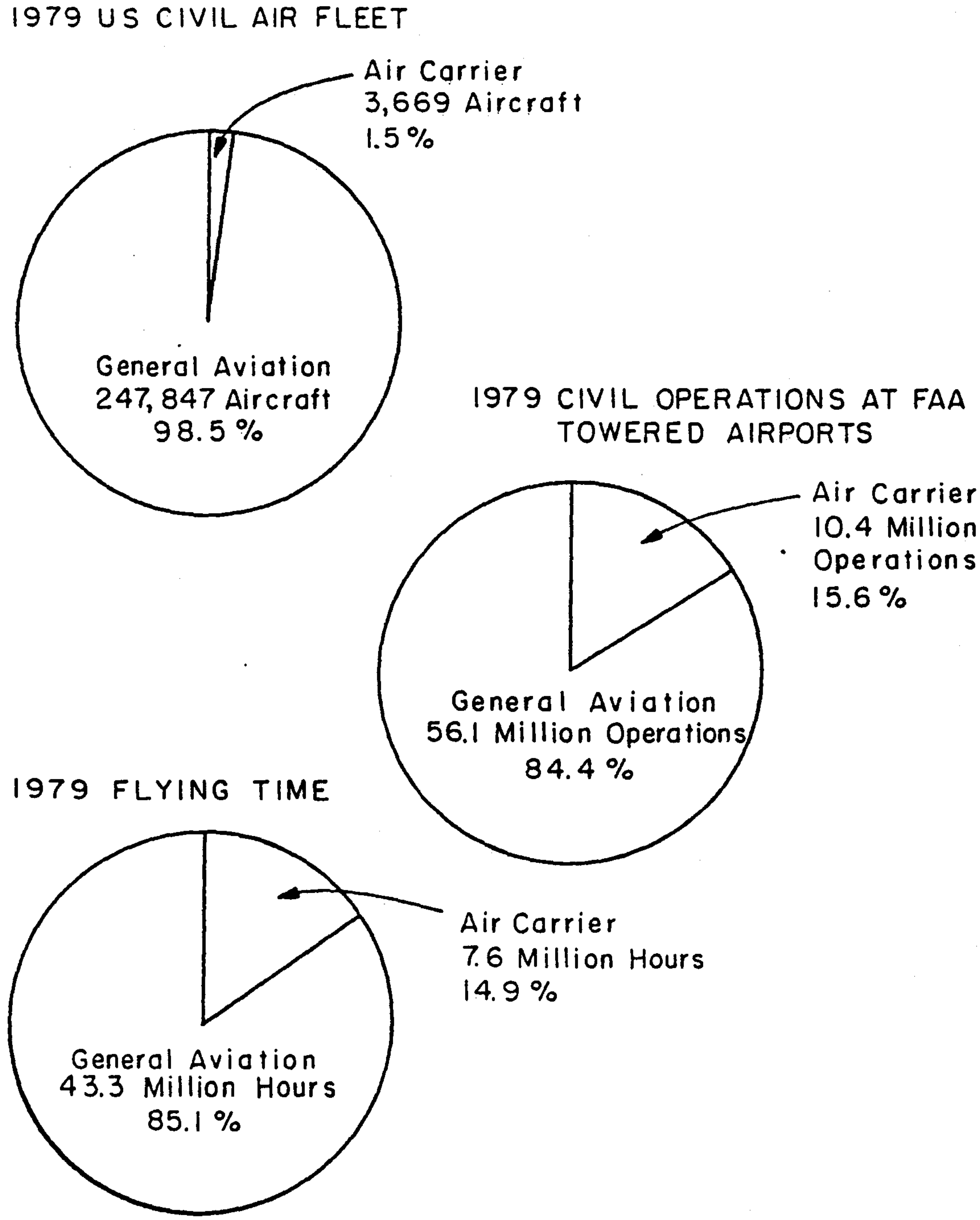
By many measures of activity, general aviation is the largest component of the aviation system and has become more so over the last twenty years (Figures 2.8 and 2.9). In terms of number of aircraft, number of operations, and hours flown, GA has expanded faster than air carrier activity. All aspects of GA activity have increased, but business flying has been lagging personal, instructional, and commercial usage (Table 2.14). Since 1970, however, it is the itinerant flights which have grown faster than local flights, indicating more sophisticated flying by the GA fleet (Table 2.9). This is verified by the greater growth of larger aircraft in the GA fleet since 1973, although the single engine piston aircraft still dominates the GA fleet (Table 2.15).

General aviation, magnitude aside, is a vital part of the aviation system. It provides transportation to individuals and businesses which otherwise have poor access to the public air transportation system. Thus GA contributes to the regional development of areas which, because of location or lack of population, have been inadequately served by the scheduled air carriers. GA provides rapid medical help to isolated areas -- the Flying Physicians Association is thriving. Agricultural aircraft improve farm efficiency and lead to increased food production. GA aircraft manufacturers also contribute to the positive export picture of the aerospace industry ($ 500 million in 1979). Finally, there is no denying the pleasure that thousands of citizens (there are 600,000 licensed pilots in the US) derive from emulating the Wright brothers.



Source: FAA

FIGURE 2.8 COMPARISON OF GA AND AIR CARRIER ACTIVITY – 1960



Source: FAA

FIGURE 2.9 COMPARISON OF GENERAL AVIATION AND AIR CARRIER ACTIVITY IN 1979

Table 2.14

Hours Flown in GA Aircraft (000,000)

FY	Total	Business	Commercial	Instructive	Personal & Other
60	13.1	5.7	2.4	1.9	3.1
61	13.4	5.8	2.5	1.8	3.3
62	14.0	5.7	2.8	2.1	3.4
63	14.8	5.7	3.2	2.4	3.5
64	15.5	5.9	3.4	2.6	3.6
65	16.2	5.8	3.3	3.0	4.1
66	18.9	6.5	3.4	4.5	4.5
67	21.6	6.8	3.7	6.0	5.1
68	22.9	6.8	4.1	6.4	5.6
69	24.8	7.2	4.8	6.7	6.1
70	26.0	7.2	4.6	6.8	7.5
71	25.5	7.1	4.3	6.4	7.6
72	27.0	7.2	4.8	6.8	8.1
73	30.0(Rev)	8.6	5.6	7.6	8.2
74	31.4	9.1	6.3	8.0	9.0
75	32.0	9.5	6.5	8.2	10.0
76	33.9	10.1	7.0	8.6	10.4

SOURCE: FAA

Table 2.15

GROWTH OF ACTIVE GENERAL AVIATION FLEET BY AIRCRAFT TYPE, 1973-1979

NUMBER OF AIRCRAFT (000)

Aircraft Type	1973	1979	Compound Annual Growth Rate in %
FIXED WING			
1-engine piston 1-3 seats	51	62	3.3
1-engine piston 4+ seats	75	106	6.0
2-engine piston 1-6 seats	13	17	3.9
2-engine piston 7+ seats	5	8	7.9
2-engine turboprop 1-12 seats	1	3	15
2-engine turboprop 13+ seats	0.5	0.5	1.0
2-engine turbojet	1.2	2.3	11.6
Other turbojet	0.2	0.3	10.9
ROTORCRAFT			
Piston	2	3	6.7
Turbine	1	3	18.4
OTHER	2	5	13.8
TOTAL AIRCRAFT	153	210	5.4

SOURCE: General Aviation Activity and Avionics Survey (1979)

3. How Do We Get from Here (1980) to There (2000)?

3.1 Introduction

The lot of the forecaster is not a happy one. The forecasts will (usually) be wrong and the person making them is (usually) fully aware of this. To remain in their line of work, forecasters cannot focus on results alone, but rather upon the nature of the forecasting process. When results go awry, they must stand ready to improve (or discard) the theory that led them astray. By paying attention to the process rather than to the results, soothsayers retain their sanity and sometimes even their clients.

The prediction of even the simplest event, e.g., the toss of a coin, has its own rules: "in the long run" an "unbiased" coin will come up heads fifty per cent of the time. But of what use is this theory to the captain of the football team when he goes on the field to call the coin toss? Well, he will not be blamed if the coin does not fall his way; after all, it was a fifty-fifty chance. Would it have helped to study the past coin tosses by the official? Suppose he had thrown nothing but heads in the last twenty chances? Is this information useful? What should the captain do?

Thus the predictions of events can be attempted using theories based on probability and statistics. Forecasters, if they are of an analytic turn of mind, can stay happy even guessing wrong, especially when they apply themselves to more complex events. Who will win the World Series? Will the Dow Jones Industrial Average climb above 2000? What are the chances that there will be a recession next year? Will World War III occur before the year 2000? -- although clearly a different meaning of probability applies here.

The baseball forecaster, armed with seasons of batting averages for hitters and earned run averages for pitchers, will attempt to assess the chances of any team against another. In the long run, a superior team (on paper) will win, but in any one game or even one season "strange" events take place (the Impossible Dream of Boston Red Sox '67, New York Mets '66). It is possible to construct an entire imaginary world based on statistics (Coover, 1968). A pseudo-realistic game can be played where real baseball averages are combined with the rolling of dice to simulate the world of seasons past, as the dice provide the missing element of chance (the "inches" of the game). Thus, to the question concerning the World Series, a rational answer would be based on an analysis of past performances of the members of the teams involved ("Smith hit .203 against left-handers, with runners in scoring position, with less than two out, in Tiger Stadium"). The forecasts may be wrong, but prediction itself is fun, given the conviction of each analyst (fan, sportswriter, manager) that he or she alone has the right analytical tools ("But only on cloudy days!"). Still, overall causes and effects are fairly straightforward, as are the cliches ("Good pitching will beat good hitting anytime"). Horseracing systems largely follow the same line (basing predictions on past performance), with the added fillip of tracking the pedigrees of young colts and fillies.

With the Dow Jones average, or the market, or even any one stock in particular, another level of complexity arises. Many facts exist related to the companies (e.g., profit, capitalization, ranking within the industry) and to the movement of the stock price (e.g., price/earnings ratios, volume, short interest, daily highs and lows). Analysts of the stock market belong to one of two schools, the fundamentalists and the technicians (although some claim to combine the best of each). The pure technicians, or chartists, will only look at the motion of the stock price and attempt to predict its future based on established systematic patterns of the past (trendlines, flags, inverted V's, five point reversals, etc.) Some systems are arcane enough that two analysts will predict totally different trends looking at the same chart. More sophisticated technicians will add such factors as up-down volume, weighted moving averages, market breadth, etc. Still, the technicians basically look at the behavior of the stock price, rather than the company. Little do they care whether they are looking at U.S. Steel or Apple Computer; in their world, everything has been discounted by the market.

Fundamentalists, at the other extreme, do not care what the price of the stock is, only what it should be. They analyze the company (trends in profit, return on investment, dividend payout, the book value, debt/equity ratios, etc.), compare it to other companies in the same industry, and attempt to estimate what the net value of the company should be (properly discounted, of course). If the price of the stock does not match its imputed value, then the stock is considered overpriced (or undervalued) and should be sold (or bought). Market dynamics are of no concern to the fundamentalist.

The dichotomy is not total; some fundamental analysts will assign risk factors to stocks based on their volatility; some technicians will group stocks within industries. The fundamentalist school attempts to discern long term trends within the company and the industry in which it operates; the technical school focuses on short term advice based on a mixed bag of statistics, market models, and sheer bravado (Adam Smith, 1968, 1972). Whether either school is correct or whether stock prices are engaged in "random walks" remains an interesting, and unending, debate. Certainly the random walk theory provides a nifty fall-back position to forecasters who happen to guess wrong. Still, practitioners of forecasts on Wall Street appear to have a good time regardless of the outcomes of their analyses. ("But where are the customers' yachts?")

In the broader question of where the national economy is going, the old fashioned judgemental forecasts of changes in the GNP (and the rate of inflation) are passé. (Change in GNP traditionally was forecasted based upon expected changes in government spending, changes in fixed investment, changes in personal consumption, changes in inventories and changes in net exports.) In vogue now are colossal computer based econometric models with very fine (disaggregated) sets of economic variables. Yet, the results of econometric forecasts (by such firms as Chase Econometrics, Data Resources, Inc. and Wharton Econometric Forecasting Associates) have been no more remarkable than the older types. Certainly, since all forecasters are wrong, they should be judged more on their credibility rather than their accuracy. Credibility, at least, seems enhanced working with a small set of numbers rather than with reams of computer printout based on tenuous relationships, all the while subject to the usual caveats of econometrics: that the underlying economic structure is not changing and that it is easier to forecast the explanatory rather than the final variables.

Aviation forecasting lies somewhere between tossing coins and predicting when (and if) World War III will break out. Certain events are fairly predictable, for example, technological improvements in aircraft and ATC systems. Other outcomes are too much subject to influence by human beings, both inside and outside the aviation system, to be assigned more than a small probability; a combination of these probabilities presents an even lesser likelihood. For example, the future of economic regulation of the airlines may depend on the influence of labor unions in Congress or the safety record of new entrants. Ultimately, the forecaster has little choice but to rely on the old economist's bromide, *ceteris paribus*, and to plow on.

3.2 The Airlines

There are a number of ways of estimating the expected future growth of revenue passenger miles, the most useful aggregate statistic in the airline business. The easiest is to simply plot the data and try some extrapolation, i.e., curve fitting. Assuming that growth will terminate at some time, useful curves are logistic S-shaped curves and Gompertz curves, symmetrical or non-symmetrical growth curves where the percentage growth gets smaller over time. Rolls-Royce (1981) shows a logistic curve on which RPMs hit 300 billion in the year 2000. (Figure 3.1)

The next level of sophistication comes when the RPM statistic is broken down into its parts. Total RPMs are equal to total aircraft revenue miles multiplied by the average aircraft load. These in turn are made up of the number of flights times the length of the flight (or the number of departures times average stage length) and the average load factor times the average aircraft size. These statistics are shown in Figure 3.2 going back to 1960 and projected out to the year 2000. Assuming that the load factor and departures will remain approximately the same as over the last ten years and that aircraft size and average stage length continue to grow as shown in Figure 3.2, then:

RPM = (No. of departures x average stage length) x (average load factor x average aircraft size)

$$\text{RPM (year 2000)} = (5 \times 10^6 \times 600) \times (0.55 \times 200) = 330 \text{ billion}$$

This number can, of course, be moved up or down by so changing the various components to taste. Anything from 300 - 360 billion would not be unreasonable. The result is thus not far from the logistic curve.

These two methods do not require any explanation as to why the variables are moving around; they are only trend analyses assuming underlying causes will continue to affect the variables as they have in the past. Moreover, since its inception air travel had been a (very) high growth industry, reflecting simultaneous improvement in the quality of the service and a decrease in its cost.

Seeking a quantifiable explanation for the growth of air travel, Wallace (1979) argued that RPMs were a function of both the traveler's ability to purchase travel and the quality of the product that he purchased. As a proxy for the ability to buy travel at any given time, Wallace chose to divide the GNP of that year by the yield to the airlines (revenue per passenger mile, itself a proxy for the price of a ticket to the average traveler). GNP accounts for both business and personal income expansion, and in current dollars also accounts for inflation. Thus, if GNP (wages) is inflating faster than the yield, the buying index increases, indicating that it is easier to purchase tickets.

The buying index (for any year i) is B_i = GNP index ÷ yield index $= (GNP_i/GNP_{1960}) \div (yield_i/yield_{1960})$

Quality improvements came from both technology (faster, larger, and longer range aircraft) and from the growth of the airline industry, resulting in service increases (additional cities served, more timely and frequent schedules, more direct flights). Quality of service, then, is a function of convenience, comfort and speed -- proxies for which are aircraft revenue miles, seats per aircraft and average aircraft speed. The quality index is defined as:

$$Q_i = 1 + 0.5\ (\text{aircraft revenue miles}_i - \text{miles}_{1960})/\text{miles}_{1960}$$
$$+ (\text{average aircraft seats}_i - \text{seats}_{1960})/\text{seats}_{1960}$$
$$+ (\text{average aircraft speed}_i - \text{speed}_i)/\text{speed}_{1960}$$

These indices are shown in Figures 3.3 and 3.4.

Figure 3.4 shows that the quality index tripled between 1960-1969 indicating that technological improvements (the conversion to jets) had a greater impact than price during the 1960's. However, since 1970 the climb has been much slower. The speed component has stabilized while the comfort factor has continued to climb (the addition of wide-bodies and bigger derivatives of early jets). The convenience of air travel also stabilized in the early 1970's, but has been increasing recently. The ability-to-buy index (Figure 3.3) reflects the fact that the price of travel at times increased faster than the economy was expanding, leading to a decreased ability to purchase tickets in 1974 and 1980, years of stagnation and finally absolute decrease in RPMs.

Using these buying and quality indices, a demand model can be constructed by analyzing the historical relationship between these pseudo-causative variables and passenger traffic. Postulating that

$$\Delta \log R_i = \alpha\ \Delta \log B_i + \beta\ \Delta \log Q_i$$

and performing a regression analysis on the data yields the following results:

$\alpha = 0.783$ standard error = 0.158 $T = 4.954$

$\beta = 0.610$ standard error = 0.148 $T = 4.119$

The model is statistically sound. It has a good statistical fit (multiple R = 0.92). The F ratio is high (52.2). F Ratio compares the explained variance (due to regression) to the unexplained variance (error sum of squares). A high F Ratio generally indicates that all of the regression coefficients are not statistically equivalent to zero. The T statistics validate this point. Generally, a T statistic greater than 2.0 means that the coefficients are significant. The standard error of the estimate is low (0.02). Finally, the signs of the coefficients are correct.

The delta log equation shows percentage changes in the passenger index from one year to the next related to percentage changes in B_i and Q_i. A 10% increase in B_i and Q_i will lead to a 14% increase in R_i. The ability to buy tickets appears slightly more important than the quality of service in generating domestic air travel.

Based on this model, a monograph can be constructed using indices for GNP, Yield and Quality of Service (Figure 3.5). With the monograph it is possible to explore a range of values for the independent variables and quickly obtain an estimate for future traffic. But what are likely values for these variables by the year 2000?

The components of the ability-to-buy variable are yield and GNP. Yield, the revenues the airlines receive per passenger mile, is affected by many things: the degree of competition on the airline's network (the much noted fare wars since deregulation); management strategy (cutting fares to stimulate traffic is a popular gambit; not willing to be undersold is in vogue too); the amount of seasonal traffic on an airline's network (flying near-empty planes to retain landing slots at airports). Still, ultimately yield must be equal to or higher than cost, as it has been in the past (Figure 3.6, Table 3.1) or else the airline closes.

The major components of cost are fuel, labor, and capital (Figure 3.7). As noted earlier, it is the fuel component which had been rising ever faster (Table 3.2), as the official OPEC price per barrel of oil seemingly doubled at will (Figure 3.8). However, these ever higher prices have naturally led to more exploration and production as non-OPEC countries tried to get in on the fun.

Fears of a world wide shortage of fossil fuels ("the energy crisis") have predictably led to a surplus of oil as the "well-advertised views of the decision-influencers tend to be believed by both profit-seeking private producers and consensus-following governments, and these two then combine to cause excessive production of precisely the things that the decision-influencers had been saying would be most obviously needed" (Macrea, 1972). World-wide recessions and energy conservation measures also helped create the surplus by cutting consumption.

Even as OPEC production has gone down from 1978's 63% of the world share to 50% in 1981, OPEC has attempted to cut its production further to eliminate the oil glut and thus maintain a higher price. With a maximum capacity of 32 millions of barrels per day (mbpd) OPEC was pumping 22 mbpds in 1981, with Saudi Arabia absorbing the largest cuts.

There is some (heated) debate about the future of oil prices and availability. The optimists note that the OPEC countries (especially the non-Gulf states) have development plans which depend on selling all the oil they can produce, and price (almost) be hanged. Thus availability, at least, is not seen as a problem, of course barring (another) major Middle East crisis, especially if it involves Saudi Arabia. As the non-OPEC countries' production grows (Figure 3.9), price stability is foreseen. The pessimists observe that exploration for oil is diminishing as the price has stabilized (and surpluses exist); that the switch to alternative fuels is slowing ("Exxon abandons the Colorado shale project" ; "Another nuclear plant halted"); and that the world may be at OPEC's mercy once again.

While it is tricky to predict what the price of oil will be, eight-fold increases (as between 1973-1981) seem farfetched; renewed energy crisis talk will certainly activate the Macrea effect. What is not difficult to predict is that conservation and efficiency measures (for example, more seats per aircraft) and fuel efficient aircraft (757, 767, 737-300, DC-9-80, A 300 series) will bring up the RPM/gallon figure as the year 2000 approaches (Figure 3.10). For the airlines, the fuel component is predicted to rise no faster than general inflation, and perhaps less, if the airlines can afford to reequip their fleets with advanced-technology aircraft.

The labor cost has traditionally been high in the airline industry, with the average worker receiving approximately twice the annual salary of other U.S. industrial wage earners. Under regulation, when the CAB based the price of all airline tickets on average industry costs, it was a relatively simple matter to pass on to the public the wage increases that the labor unions extracted. Those airlines whose managements tried to keep their labor costs as low as possible (either by hiring relatively fewer workers or by maintaining pay scales below industry standards, or both) usually had high profits, Northwest Airlines was the most notable follower of this strategy.

Since deregulation, as the price of the ticket became based on what the market will bear, airline managements have taken a much harder line in labor negotiations as they saw non-union, low-paying upstarts (and low priced tickets) invading their markets. Airlines which have been under severe financial stress (i.e., Braniff before bankruptcy, Continental, Eastern, Pan Am, Republic, Western) have even been able to persuade their workers to cut back their salaries. The May, 1982, Braniff bankruptcy will, among other things, add a certain amount of caution to management-union discussions, as both sides will be more aware of the alternative to labor peace and cooperation. With this spirit of cooperation, however, labor will insist on closer surveillance of management decisions. (Indeed, the unions already have a member on the board of directors of Pan Am .)

Deregulation thus has drastically cut the power of labor unions. Although the discussions preceding deregulation were long and acrimonious, it was basically a debate whether the airlines should be viewed as public utilities or as normal industries where market forces shape prices, rather than regulatory agencies. Since the pro-competitive arguments won the day by promising lower fares, deregulation is likely to remain the law in the future unless a series of accidents occur whose causes will be attributed to lack of care in the operation of aircraft due to the desire to cut costs. Regulation of fares can also return if airlines start raising the prices of tickets in non-competitive thin markets so high that Congressional investigations occur. These scenarios, however, are not very likely. The FAA is still regulating the airlines as far as safety is concerned; very high fares will eventually attract new entrants. Thus the labor component of cost will not rise faster than inflation, and may in fact decrease.

Once the decision has been made to borrow money, airline managements have no control over their capital costs, which are tied to the average prime rate charged by banks (Figure 3.11). These interest rates have traditionally moved up and down with the inflation rate (the rule of thumb for the prime rate had been inflation rate plus three percent), except in the past two years when they have remained uncharacteristically high. Many reasons have been advanced for this aberration. Fear in the capital markets that the decline in inflation is illusionary or, alternatively, that the Federal Reserve Board will not stay the course in the fight against inflation, are major psychological reasons. Lack of confidence in the major premises of the Reagan Administration economic policies is another. Heavy borrowing by the Treasury to underwrite the existing (and growing) Federal budget deficits is certainly a real factor. Whether the prime rate remains high or not, airline managements will not be able to do anything about their capital costs, which will ultimately be correlated with inflation. Relative to current GNP growth, capital costs will be neutral.

Thus the major components of airline costs (fuel, labor, capital) are seen to be equal to or somewhat below the inflation rate over the next twenty years. Consequently, yields will remain steady in real terms or decline slightly.

High inflation has contradictory effects on travel. If GNP inflation stays ahead of yield inflation, it is positive for travel. For people whose income is not indexed to inflation, high inflation reduces real income and propensity to travel. On the other hand, inflationary expectations (and interest deductions on taxes) lead people to borrow and spend now while expecting to repay with cheaper dollars.

GNP growth is hardest to predict, from year to year or even decade to decade; witness the plethora of economic forecasting experts. Unless the U.S. economy suffers a major collapse (and causes world-wide hunger in the process), over the next twenty years the long-term U.S. trend (since 1910) of 3% average annual real growth should continue. (Productivity, however, has been declining recently.) Even at the risk of aggravating inflation, no U.S. government tries to retain conditions suitable to a recession past its third year in office. Wall Street recognizes this. Since Truman, no matter which party was in the White House, in the third year the Dow Jones Industrial Average rose anticipating that the Federal Government would attempt to stimulate economic growth before the next election (Figure 3.12).

Being slightly more pessimistic, since the days of cheap energy have passed from the U.S. scene, 2.5% real annual growth over the next twenty years seems reasonable. This means that GNP in the year 2000 will be 1.6 x GNP_{1980}, in real terms. Since the yield has been estimated as staying within the inflation rate the buying index is:

$$B_{2000} = GNP_{2000}/GNP_{1960} \div yield_{2000}/yield_{1980} = 1.6$$

The quality of service components by the year 2000 -- speed, convenience of service, comfort -- are likely to be as follows:

a) speed will be the same

b) convenience (aircraft revenue miles) will increase to 3.5×10^9 miles as there will be more point-to-point service by new entrants, old local service airlines, and regional airlines using smaller planes (737-DC9 size).

c) comfort (seats per aircraft) will rise to 200 seats, but this component will only be half as important as it has been over the past twenty years since a higher level of comfort is now assumed as given.

$$Q_{2000} = 1 + 0.5\ (\text{aircraft revenue miles}_{2000} - \text{miles}_{1980})/\text{miles}_{1980}$$
$$+ 0.5\ (\text{average aircraft seats}_{2000} - \text{seats}_{1980})/\text{seats}_{1980}$$
$$+ (\text{average aircraft speed}_{2000} - \text{speed}_{1980})/\text{speed}_{1980}$$

$$Q_{2000} = 1 + 0.5(3.5 \times 10^9 - 2.5 \times 10^9)/2.5 \times 10^9 + 0.5(200 - 140)/140$$
$$+ (400 - 400)/400$$

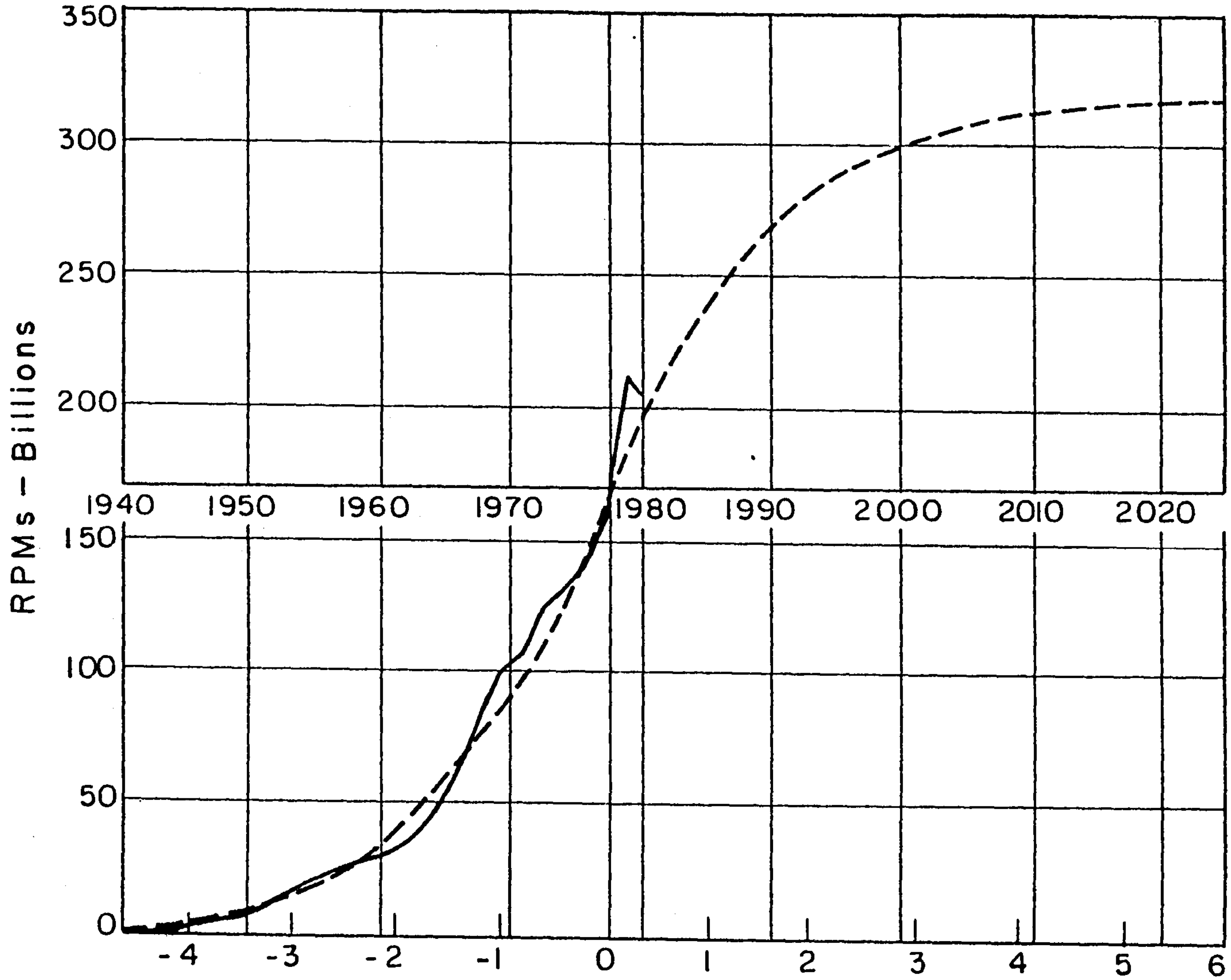
$$Q_{2000} = 1.4$$

Thus by the year 2000 the quality of service will be 40% higher than it was in 1980. Using the model:

$$RPM_{2000}/RPM_{2000} = (B_{2000}/B_{1980})^{0.78} \times (Q_{2000}/Q_{1980})^{0.61}$$

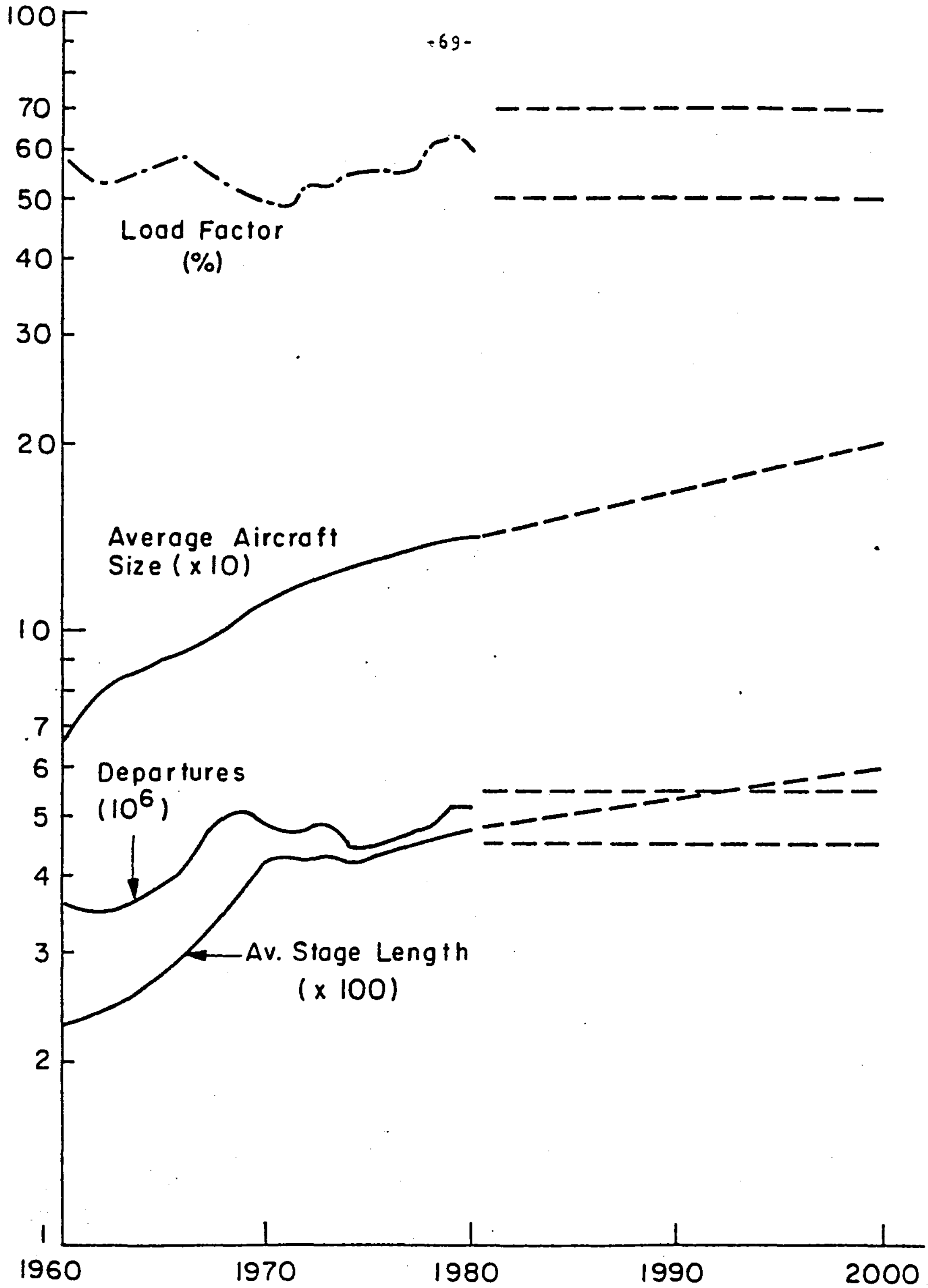
$$RPM_{2000}/RPM_{1980} = (1.6)^{0.78} \times (1.4)^{0.61} = 1.77$$

Consequently revenue passenger miles for the year 2000 are projected as 356 billion. This is a compounded growth rate of slightly less than 3%, compared with the previous two estimates of 300 billion and 330 billion rpms, which were 2.0% and 2.5% growth rates, respectively. All of these guesses fall within the shaded area shown in Figure 3.13. The principal caveat of forecasting should not be forgotten -- the final result is only as good as the assumptions that have been used. If any components (GNP, fuel, labor, etc) change drastically from what has been forecasted, the final estimate will be off -- up or down. In general these estimates indicate that the airline industry will behave more like a mature industry rather than the robust growth industry of the past twenty years when simultaneous quality improvements and unit cost decreases combined for explosive expansion.



Source: Rolls – Royce (1981)

FIGURE 3.1 U S CERTIFICATED AIR CARRIER GROWTH



Source: CAB

FIGURE 3.2 AIRLINE SYSTEM STATISTICS

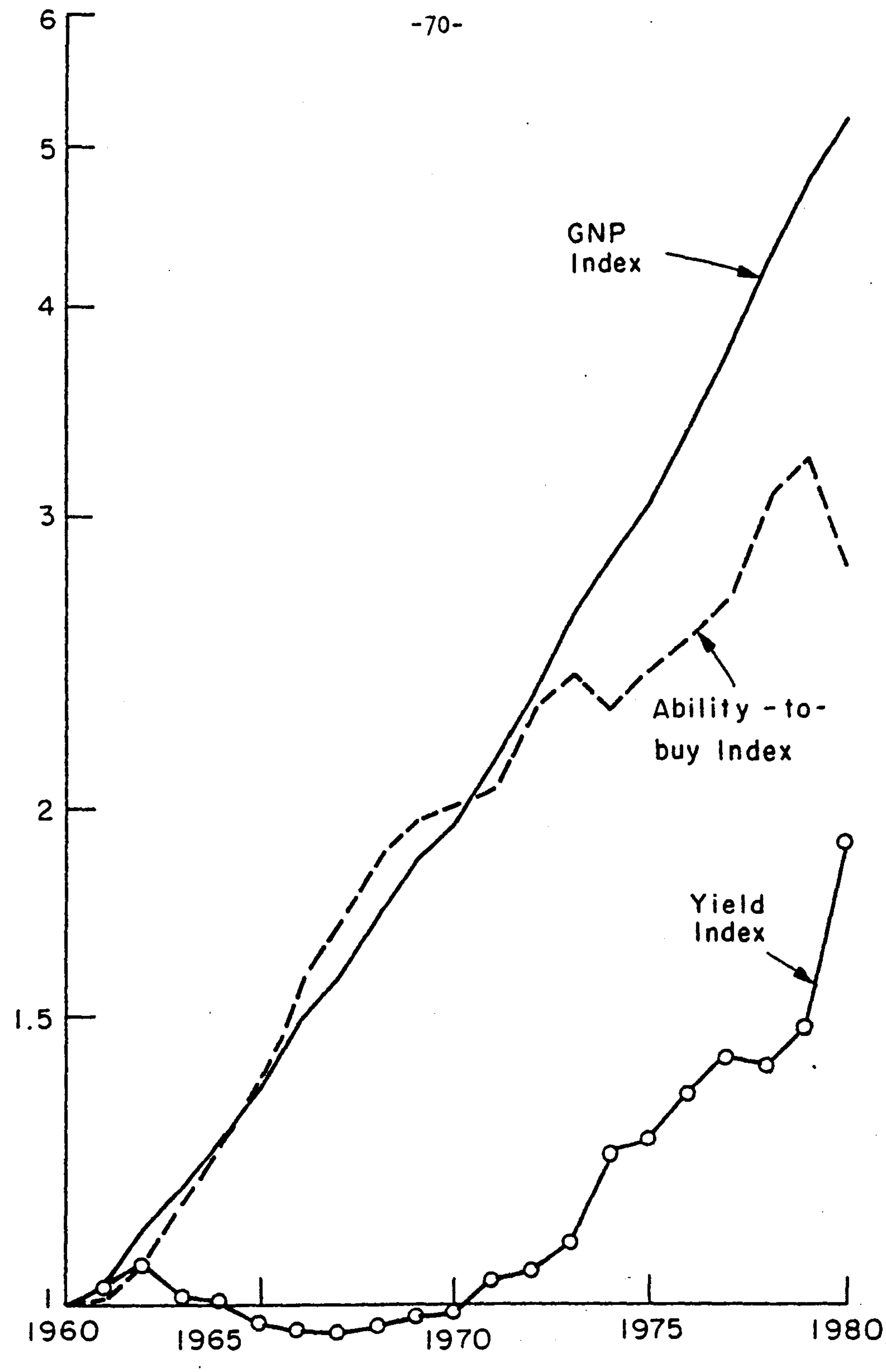


FIGURE 3.3 ABILITY-TO-BUY INDEX (AND COMPONENTS)

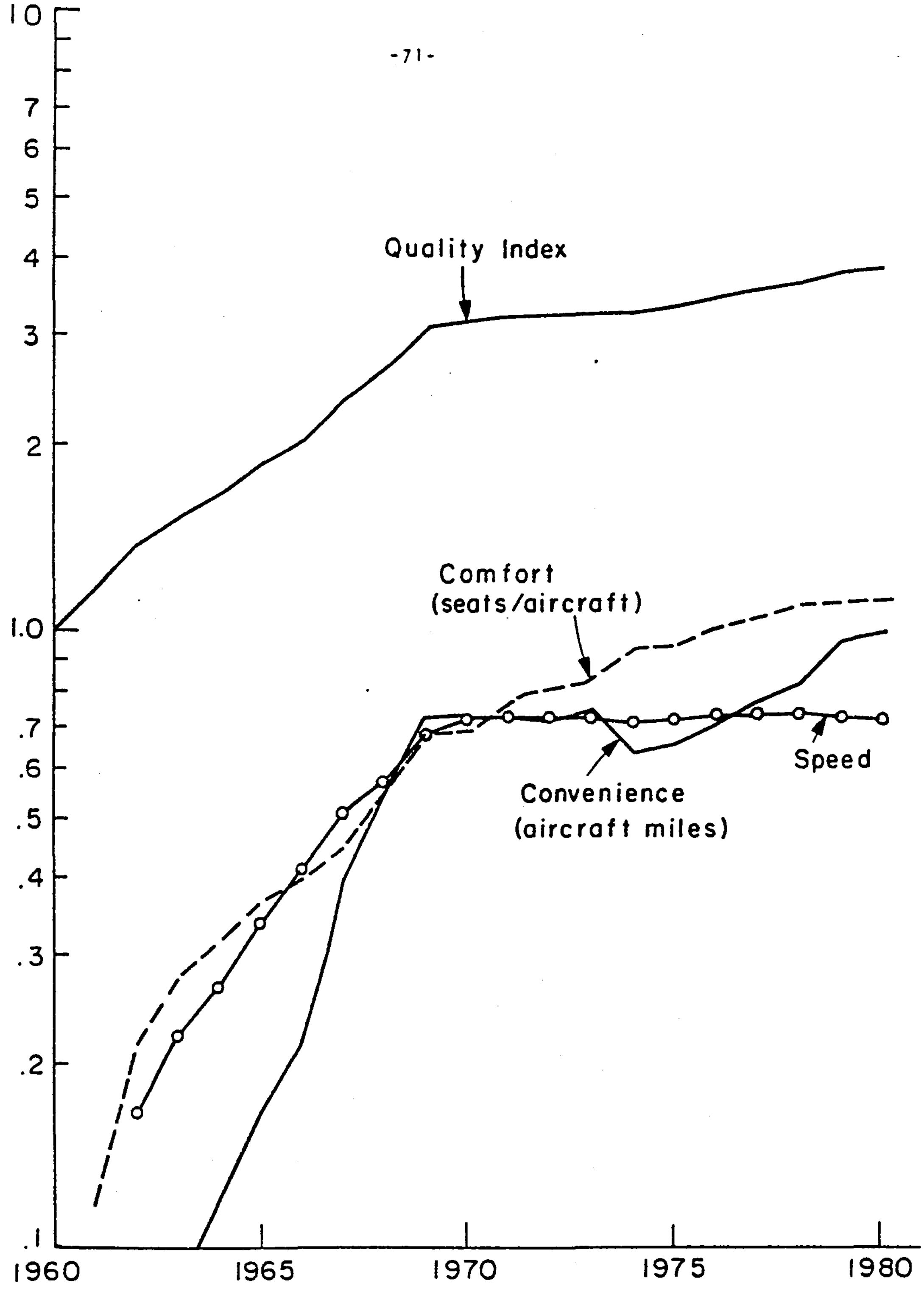


FIGURE 3.4 QUALITY INDEX (AND COMPONENTS)

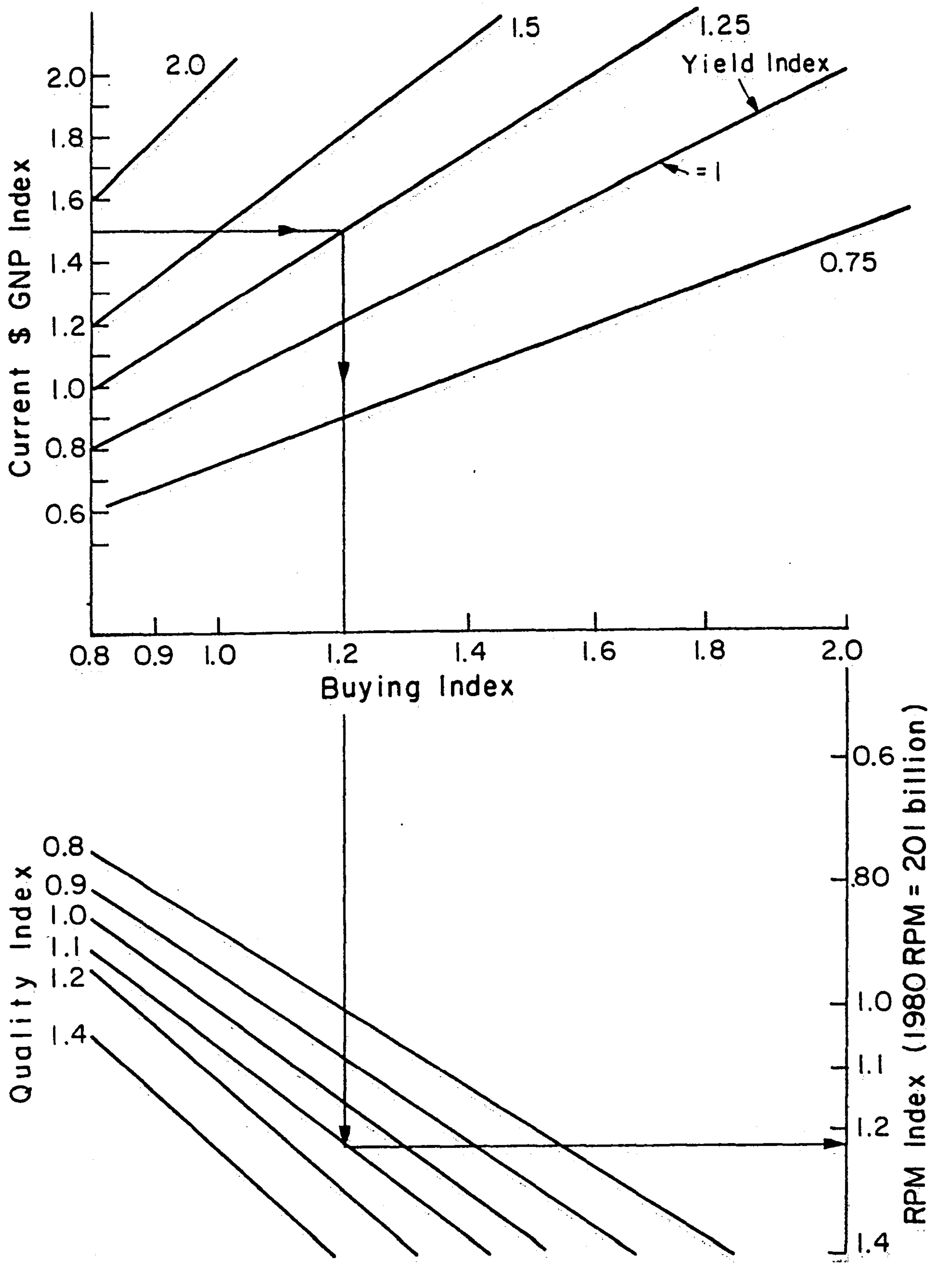
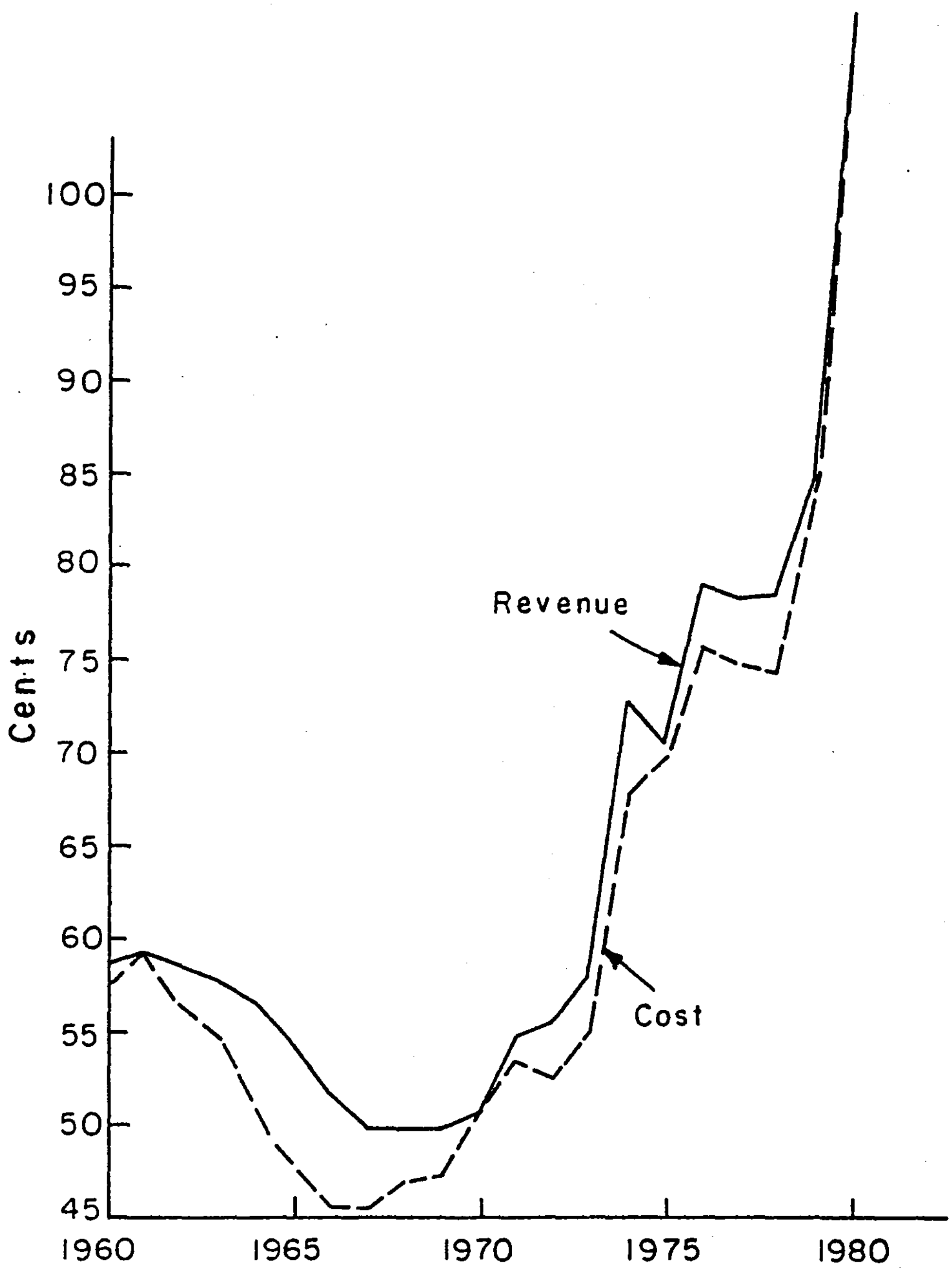
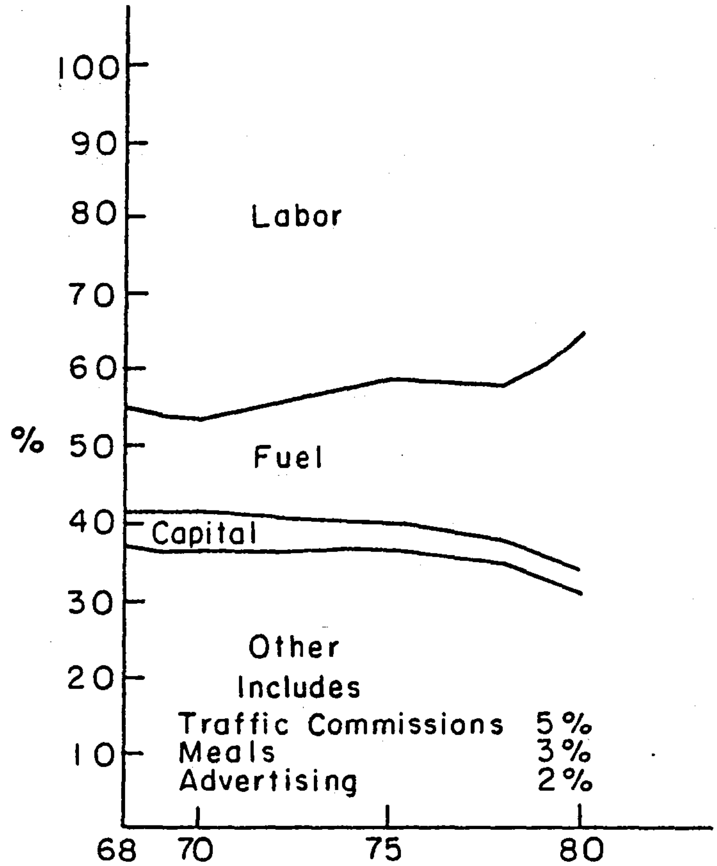


FIGURE 3.5 EFFECT OF GNP, YIELD, AND QUALITY ON PASSENGER TRAFFIC



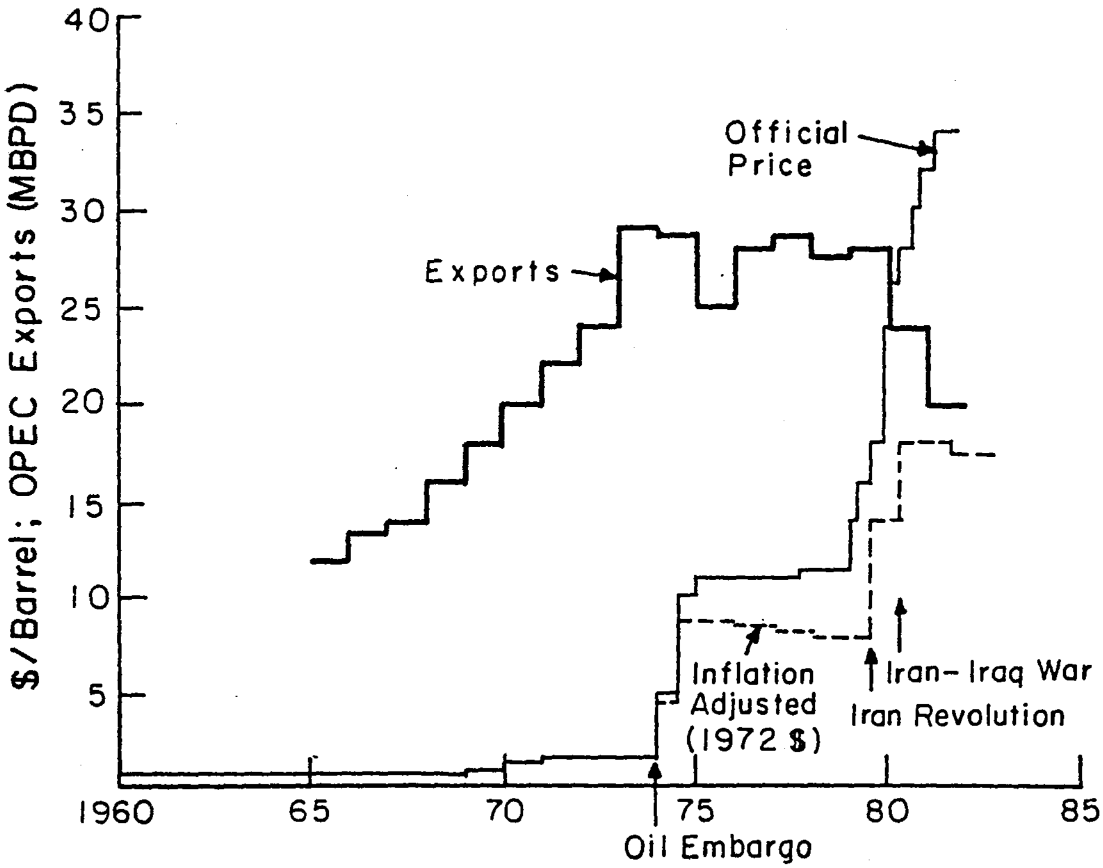
Source: CAB

FIGURE 3.6 REVENUE AND COST PER TON MILE (DOMESTIC SERVICE) (CURRENT $)



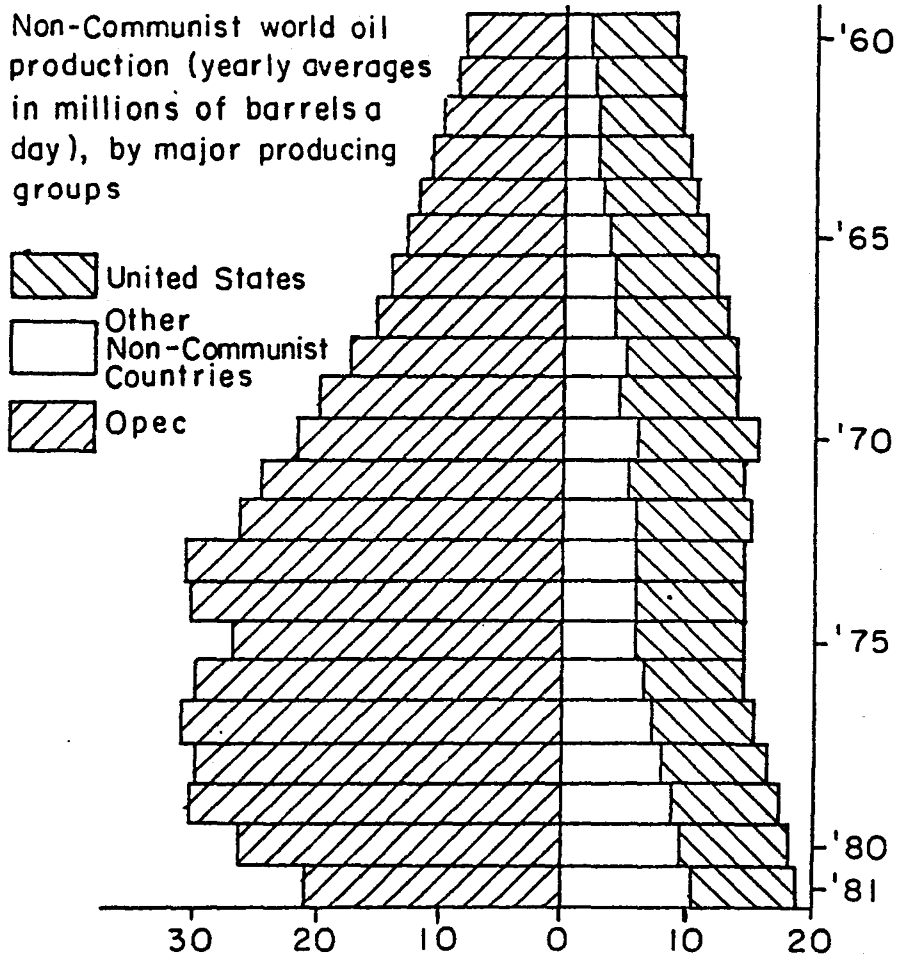
Source: ATA

FIGURE 3.7 PERCENT OF CASH OPERATING EXPENSES (TRUNKS AND LOCALS)



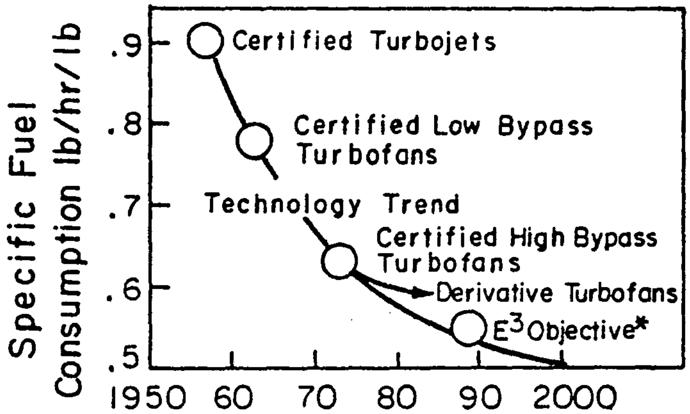
Source: Brown (1981)

FIGURE 3.8 OFFICIAL PRICE OF SAUDI LIGHT CRUDE OIL AND OPEC EXPORTS ($/BARREL) (42 US GALLONS = 1 BARREL)



Source: New York Times (1982)

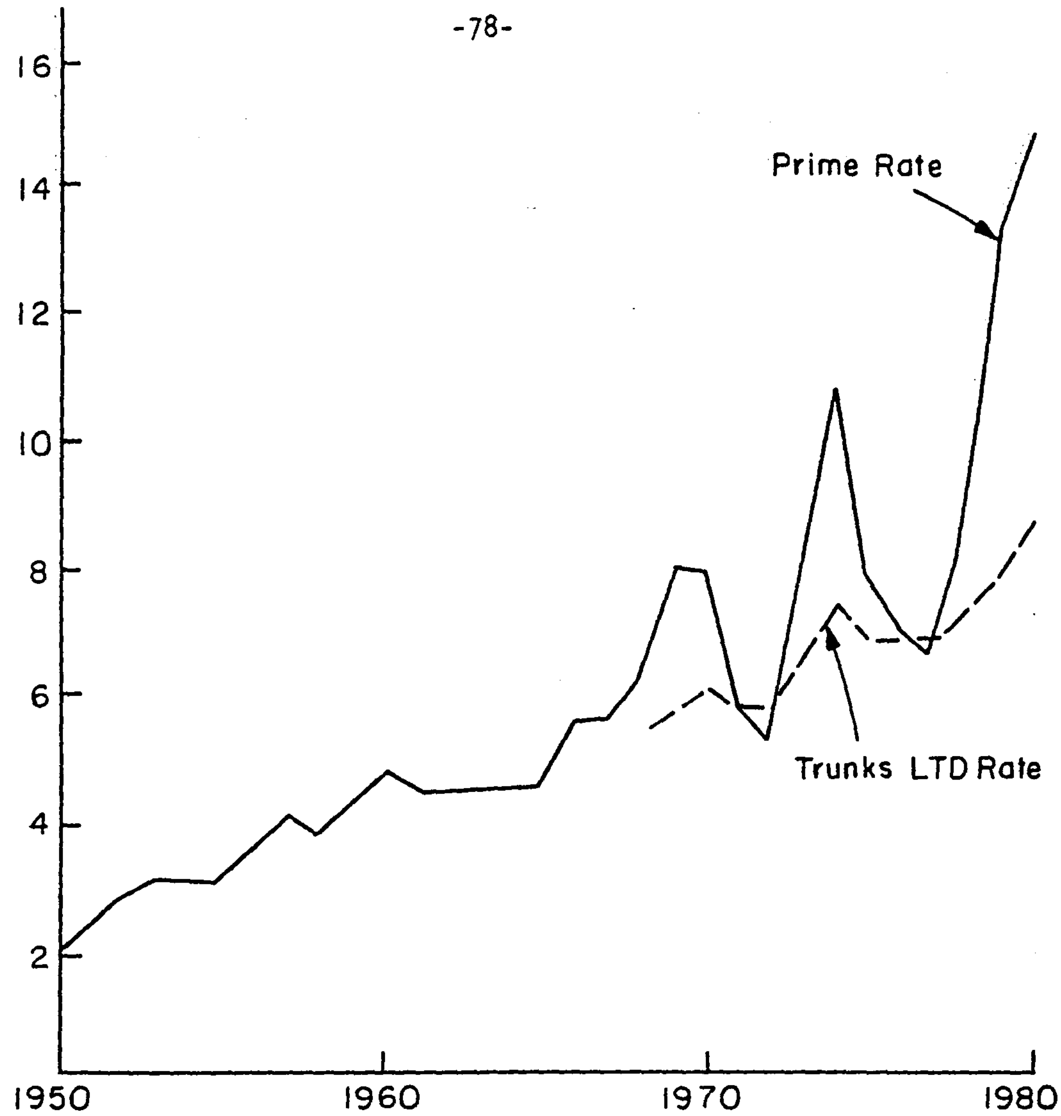
FIGURE 3.9 THE SHIFTING PATTERN OF WORLD OIL PRODUCTION



Source: Aviation Week and Space Technology (1982)

* E^3 = Energy Efficient Engine

FIGURE 3.10 LARGE US COMMERCIAL TRANSPORT FUEL CONSUMPTION



Source: Rolls - Royce (1981)

FIGURE 3.11 US INTEREST RATES

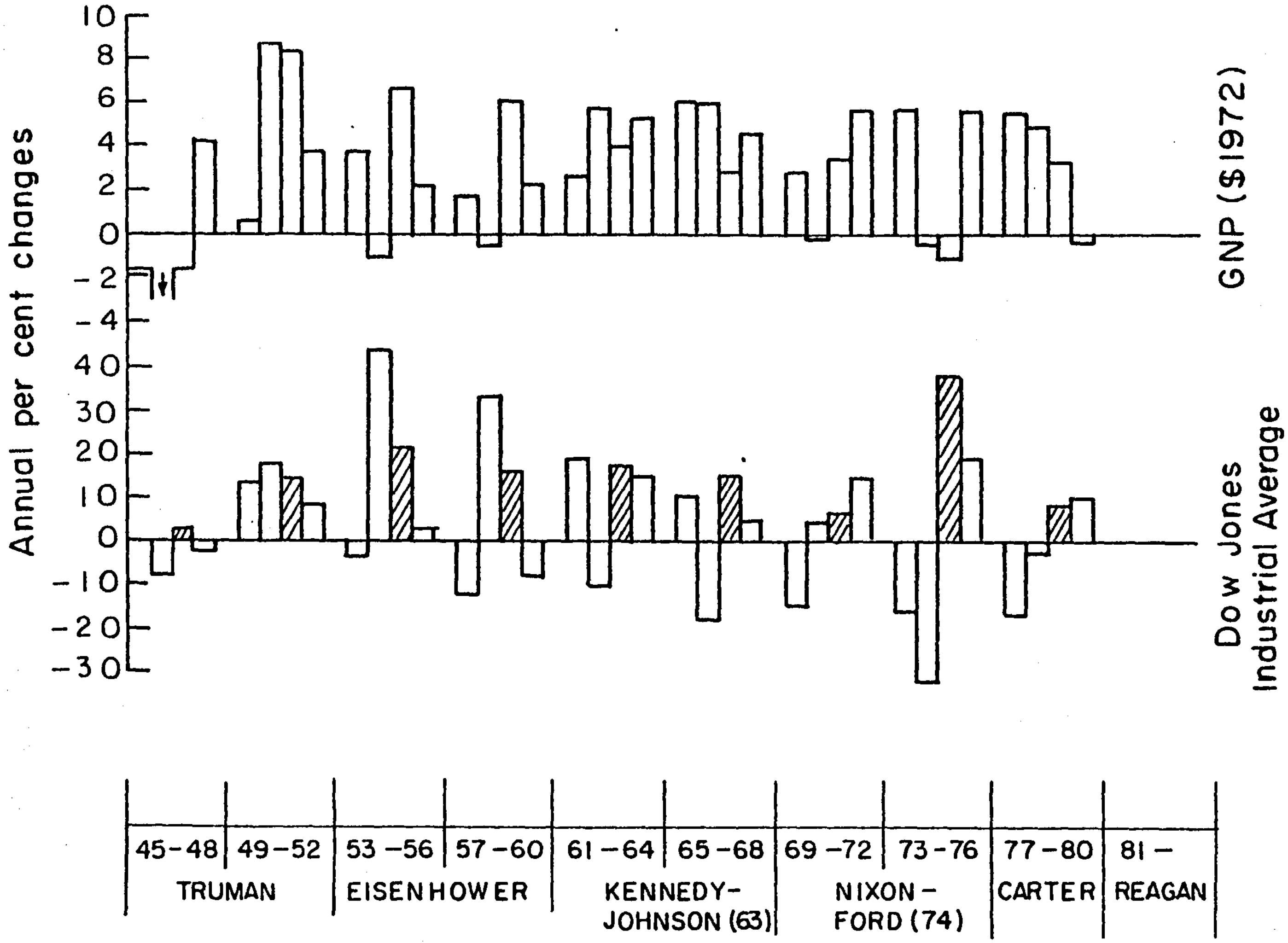


FIGURE 3.12 PRESIDENTIAL TERMS, GROSS NATIONAL PRODUCT, AND STOCK PRICES

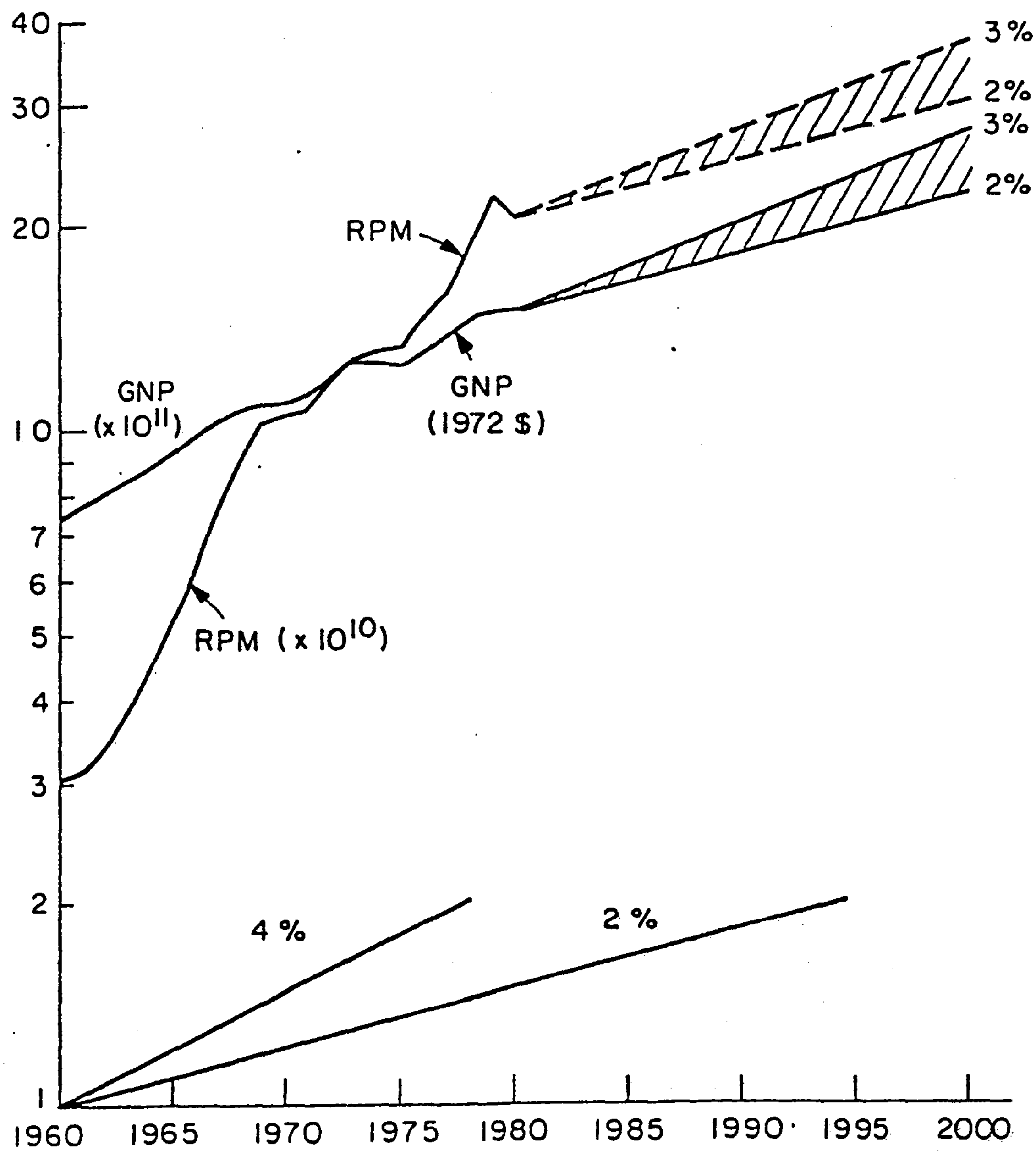


FIGURE 3.13 GNP AND RPM GROWTH

Table 3.1

DOMESTIC AIRLINE REVENUE, COST AND PROFIT PER REVENUE TON MILE
(cents per mile)

	Current $			1972 $ (Implicit Price Deflator GNP)	
Year	Revenue	Cost	Profit	Revenue	Cost
1960	58.35	57.35	1.00	84.9	83.5
1	59.11	59.17	(0.06)	85.3	85.35
2	58.29	56.03	2.26	82.6	79.4
3	57.75	54.77	2.98	80.6	76.4
4	56.58	50.87	5.71	77.8	69.9
1965	54.48	47.81	6.67	73.3	64.3
6	51.79	45.57	6.22	67.5	59.4
7	49.90	45.67	4.23	63.1	57.8
8	49.86	47.00	2.66	60.4	56.9
9	49.74	47.43	2.31	57.3	54.6
1970	51.74	51.75	(0.01)	56.6	56.6
1	54.76	53.03	1.73	57.0	55.2
2	55.51	52.35	3.17	55.5	52.4
3	58.02	55.07	2.95	54.9	52.1
4	72.65	67.70	4.95	63.2	60.7
1975	70.42	69.73	0.69	56.1	55.5
6	78.90	75.63	3.27	59.7	57.2
7	78.06	74.82	3.24	55.8	53.5
8	78.53	74.10	4.43	52.3	49.4
9	84.26	83.76	0.50	51.8	51.4
1980	109.75	109.75	--	61.8	61.8

SOURCE: ATA Annual Reports

Table 3.2

FUEL CONSUMPTION AND PRICE (DOMESTIC)

	YEAR												
	60	63	65	68	70	72	73	74	75	76	78	79	80
Gallons of Jet Fuel (10^9)	.988	2.34	3.37	6.45	7.78	7.89	8.24	7.42	7.56	7.91	8.62	9.32	
RPM (10^9) (Domestic)	30.6	38.5	51.9	87.5	104.1	118.1	126.3	129.7	131.7	145.3	187.8	208.6	
RPM/Gallon	30.9	16.5	15.4	13.6	13.4	15.0	15.3	17.5	17.4	18.4	21.8	22.4	
¢/gallon (current $)	10	10	10	10	11	12	15	25	30	32	40	58	95
¢/gallon (1972 $)	15	14	13	12	12	12	14	22	24	24	26	36	54

3.3 General Aviation

Just as in the airline industry, general aviation also has benefited from technological improvements to aircraft. These qualitative improvements, which have come about at relatively little cost, have in turn led to increased purchases of larger aircraft with more sophisticated avionic packages. Although the price of the average aircraft rose from $28,000 to $67,500 (1972) from 1960 to 1979, this was quite in line with the rise in real GNP ($737 to $1,483 b) (Table 2.5). Consequently GA has made more use of the ATC system. Sixty percent of the fleet is now capable of IFR flights.

This trend of purchasing larger aircraft is expected to continue. Estimates for the various GA aircraft types to the year 2000 are shown in Table 3.3. These projections assume, as in the airline sector, that the economy will continue to expand; that congestion problems will not become much more severe (i.e., that GA aircraft will continue to access large hubs, albeit at non-peak hours); that the price and availability of fuel will not become a constraint. A further assumption is that the production capacity of GA aircraft manufacturers can be maintained at 15,000 aircraft per year, at which rate three-quarters of the year 2000's fleet will consist of aircraft built after 1980. Since almost all of the current GA aircraft have been built since 1960, this production rate assumes that replacement will be necessary of only half of the current fleet by 2000. The best estimate is a GA fleet of 430,000 aircraft.

By estimating the yearly utilization of these various types of aircraft, the total number of annual hours can be derived and then broken down into itinerant and local hours. By estimating the duration of a typical itinerant and local flight, the total number of flights is obtained by dividing the number of hours by the duration of the flights. To obtain the number of operations, it is estimated that a typical local flight consists of six operations (3 take-offs and 3 landings), while an itinerant flight by definition consists of 2 operations. Thus the total number of operations is obtained by summing the local and itinerant operations. Finally, by estimating the percentage of all operations which are made at towered facilities, the total number of tower operations is obtained. This process is shown in Table 3.4. The results are shown in Figure 3.14.

The estimate of a 3.5% average annual growth rate for the GA fleet is lower than the historic trend (1960-1980) of 5%, indicating that general aviation is approaching maturity as well.

Table 3.3

GROWTH OF ACTIVE GENERAL AVIATION FLEET BY AIRCRAFT TYPE TO THE YEAR 2000

NUMBER OF AIRCRAFT (000)

Aircraft Type	1973	1979	Compound Annual Growth Rate in %	Extrapolated to Year 2000	Best Estimate Percent Growth	Best Estimate Total Aircraft
FIXED WING						
1-engine piston 1-3 seats	51	62	3.3	124	2	90
1-engine piston 4+ seats	75	106	6.0	354	2	160
2-engine piston 1-6 seats	13	17	3.9	38	4	35
2-engine piston 7+ seats	5	8	7.9	39	6	25
2-engine turboprop 1-12 seats	1	3	15	55	10	20
2-engine turboprop 13+ seats	0.5	0.5	1.0	1	5	1
2-engine turbojet	1.2	2.3	11.6	23	10	28
Other turbojet	0.2	0.3	10.9	3	6	1
ROTORCRAFT						
Piston	2	3	6.7	12	6	10
Turbine	1	3	18.4	93	11	25
OTHER	2	5	13.8	72	10	35
TOTAL AIRCRAFT	153	210	5.4	814		430

Table 3.4

<u>GA Forecasting Matrix (Year 2000)</u>

Aircraft Type	Projected No. (10^3)	Average Utilization	Total Hrs (10^6)	Total Hrs (10^6) Itin.	Total Hrs (10^6) Local	Flights (10^6) ΔFlight (Hr) Itin.	Flights (10^6) ΔFlight (Hr) Local	Operations (10^6) Op/Flight Itin.	Operations (10^6) Op/Flight Local	Total Ops (10^6)	Ops at Towers
				70%	30%	1.0	0.8	2	6		20%
Single Engine, Piston	250	200	50	35	15	35	19	70	110	180	35
				90%	10%	1.3	0.6	2	6		30%
Multiengine, Piston	60	280	17	15	2	12	3	24	20	44	15
				95%	5%	1.2	0.7	2	6		60%
Turbine (Prop & jet)	50	500	13	12	1	10	1	20	6	26	15
				80%	20%	0.7	0.5	2	6		10%
Other	70	300	20	16	4	20	8	40	48	88	10
TOTALS	430	250	100	78	22	77	31	154	184	338	75
Annual Growth Rate	3.5%	1%	4%								2%

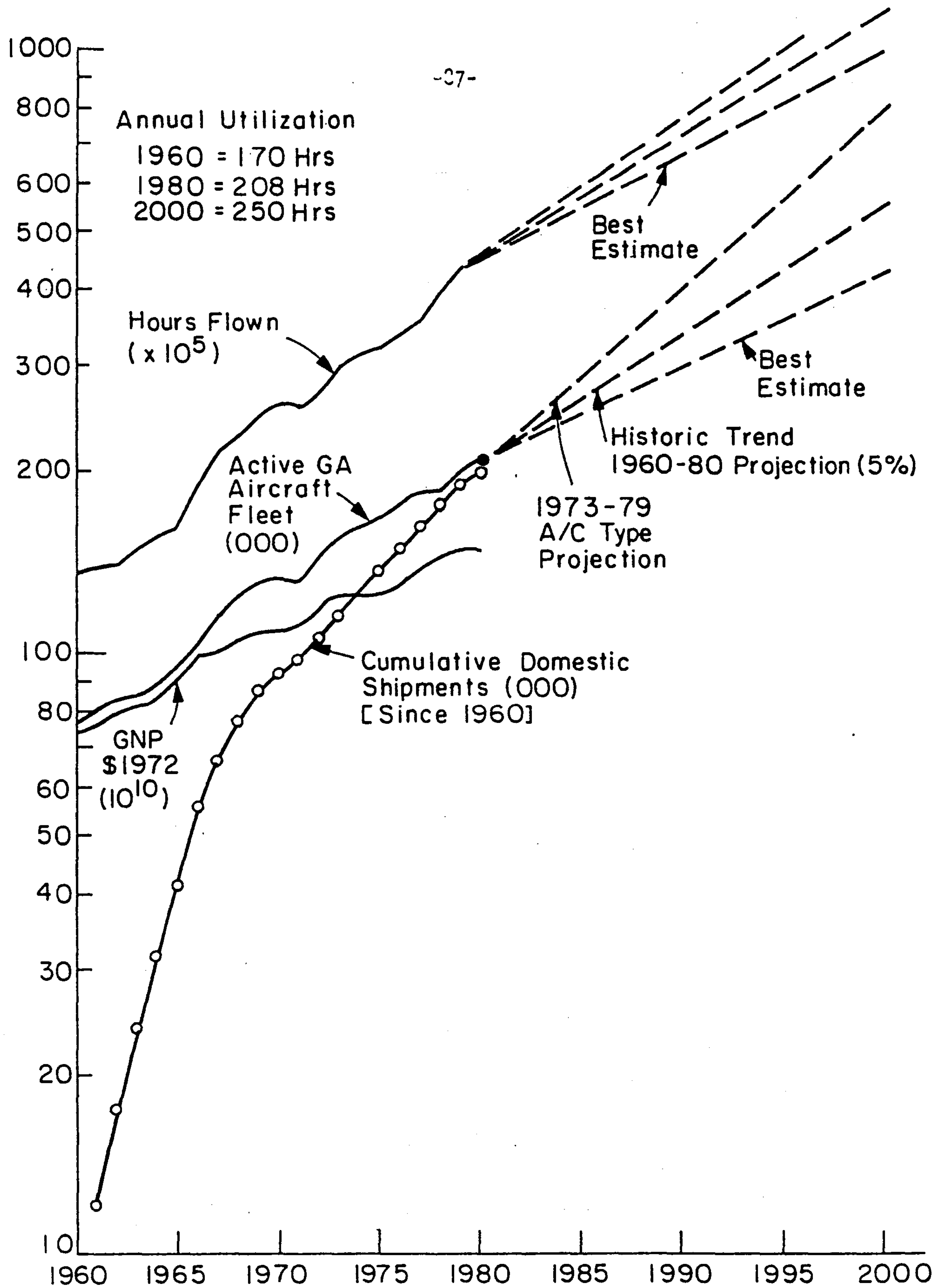


FIGURE 3.14 GA ACTIVITY

3.4 The Airports and the ATC System

The concept of "better lucky than smart" applies to the forecaster as well as to the lottery player -- perhaps even more so. Thus the fortuitous development and publication of the FAA's "National Airspace System Plan" in early 1982, which details the step-by-step development of the ATC system that the FAA intends to undertake to the year 2000, makes the forecast for this area seemingly as simple as copying appropriate pages of the report and including them in this section. Table 3.5 provides an overview of expected developments.

To be sure,some complaints about the plan have come in, but in general it is supported by all segments of the aviation community (Simpson, 1982). General aviation, as usual, complains about the implied user equipment costs to operate in the system. The Airline Pilots Association's (ALPA) favorite technological solution to ATC, the CDTI (Cockpit Display of Traffic Information), is given short shrift as Administrator Helms feels the FAA cannot share ATC responsibility with pilots in this century. The major attacks on the program have come on the FAA's treatment of airport capacity. Although there are capacity improvements, such as MLS, advanced metering and spacing of arrivals, and wake vortex detection systems, the FAA projects congestion to continue (Table 3.6). The Plan notes that:

> ... it is the growth in major metropolitan areas... which causes special concern. These areas contain the largest concentration of aviation industry consumers, representing 90 percent of the air carrier enplanements and 40 percent of itinerant aircraft operations (in 1981 figures). They also represent areas in which growth is most difficult. Because of their high population density, increasing resistance to the adverse environmental impact of airport growth, and the expensive and difficult task

> of land acquisition for the enlargement of existing facilities or construction of new airports, expansion in these areas is nearly impossible. Additionally, citizens in many metropolitan areas are pressing to limit, not expand, aircraft operations.
>
> Strained commercial airport capacity and constricted growth translate into system congestion...(at) those airports which already are or will experience severe airside congestion...during peak hours, aircraft are expected to encounter average delays of 30 minutes per operation. Some congestion will be relieved through developments in airport design, reductions in aircraft separation standards, improvements in landing aids and use of advanced STOL aircraft. However, these alone will not provide the capacity for expansion which is needed to meet future aviation demands at these locations. It may therefore become necessary to impose quotas and flow control restrictions at the affected airports. This will result in schedule changes for alleviating peak hour congestion, flights being shifted to alternate airports, and some flights being cancelled altogether....

A fairly bleak picture, all after an estimated expenditure of $1 billion per year to the year 2000 to put the plan into place. However, there may be a more cheerful resolution. The FAA's gloomy view of congestion is predicated upon its demand forecasts which envision much more airline industry activity than is deemed possible in this analysis. A smaller (25%) set of estimates based on the work of the preceding chapters is shown in Figure 3.15. Thus the FAA, too, may be more lucky than smart, and with the aid of non-capital techniques (Table 3.7), the airlines and general aviation may have far better service than that indicated in Table 3.6. It is imperative, however, that the FAA's plan, or something similar to it, be implemented for the aviation system to remain viable in the year 2000.

Table 3.5: ATC System Utilization

	1981	1985	1990	2000
NAVIGATION				
VOR/VORTAC	W	W	W	W
SATELLITE NAV			L	L
DME	W	W	W	W
INS	L	I	I	W
LORAN C	L	L	L	L
OMEGA/VLF	L	L	L	L
DOPPLER	L	D	D	D
NDB	W	W	W	W
RNAV	W	W	W	W
4D RNAV		L	W	W
MAPPING (an enroute map display)	L	I	W	
COMMUNICATION & DATA LINK				
VHF COMM	W	W	W	W
UHF COMM	W	W	W	D
HF COMM	W	W	W	E
MODE S			L	W
ACARS	W	W	W	W
SATELLITE			L	I
VHF WEATHER DATA BROADCAST (VOR)		L	W	W
HF DATA LINK			L	W
AIRCRAFT SEPARATION				
EFR (Electronic Flight Rules)				L
TCAS II		L	W	W
TCAS I			L	I
ATAS (TERMINAL) (Automated Terminal Advisory Service)			L	I
CDTI (Cockpit Display of Traffic Information)			L	I
ALTIMETRY			L	W
ATCRBS	W	W	D	D
MODE S			W	W
FMS (Flight Management Systems)	L	I	W	W
LANDING SYSTEMS				
MLS			W	W
ILS	W	W	W	D
ADF	W	W	W	D
VOR	W	W	W	W
RNAV	L	L	I	W
CAT IIIA	L	I	W	W
CAT IIB		L	W	W
HUD (Head Up Display)		L	I	W
ADVANCED HDD (New generation CRT displays)		L	I	W
ELEC. APPR. PLATE (Electronic stored and displayed approach plates)			L	I

LEGEND: L-LIMITED USE
I-INCREASING USE
W-WIDESPREAD USE
D-DECREASING USE

Table 3.6

AIRPORTS WITH SEVERE AIRSIDE CONGESTION

YEAR	AIR CARRIER	COMMUTER	RELIEVER	GENERAL AVIATION	TOTAL
1981	8		3		11
1985	10	1	7		18
1990	23	5	11	2	41
2000	46	9	29	7	91

SOURCE: National Airspace System Plan (1981)

Table 3.7

NON-CAPITAL ALTERNATIVES FOR REDUCING CONGESTION

		TYPE OF ALTERNATIVE	
GENERAL APPROACH	SPECIFIC APPROACH	PRICE	NON-PRICE
Redistribution of activity by time	Transfer between hours	Time differentiated fares	Quotas on aircraft operations
		Peak period activity fee	
Redistribution of activity by area	Transfer between airports	Fare differentiation by airport with rebate at non-congested hub airports	Quotas on aircraft operations
			Perimeter rule
			Aircraft type restrictions
Reduce overall activity level	Reduce frequency	Peak period activity fee	Quotas on aircraft operations
		Fuel tax	Perimeter rule
			Aircraft type restrictions
			Capacity limitation agreements
	Change aircraft mix	Peak period activity fee	Quotas on aircraft operations
			Perimeter rule
			Aircraft type restrictions
	Change network	All of the above have the potential to modify the network structure	

SOURCE: Peat,Marwick & Mitchell (1979)

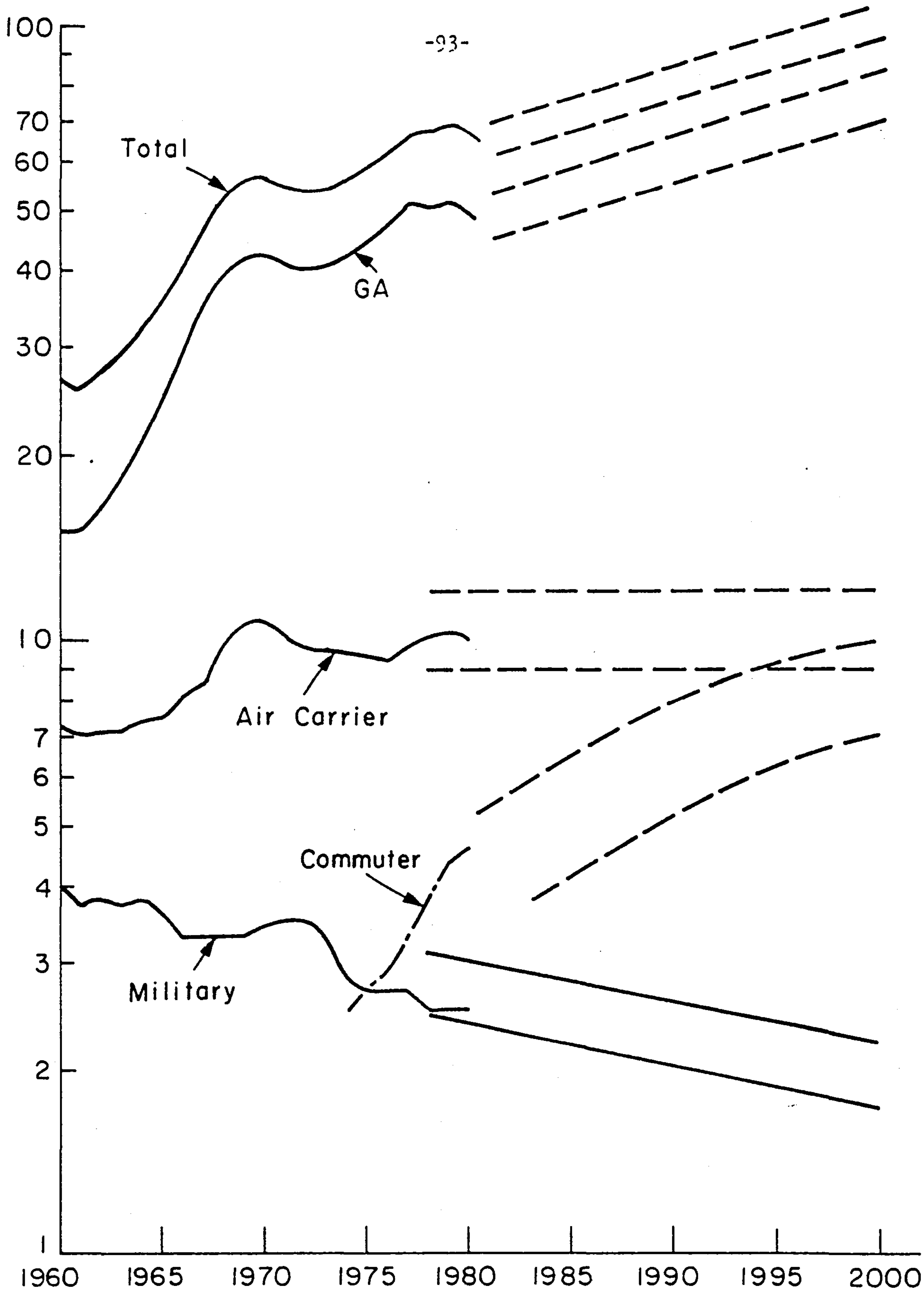


FIGURE 3.15 AIRCRAFT OPERATIONS AT FAA CONTROL AIRPORTS (MILLIONS)

3.5 Technology Forecasts

Technological forecasting is generally defined as the forecasting of technological change. It can be divided conveniently into invention (the creation of a new product or process), innovation (the first introduction of that product or process into use), and diffusion (the spread of that product or process beyond the first use)(Schon, 1965).

Technological forecasting is an arcane enough branch of futurology (also called futuristics or futurism) and a cottage industry large enough to have started its own journal. However, the journal was quickly coopted by social scientists (Technological Forecasting (1969-1970); Technological Forecasting and Social Change (1970-1982)).

Futurology itself is hardly a cottage industry but a thriving field with its own monthly (The Futurist), association (World Future Society), and conventions (General Assembly of the World Future Society). In a primer on futurology, Cornish (1977) provides a bibliography of over a hundred future-oriented books (and a reference to a longer listing), ranging from the simplistic (Bright, J.R. A Brief Introduction to Technology Forecasting Concepts and Exercises, 1972) to the far out (Arthur C. Clarke's Imperial Earth, a science-fiction novel about the U.S. in 2276); also included are the better known works by Herman Kahn (i.e., The Year 2000) and Alvin Toffler (i.e., Future Shock). At one extreme of futurology, all works of science-fiction can be included, although futurists tend to fancy themselves more portentously and liken their work to research produced by the more commonly accepted physical (or even social) scientists.

In the very first issue of Technological Forecasting (June, 1969), Bouladon considered the question of "Aviation's Role in Future Transportation" up to the year 2000. While noting that "technological forecasting is an art and not a science," he advanced a number of techniques of the field. One is the theory of technical development cycles (10 years for aviation). The envelope curve method combined with the pilot phenomenon (correlation with speeds of military aircraft which shows a 20-year lag for commercial aircraft) indicated that speeds in excess of Mach 12 would have little commercial value. By next considering the "transport function" (an envelope of all transportation speed curves) and extrapolating it to the year 2000, Bouladon foresaw not only the need for a supersonic (Mach 2), but also a hypersonic (Mach 6) aircraft. The transport function also identified a need for a V/STOL aircraft (or a compound rigid rotor helicopter) for distances between 50 and 250 miles. Aviation technology saw no limits in 1968, except human; worth noting are Bouladon's concluding remarks:

> Thus, the future of aviation seems bright, but there is one condition: it must be realized that its limitations are human and not technical. Administrators must tackle the difficult problem of airports with imagination and courage, and scientists must try to introduce their techniques into human life in such a way as to respect man's nature and environment.
>
> In the last resort, it is the way the problems of safety, noise, pollution, and pilot training, among other factors, are handled that will determine whether this brilliant potential future actually comes about.

With the death of the U.S. SST in Congress in March, 1971, technological virtuosity in itself no longer justified a production line in aviation. The old transport function had become inoperable and airlines could no longer count on improved quality of air service (by virtue of higher speed) to attract customers. But technological optimists have not totally given up on the SST (or even the hypersonic transport (HST)), and engineers (mostly at NASA) are continuing research on aerodynamics with hopes of minimizing, if not eliminating, the sonic boom. While most of the technology for a second generation Mach 3 SST seems in place, with the variable cycle engine in particular showing high promise for fuel efficiency, the sonic boom problem effectively limits the SST to over water operations and thus curtails the marketability of the aircraft. American manufacturers, while maintaining skeleton design teams for supersonic aircraft, see the remaining decades of this century in subsonic terms (Steiner, 1977). Yet deep inside these companies some SST moles remain (Schairer, 1976).

Of more immediate concern to the U.S. manufacturers (and Airbus Industrie) is the glut of available airline seats in the US which has come about as a result of declining (even reversing) traffic,whereas the airline fleet plans had been based on ever expanding growth. This excess capacity, (calculated as the equivalent of 315 175-seat aircraft) has caused cessation and cancellation of new aircraft orders and options (Merrill Lynch, 1982). Boeing, Douglas and Lockheed have been in this situation before in the early 1970's when misplaced exuberance of the airlines in the late 1960's led them to order and the manufacturers to build too many airplanes of the wrong size (Newhouse, 1982). It is estimated that there are currently some 200 used widebodies for sale (as well as the entire Braniff fleet, of course).

The pattern of surplus seats and dwindling orders at the beginning of each decade of the jet age seems to have become permanent. How many more times the airframe (and engine) manufacturers will continue to bet their companies on new aircraft (and engines), rather than build derivatives of old types, is a question that will become harder and harder to answer. General Dynamics (Convair) got out of the game after the 880 and 990 fiascos. Lockheed has just abandoned the L-1011 -- to cheers from Wall Street. Only the DC-9 has any orders left at Douglas. Boeing has seen millions of dollars worth of cancellations and delays of orders and options of the 757 and 767 come in from American and United Airlines. Only Delta is holding firm. As fuel prices have stabilized, fuel efficiency, the major advantage of the new airplanes, has become less of an issue than plain survival of the airlines. Boeing, which currently makes six of every ten commercial aircraft in the world, should survive its latest crisis, having learned some lessons from the 1969-1971 period when employment had to be cut from 101,000 to 37,500 (although it now has the Airbus A300 and A310 to contend with). After the near term problems of declining traffic have resolved themselves, i.e., the economy improves, which it will sooner (maybe this year) or later (?), orders for airplanes will come in. Timing may be crucial, however. Even though Boeing is estimating that 40% of the total world-wide commercial fleets will need replacement before 1992 (worth $126 billion) (Aviation Daily, 12/81), it can be postponed. Many airlines may retain a substantial number of standard-body twin and trijet aircraft into the 1990's. Only when an airplane is economically obsolete (it can no longer generate a positive cash flow) must it be replaced (Munson, 1982). Certainly Boeing and Airbus Industrie will be building large jet transport aircraft into the rest of the 1900's (Table 3.8).

At the lower end of the market, second generation small turboprop aircraft are beginning to arrive to serve the commuter (now called regional) industry to supplement (and replace) the DeHavilland of Canada Twin Otters (1966 vintage) and Beech 99's (1968), which have been the mainstay of the upper end of the industry up to now. (The lower end will continue to be served by the likes of the Piper Chieftain and the Cessna 402.) The unregulated commuters, which had been limited to aircraft of less then 30 seats prior to the Deregulation Act, can now fly aircraft of up to 60 seats, and manufacturers are rushing in to fill the void between 30 and 60 seats. At least seven new turboprop aircraft are being offered. Only one of the manufacturers is strictly American, and it is also the one that is least likely to succeed (the four engine CAC-100). The others are: (1) French-Italian ATR 42; (2) Spanish-Indonesian CN-235; (3) Swedish-US SF-340; (4) Canadian DHC-8; (5) Brazilian Brasilia; (6) Northern Irish Shorts 360. It is hard to see how all these lines can be successful.

All these new aircraft, small and large, have lower operating costs due to technological advances of the past twenty years. These advances will continue. Noted earlier were expected engine improvements which will cut fuel consumption (Figure 3.10). Additional improvements are expected in aerodynamics, structures, systems, and flight management. Active controls are already in airline use on the L-1011; more will be employed. (Active control technology combines sensors and computerized electronics to reduce structural loading and to impart artificial stability; consequently the size of the horizontal tail can be reduced.) In structures more use will be made of advanced composites which will lead to significant weight reductions.

All-electric systems technology will continue to develop and make fly-by-wire airplanes possible during the 1990's. The elimination of cables and hydraulic systems will lead to significant redesign of the cockpit and reduction of pilot workload. Finally, if laminar flow control can be achieved, fuel savings of 25% to 30% will be realized (Steiner, 1980).

Aside from changes in commercial transport aircraft, other technological developments will take place in the aviation system. A prop-fan aircraft in commercial use for short-medium ranges holds out the promise of significant fuel savings, 8% to 15% compared to equivalent technology turbofans (Gatzen and Adamson, 1981). Problems with the gearbox, propeller, and installation aspects (noise and vibration) remain; airline acceptability is yet another question (Fairless, 1980). In the short-haul area rotorcraft have long been considered as the answer to airport congestion, yet implementation of commercial service has been notable for failures (in New York, Chicago, San Francisco and Los Angeles). With the technology of advanced helicopters and tilt-rotors, this long-held promise may yet be fulfilled (Williams, 1980). In the STOL area, aside from the DeHavilland of Canada Dash 7, transports using augmented lift may appear. Although the technology to build very large (super large) aircraft exists today, there appears to be little demand for them, either in passenger or cargo configurations. Studies of very large aircraft,with or without nuclear propulsion, will continue (Layton, 1979). Other advanced concepts, such as the Aerial Relay System (Kyser, 1979), will also be left for the next century.

Only a sickly economy stands in the way of increased use of business jets. There are now more private jet planes in the US than commercial transport aircraft. US companies (more than half of the top 1,000 corporations) operate one or more aircraft, and this trend is expected to continue, with jets expected to have one of the highest growth rate in the GA fleet (Table 3.4) ("Torch up the Learjet!")

The use of the business jet is not the only potential constraint on business travel on the domestic airlines. There will also be technological improvements in telecommunications. The growth of cable television will continue, with two-way communication (videotex and teletext) becoming more prevalent; 40% of American households are projected to have two-way videotex service to the end of the century (Institute of the Future, 1982). People will become glued to the TV -- information fanatics. However, it is the growth in teleconferencing that may be more important for the travel industry. Although closed circuit television has been around for years, the proliferation of communication satellites in the last five years has made multi-city,audio-video hook-ups cheaper and easier. Hospitals, colleges and hotel chains are equipping themselves with video dish receivers that can be used for cable television and teleconferencing. Companies have sprung up that arrange satellite hook-ups for any occasion. Large multinational corporations can hold video conferences that tie together their world-wide activities via satellite networks.

And not to forget Mother Bell -- she wants to replace her old two-way Picturephone service, which has been in operation for 15 years, with an expanded, more advanced system. When in place in 1983, there will be studios in 42 cities. Businessmen in two (or more) of these cities will be able to lease these facilities from AT&T and hold meetings over closed-circuit color television. Whether all this teleconferencing capability will reduce travel or simply enhance communications is not clear (Mitre, 1978). Certainly a great deal of intra-company communication can be accomplished via teleconferencing.

However, executives have come to regard some travel as a perquisite -- conventions, industry association meetings, and similar junkets will continue to attract the travelers anxious to get away from the office for a few days. This state of affairs is unlikely to change by the year 2000 (or later).

Table 3.8

JET AIRCRAFT TO THE YEAR 2000

Category	Current and Committed	Possible Additions
SHORT RANGE	737-200/300	F-29
	DC-9-30/80	757 Derivative
	747SR	A 320
	BAC-111	
	F-28	
	BAE 146	
MEDIUM RANGE	727-200	727-RE
	A300	767 Stretch
	A310	DC-10 Derivative
	DC-10-10	
	L-1011	
	767	
	757	
LONG RANGE	707-320C	7-7
	DC-10-30/40	747 Derivative
	747-100/200	A300 Derivative
	747SP	DC-10 Derivative
	L-1011-500	
	DC-8-70	
FREIGHTER	747F/C	A300F/C
	DC-10CF	767F/C

SOURCE: Steiner (1980)

4. What Is to be Done: A Summary

Technological progress in the form of higher productivity aircraft accelerated the growth of the aviation system in the United States, abetted by favorable economic and demographic changes. Productivity improvements led to lower operating costs and fares; the economy cooperated by providing more real income. As the quality of air transportation improved simultaneously with price reductions, airline passengers multiplied. General aviation activities showed similar growth.

Whereas the first cycle of the jet age continued the aviation technology trends of increased speed at lower seat-mile costs, the second cycle - the wide-bodies - no longer moved upward on the speed scale. (The favorable seat-mile trends continued - no mean feat.) Even as the wide-bodies were being introduced, it was still thought that the SST's would soon appear on their rightful place on the speed curve and that the slow 747's would be confined to freight and charter work. But SST technology ran into economic and environmental thickets. While the Concorde flies on, it is one of a kind, and not the forerunner of fleets of SST's and HST's. The 757's, 767's and A300's are being bought for fuel efficiency, not speed. Nor are the airplanes getting larger, although seating densities are increasing - utilization aside, is the long productivity improvement game over?

For long range aircraft, certainly, quantum jumps appear unlikely. While technological improvements will be gradually integrated into the new jets (digital avionics, fuel efficient engines, active controls, etc.) the emphasis at Boeing, Douglas and Airbus will remain on cost reductions rather than speed increases. General aviation and commuter-sized turboprop production aircraft will also continue to benefit from technological progress.

Still, serendipidity can also play a part in the aerospace industry. Laminar flow control, a new shape ("Pepsi - bottle"?), or super-composite materials could bring forth new aircraft designs with quantitative (cost) and qualitative (speed) gains greatly stimulating personal air travel, as did the original jets. Barring revolutionary breakthroughs at airframe and engine manufacturers, where should research be concentrated?

High speed and short haul are the logical answers. Although the SST is temporarily sidetracked, a boomless (or near-boomless) SST over land, if economically feasible, would have the airlines rushing to place orders (and people rushing to fill the seats). These two big ifs, noise and economics, should be the main areas of high speed research. Solutions would lead to the third cycle in jet technology, or more properly, the long delayed second.

The other logical candidate for research is short haul travel. Great as the airline boom has been, it still has not penetrated the 85% of intercity travel done by car. Perhaps it is an impossible task, given the economics and the convenience of the personal automobile. Perceived costs amount to gasoline purchases; there is no hassle changing modes at either end of the trip to reach the ultimate destination (which is hardly ever an airport). Still, the promise of rotorcraft or short take-off and landing technology for public transportation has largely been unfulfilled. STOL systems (Twin Otter or Dash-7 demonstrations in Canada aside) foundered, among other factors, on the unavailability of the downtown STOLport. High operating costs of rotorcraft made them useless for public travel.

Even if people want to travel from downtown to downtown, large cities, which could support this kind of service, lack the empty spaces required for STOL operation; only rotorcraft will suffice. STOL aircraft, however, are well suited to offload short haul traffic from the long runways at major airports and thus ameliorate the capacity problem. Thus both rotorcraft and STOL aircraft are worthy of continued research efforts.

Basic research in aeronautics must also continue since it is here that revolutionary, as well as evolutionary, advances can be made. Nor should analyses of different concepts of travel be neglected: often today's far-out idea is tomorrow's commonplace.

5. Apocalypse Now?

The aviation system is maturing rapidly, if indeed it is not already mature (in the sense of rising and falling with the GNP). This is as true in general aviation (although some sectors will remain high growth areas) as in the airline industry. But while maturity is hardly cause for despair, it will call for greater wisdom in the management ranks -- no longer will automatic traffic growth (and the CAB) protect the airlines from themselves. The race will go to the swift -- those airlines able to reequip themselves with the technologically advanced aircraft of the eighties and nineties and those airlines which structure their networks (and fares) to fit their equipment (and cost structures) best.

This will be true (especially true) if another oil crisis occurs: either a second Arab oil embargo or the interruption (cessation) of the flow of Saudi Arabian oil. Although oil imports have stabilized since 1977, the US is still importing 2,300 millions of barrels annually, accounting for some 20% of the consumption (80% are OPEC barrels, of which 20% is Saudi crude). Only 265 million barrels have been stored in the Strategic Petroleum Reserve (some 40 days worth of imports). Even pessimists agree that another surge in oil prices is unlikely until the world recovers from its current economic malaise (induced in part by the first two oil shocks of 1973 and 1979). When (and if) demand for oil increases, and prices should double, a sharp increase in inflation will be followed by a severe recession -- businesses would fail and unemployment rise -- a not unfamiliar picture. Observers note that the Middle East is becoming more unstable -- revolutions, coups, social upheavals, regional wars, possible Soviet expansionism -- and that continued US (and world) dependence on that region for oil supplies is foolhardy (Yergin, 1982). Should a world energy crisis occur, and some postulate this as a possible scenario before the year 2000 (Ayres, 1979), aviation will be only one of many sectors that will suffer severely. (It will take truly bad luck for the world to blunder into outright cataclysmic events -- a nuclear war, for example -- these are not considered further.)

The rise in US airline RPMs to the 300-360 million range by 2000 has been postulated on continued economic growth (not year to year, necessarily, but cumulatively over the next twenty years) of about 2.5%, compounded annually. Traffic growth will be accommodated not by increased operations but by a continued shift to larger aircraft. Although aeronautical engineering has progressed to the point where small (130 seat) jet aircraft can be operated at the same seat-mile costs as large (400 seat) aircraft, congestion at major airports will lead the major airlines to purchase large aircraft. However, the low seat-mile costs of the smaller new technology aircraft will also increase direct service by the smaller airlines between smaller hubs, relieving pressure at the larger hubs (and relieving the major airlines of connecting traffic). GA traffic will continue to use small and large hubs (sharing non-duty runways with commuters), although reliever airports will also increase. Ground access problems will plague various airports, and airport authorities will continue their struggles to solve them. Certainly they will not inhibit traffic growth to any measurable degree.

Deregulation, a dozen new airlines, recessions, falling traffic, suicidal fare wars, the ATC controllers' strike plus mass firings and reregulation by the FAA via the slot assignment route, loss of faith by the travel agents, and, above all, poor management, led to Braniff's bankruptcy. By the year 2000, will others join?

In any analysis of the airline industry it is important to remember that not all airlines are created equal. The big airlines are really large. In domestic operations in 1981, American flew 26 billion RPMs; Delta 23; Eastern 24; Pan Am 8 (29 including international operations); TWA 16 (26 including international) and United 34. (All of these airlines also had operating revenues of over $3 billion). In domestic operations the old trunks (the above plus Braniff, Continental, Northwest and Western) generated 160 billion RPMs while the old locals (Frontier, Ozark, Piedmont, Republic [i.e., North Central plus Southern plus Hughes Airwest], Texas International, and US Air [old Allegheny]) flew 24 billion rpms. Thus any of the top five trunks flew more RPMs than all the locals.

However, since deregulation the trunks' share of the total US market has declined from 88% in 1978 to 81% in 1981. Their own RPMs have been slipping (164 billion in 1978 versus 160 billion in 1981) while the old locals' have been rising (16 billion 1978; 24 billion in 1981). Also rising has been traffic on old intrastate and commuter airlines, as well as new entrants. New entrants are mere gnats in the airline aviary -- combined they managed to fly 1.4 billion RPMs in 1981. Talk of the new entrants bringing down an established carrier is somewhat premature. Braniff's (6.3 billion domestic RPMs, 8.8 total) demise was not caused by its long feud with Southwest (2.3 billion RPMs) -- only when it tried to undercut American, which had established a rival hub at Dallas, did its troubles magnify.

However, RPMs, or even operating revenues, are but one part of the picture. To keep flying, the airlines must at least break even; to expand or to reequip obsolescent fleets they must make a profit. The operating margin, the difference between passenger yield and cost per available seat mile, reflects how well management runs its operations. Any non-operating expenses, such as interest expense and debt load, will further reduce the overall profit. Although Braniff's yield/cost spread was approximately in the middle of US airlines (3.34 cents), non-operating expenses expedited its collapse.

Managements can increase the spread by increasing yield (fares), or at least not decrease it through ineffective discount fares or predatory fare wars. However, competition can always appear on one's routes. More likely to be affected by management action is the cost side of the spread equation. It will be even more important in the future after all price controls will be abandoned by the CAB after the end of 1982. In any future head-on competition, the low-cost carriers will have the advantage. That is why the large carriers feel so threatened by the pygmies, the new entrants. As noted earlier, labor is the easiest (the only, sometimes) cost factor for managements to control and will remain so in the future. How labor responds will determine the future of the industry.

Three scenarios of the airline industry can be considered for the year 2000. They cover a range of possibilities, but obviously are not an exhaustive set. Even if none are likely to come about in their entirety, some elements of each scenario can be considered as strong probabilities. An assumption common to all scenarios is that deregulation will continue at the entry and exit level, i.e., franchises will no longer be handed out (or sold) for routes by the CAB (or its successor agency). A return to some minimal fare regulation is permissible under these scenarios, with fares possibly differentiated by equipment type as well as quality of service (first class, business class, economy class, cattle-car class), but basically fare distinctions will also prevail.

Some type of essential air service (possibly under another name) will be provided by small airlines to small communities. Subsidy payments by the federal government will continue to underwrite these flights which will use small (less than 60 seat) propeller-driven aircraft.

Under Scenario A (Table 5.1) a continuation of present trends is expected. Growth of the old local airlines (the second tier) continues as they take over more of the short-haul (under 1,000 mile)markets from the trunks; continued profits allow them to acquire new aircraft when needed. Some trunks purposefully reduce their size: unable to purchase efficient new aircraft, they shed routes as planes become obsolescent. After another major carrier (the Lorenzo conglomerate of Continental, Texas Int'l and NY Air) goes under, labor continues to concede in wage and productivity negotiations at larger, high-cost airlines, allowing them to stay in business. However, the specialized third-tier carriers continue to have cost-advantages, especially as new ones are created. These new entrants continue serving short-medium haul markets of medium traffic density. Some third-tier carriers move up into the second tier after expansion. Mergers subside after TWA and Northwest combine to provide better feed to a rationalized international network. Commuters feed the first and second tiers.

Scenario B (Table 5.2) continues where scenario A leaves off. As traffic growth resumes, all airlines are making profits and labor demands its share. Managements, having barely survived the lean years, balk and insist on conserving profits to reequip their fleets. Strikes and slowdowns hit major and minor airlines alike. Some (Eastern, Republic, Western) do not survive because labor and management are obstinate. After labor protective provisions for airlines are eliminated in Congress, U.S. Air and Ozark merge to create a two-hub (Pittsburgh, St. Louis) middle-America airline. A bill passes Congress granting anti-trust immunity to U.S. international airlines as Pan Am and TWA/NWA merge to create American World Airways, "the chosen instrument".

Scenario C (Table 5.3) takes scenario B one step further. Tired of losing market share to the second tier, the remaining large airlines coopt their local regional airlines to provide themselves with better feed out of their major hubs. Four mega-airlines in the US emerge: three domestic and one international. American/Southwest controls the southwest from Dallas; United/Frontier the middle and west from Chicago and Denver; and Delta/Piedmont the east from Atlanta. The international airline, American World Airways, acquires US Air to serve as an internal feeder, carrying the Allegheny commuter idea to its logical conclusion. These large, capital-rich airlines do not tolerate competition on their routes as they undersell the small third-tier airlines and force them to disband. Some regional airlines (i.e., Air Wisconsin) survive to serve those medium-sized points which the mega-airlines cannot economically serve due to equipment limitations (the

737-300 is the smallest aircraft in their fleets). The commuters, under whatever name, continue to exist.

While scenarios are interesting, twenty years is a long time. Even broad trends upon which they are based can be reversed -- a large amount of uncertainty always masks the future. However, there appears to be nothing inherent in the aviation system that will stop the projected growth, although it may be choppy at times. All potentially retarding elements come from outside the system. Should they come into play, much more than aviation will suffer. The economy of the United States and its aviation system will rise and fall in tandem.

As Ira, the resident first-grade philosopher in the Miss Peach comic strip, observed many years ago: "And suppose if once I become mature, I find I don't like it..? --There's no turning back, is there?"

Table 5.1

SCENARIO A: LABOR PEACE

TIER	SURVIVORS	MERGERS	DISBANDED/BROKE
1ST TIER (Super-Markets)	American Delta Eastern Pan Am United	TWA/Northwest	Braniff Continental
2ND TIER (Large neighborhood Stores)	Frontier Ozark Piedmont Republic Southwest US Air Western		New York Air Texas International
3RD TIER (Discount Houses and Boutiques)	20-30 (with intermittent changes in name): Midway, People Express, New York Air, Capital, World, etc. Some try to move to 2nd tier (Air Florida)		
4TH TIER (Ma-and-Pa Stores)	About 50-100 commuters (regional airlines with intermittent changes in name). Some try to move to 3rd tier (Altair, Empire, Air Wisconsin)		

Table 5.2

SCENARIO B: LABOR TURMOIL

TIERS	SURVIVORS	MERGERS	DISBANDED/BROKE
1ST TIER (Super-Markets)	American Delta United	Pan Am/TWA/Northwest	Braniff Continental Eastern
2ND TIER (Large Neighborhood Stores)	Frontier Piedmont Southwest	US Air/Ozark	New York Air Republic Texas International Western
3RD TIER (Discount Houses and Boutiques)	Same as Scenario A		
4TH TIER (Ma-and-Pa Stores)	Same as Scenario A		

Table 5.3

SCENARIO C: ASSET PLAY

	SURVIVORS	MERGERS	DISBANDED/BROKE
1ST TIER (Mega-Markets)		American/Southwest United/Frontier Delta/Piedmont PA/TWA/NW/US Air	Braniff Continental Eastern
2ND TIER		All Survivors merged into 1st tier	Republic Texas International Western
3RD TIER (Small Neighborhood Specialty Shops)	Air Wisconsin Altair Air Cal PSA		Midway People Express Air Florida New York Air
4TH TIER (Ma-and-Pa Stores)	About 50-100 commuters providing feed to 1st Tier		

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15. Supplementary Notes
Technical Representatives: R. Letchworth, M. Winston, ASD
NASA Langley Research Center
Hampton, Virginia 23665

16. Abstract

The aviation system of the U.S. is described. Growth of the system over the past twenty years is analyzed. Long-term and short-term causes of air travel are discussed. A nomograph is developed which shows the interaction of economic growth, airline yields, and quality of service in producing domestic traffic. Forecasts are made for airline and general aviation growth. Potential airline scenarios to year 2000 are presented.

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