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Cargo/Logistics Airlift System Study (CLASS)

Volume I

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INTRODUCTION

Background

Although cargo has been carried in aircraft since the 1920's, aviation was not seriously considered as a viable civil cargo mode until after World War II. The massive requirements for men and machinery during the war had forced the development of air support systems which could transport men and material all over the world. There were major technological breakthroughs during this period not the least of which was the jet engine. After the war, this expertise was transferred to commercial operations.

The big breakthrough in aircraft performance & economics occurred with the introduction of larger, jet-powered planes in the sixties. Air carriers found the Boeing 707 or Douglas DC-8 could carry full load of passengers and their baggage and still have surplus belly capacity which could be used for cargo.

Another major inducement for increased air freight transportation at that time was a decrease in operating costs brought about by these new aircraft. The total operating costs of the 707/DC-8 jet freighters were near 12 cents per ton-mile (17.28 cents per metric ton - km) when they were introduced in 1963, compared with the propeller-driven aircraft still in use at that time which generated costs around 30 cents per ton-mile (43.2 cents per metric ton - km). Total fleet operating costs dropped from the 30-cent (43.2-cent) level with all propeller aircraft to about 16 cents (23 cents) in 1966 with a mix of prop and jet aircraft.

Jet freighters also had a much higher productivity. A 707-320C can carry about three times the payload of the DC-7F and will fly twice as many miles per year, meaning a six-fold increase in productivity. The maintenance cost of a 707, per flight hour, was not substantially higher than that of a DC-7, indicating operating economics which led to a fairly rapid conversion in the airline fleets to jet aircraft.

There was a parallel revolution in freight handling. Unit loading of aircraft began. Cargo was unitized on pallets or in unique containers designed to the internal configurations of the aircraft. This had a favorable influence on indirect operating costs. The comparatively recent introduction of the wide body jets such as the 747, DC-10 and L-1011 has dramatically increased the cargo capacity of the air freight industry. The L-100 commercial freghter version of the military C-130 Hercules has also had an impact on the development of commercial air cargo transport. The increased range and fuel efficiency of these aircraft coupled with an interior design that can accommodate 8 x 8 x 40-foot (2.4 x 2.4 x 12-meter) intermodal cargo containers allows a much wider variety of cargo to be transported on an extremely efficient, i.e., intermodal, basis.

Despite the economies of the jet freighter, the air cargo industry has operated at a profit only during 1965 to 1969. Operating costs fluctuated until 1973, when they took a sudden jump brought about by the surge in fuel prices. Operating costs escalated 15 percent per year, compared with average increases of 5 percent in earlier years. That is not unlike the air passenger picture of the same period.

The air cargo industry needs an aggressive marketing plan which will capture more and nontraditional air freight, and it needs new equipment which will facilitate integration with surface transport modes.

The traditional market for air freight service has included items such as perishable foods or medical supplies which need to be delivered in the shortest time possible. Other common cargo includes electronic components, flowers, and other high-value, low-volume freight where shippers can justify the higher air freight rates. Although the percentage by weight of U.S. goods shipped by air in 1975 was only 0.2 percent, the dollar value was almost 15 percent. Cargo carriers could and should tap new markets for air freight. Restructuring of the air cargo rate system. Should also attract larger and higher-volume shipments, thus increase the air mode share of the total market - both domestic and international.

In order for the air carriers to tap new air freight markets, it will be necessary for the air mode to integrate with the surface modes and become a part of an intermodal transportation structure. The air and surface carrier industry must make a major contribution to the development of new intermodal containers that will be strong enough to endure stacking for marine transport, but be light enough for air transportation.

A heavy lift air cargo aircraft possessing such capability could be designed and built for the private sector marketplace. Such a generation of aircraft would need to be designed for cargo from the ground up, not converted from passenger capability as has been the case with previous civil jet cargo aircraft.

By 1990, this a new generation of A/C freighter could be available to accommodate larger intermodal containers and other surface freight transport vehicles. Assuming that predictions of substantial increases in the percentage of freight carried by air are accurate, unique financing options might be considered to ensure capacity to meet the demand. A joint military-private industry approach may be the way to develop a transport aircraft that can carry both military and civilian freight on an intermodally compatible, high-productivity system basis. Consideration is already being given to the generation of such an aircraft. It is generally agreed that industry should own and operate the majority of such air transport vehicles and that they be available to the government on a Civil Reserve Air Fleet (CRAF) basis in the event of emergency. That program could bring into being a new generation of air cargo aircraft that could ultimately increase the air cargo share of a continually expanding total market.

The role of air cargo would see application in civilian, military, domestic, and international markets, and the airplane would be a major item of international trade, balance of payments, as well as an important instrument of international trade of goods and commodities.

Purpose of Study

The Cargo/Logistics Airlift Systems Study (CLASS) is part of a program sponsored by NASA's Langley Research Center to define system characteristics and broad design guidelines for future air cargo aircraft, and to provide direction for subsequent technology studies in support of future all-cargo aircraft design. Investigations over the past several years have quantified the potential line-haul cost savings realizable by several new cargo transport concepts. To identify the total door-to-door delivery costs associated with any of these new vehicle concepts, to derive design guidelines for future aircraft studies, and to evaluate potential national benefits of an advanced air cargo system, shipper and carrier requirements must be fully understood. The CLASS Study has been designed to identify some of those requirements through the collection and analysis of data from the shipping and transportation community.

Discussions with the shipping and transportation industry generally appear to support the contention that a substantial growth in air freight volume is possible if an advanced, dedicated, air freighter design is carefully tailored to an integrated freight transportation system. However, the potential of such a system being developed for the private sector is predicated solely on its economic viability and the ability of advanced technology to aid in achieving those economics. The need for essential new knowledge in these areas gave rise to the CLASS program.

The purposes of this study program are to: (a) study, evaluate, and characterize the current air cargo operation; (b) conduct a mini-survey of major shippers to determine the nature of the demand for air cargo, present and future; (c) develop commodity and distribution characteristics leading to high eligibility for air transport; (d) determine the sensitivity of demand to improve efficiency of the air cargo operation; and (e) identify research and technology requirements.

In an attempt to assure realism in these studies, NASA has initiated a multifaceted interaction with airframe manufacturers, major shippers, the airlines, freight forwarders, and the Departments of Defense and Transportation. The results of the CLASS study will impact future resource commitment by NASA to studies of advanced air cargo systems and could be of fundamental value to these future users and operators of an advanced intermodal air freight system. Key representatives from several of these organizations have assisted NASA in monitoring the study through their service on a review committee.

This report documents the results of analyses conducted under contract with NASA-Langley by the Lockheed-Georgia Company with support from Trans World Airlines, Inc., the Equipment Interchange Association, and D. L. Paden and Associates.

I - ANALYSIS OF CURRENT AIR CARGO SYSTEM

Introduction

This portion of the CLASS study, the Analysis of the Current Air Cargo System has been prepared to provide a base for the comparative evaluation of the alternative systems proposed in succeeding sections of the study. A forecast of 1990 surface freight transportation trends, together with a 1990 world economic scenario, are included to form a basis for projecting the future air cargo market environment.

The main topics addressed in this analysis of the current air cargo system are:

- An evaluation of current air cargo systems using appropriate industrial and consumer statistics, readily available airline schedule information and other macro transportation data, and provision of route networks depicting air freight tonnage by commodity at the three-and four-digit level/commodity class, mix, and directionality of flows.

- Identification of market and commodity characteristics that influence use of the air mode, and correlation analyses of various characteristics including density, value, etc., is presented. Based on values determined, commodity/market combinations are identified for achieving larger air-mode penetration.

- A comparison of air and surface mode carriage on typical routes with rate, operating factor, service and delivery time comparison has been prepared. A market profile indicating present modal splits for several "air-eligible" commodities for each market investigated is presented.

- The results of on-site surveys/evaluations of cargo processing facilities at a number of airports are presented. Operational factors include freight volume, flow characteristics, level of mechanization/automation, random versus containerized cargo, and operationally significant features. Airports surveyed represent different levels of automation and scales of operation.

- Various institutional controls and influences on air cargo operations are discussed. Included are proposed changes in scope and/or incidence of government regulation covering route and tariff controls, energy policies, noise, and other factors such as the Civil Reserve Air Fleet - CRAF.

In meeting the requirements of this task, a variety of approaches and sources were used. As indicated above, for certain areas, published works and readily available industry statistics have been reviewed and used to describe and analyze certain aspects of the task.

In addition, other areas were researched and analyzed using survey research techniques that included written surveys and oral interviews and on-site inspections. Finally, due to its position as a major cargo operator an industry leader, TWA was called upon to use the experience of its staff and its relationships with other carriers to develop material where this approach was found to be desirable.

Current Air Cargo System Description

General - Prior to a detailed discussion of the current air cargo system, a more general, descriptive overview of the topic would seem helpful. This subsection presents such an overview; the following subsection presents the more detailed analysis of the current system's characteristics.

Carriers/Routes/Aircraft - Although air cargo carriage is a relatively recent innovation, especially compared to some surface modes, air cargo today operates in a well-developed system which includes extensive routes both in the United States (Figure I-1) as well as throughout the world (Figure I-2). This extensive route coverage is provided by a wide number of carriers, as shown on Figures I-3 and -4.

In addition to the diversity of routes and carriers, many different aircraft types are involved in the carriage of air cargo. These range from the belly compartments of small passenger aircraft such as DC-9's and 737's to 747's devoted entirely to cargo. Between these extremes, large amounts of cargo lift are provided by the traditional jet freighter aircraft, such as the 707 and DC-8, supplemented by more recent use of the large quantity of belly-lift inherent in widebodied passenger aircraft such as the 747, L-1011, and DC-10. Figure I-5 shows that quite a large amount of cargo lift exists, even if only aircraft suitable for all- cargo operations are considered.

Cargo Terminals and Terminal Operations - As shown in Figure I-6, some of today's airport cargo terminal facilities can be quite sophisticated, although the majority of air cargo airport installations are relatively simple. Figure I-7 shows the typical work flows involved in the processing/handling of air cargo at an airport, the basic processes involved are relatively the same from one location to another, in spite of the relative scale of operations and/or the degree of automation/mechanization. Note that all shipments moved by the air mode must be specifically adapted for carriage on an aircraft; there is no significant exchange of fully intermodal shipments such as is common with surface carriers.

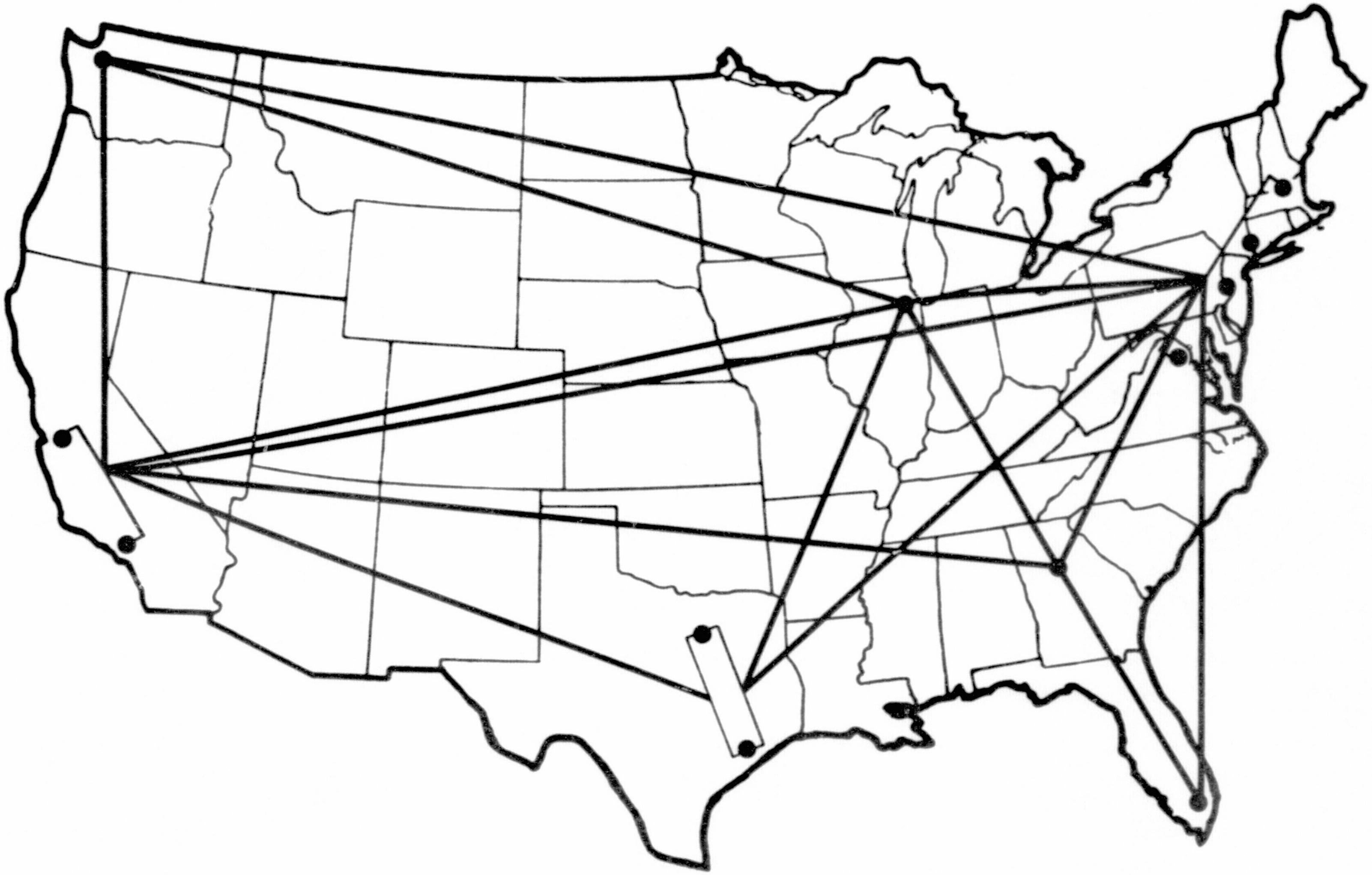


FIGURE I - 1. MAJOR U. S. AIR FREIGHT ROUTES

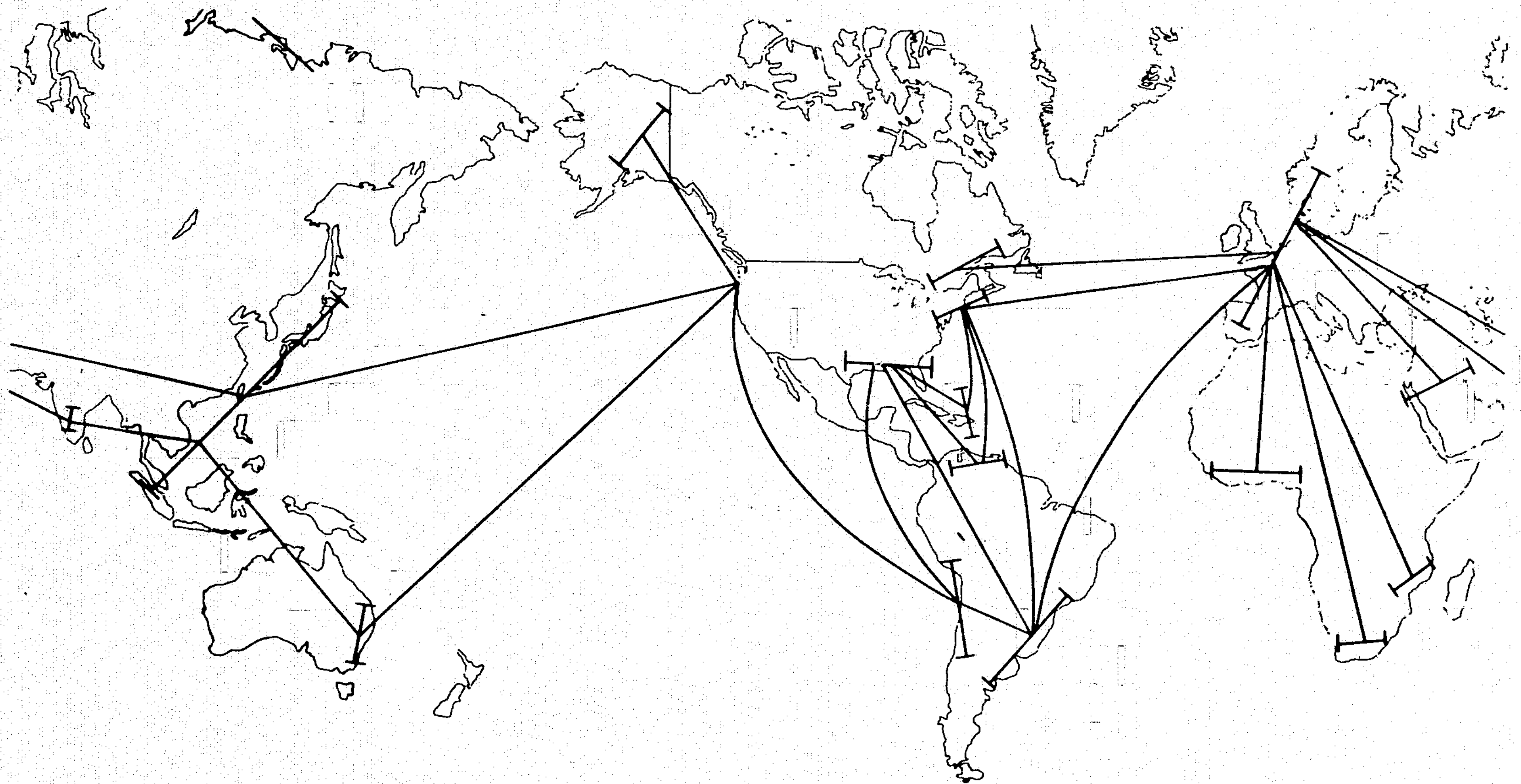


FIGURE I - 2. MAJOR INTERNATIONAL AIR FREIGHT ROUTES

		All-Cargo Service: Scheduled	All-Cargo Service: Non-Scheduled	Combination: Scheduled
U.S. DOMESTIC	11 TRUNKS	7	7	11
	2 ALL-CARGO	2	2	-
	20 LOCAL SERVICE AND OTHER	3	2	20
	4 SUPPLEMENTAL	-	4	-
U.S. INTERNATIONAL	10 TRUNKS	6	7	10
	3 ALL-CARGO	3	3	-
	6 SUPPLEMENTAL	-	6	-
NON-U.S. INTERNATIONAL (FREE WORLD)	4 NORTH AMERICAN (NON-U.S.)	1	1	4
	47 LATIN AND CARIBBEAN	12	17	46
	41 EUROPEAN	26	21	39
	15 MIDDLE EAST	4	4	14
	32 AFRICAN	3	6	30
	27 ASIAN AND PACIFIC	5	5	27

FIGURE I-3. FREE WORLD AIR FREIGHT AIRLINES

TRUNK

AMERICAN
BRANIFF
CONTINENTAL
DELTA
EASTERN
NATIONAL
NORTHWEST
PAN AMERICAN
TRANS WORLD
UNITED
WESTERN

LOCAL SERVICE

ALLEGHENY
FRONTIER
HUGHES AIRWEST
NORTH CENTRAL
OZARK
PIEDMONT
SOUTHERN
TEXAS INTERNATIONAL

HELICOPTER

CHICAGO HELICOPTER
NEW YORK AIRWAYS
SAN FRANCISCO AND OAKLAND HELICOPTER

ALL-CARGO

AIRLIFT
FLYING TIGER
SEABOARD WORLD

INTRA-ALASKA/HAWAII

ALASKA
ALOHA
HAWAIIAN
KODIAK WESTERN
MUNZ NORTHERN
REEVE ALEUTIAN
WIEN

FIGURE I -4. U. S. AIR CARRIERS

TYPE	IN SERVICE	ON ORDER
JET		
VC-10	5	0
BAC-111	3	0
707	302	2
727	32	0
737	62	2
747	38	12
F28	7	0
DC-8	131	0
DC-9	95	2
DC-10	17	3
TURBOPROP		
ALL	211	4
TOTALS	903	25

NOTE: INCLUDES ALL AIRCRAFT WITH CARGO CAPABILITY

FIGURE I - 5. CARGO AIRCRAFT (AS OF JANUARY 1, 1977)

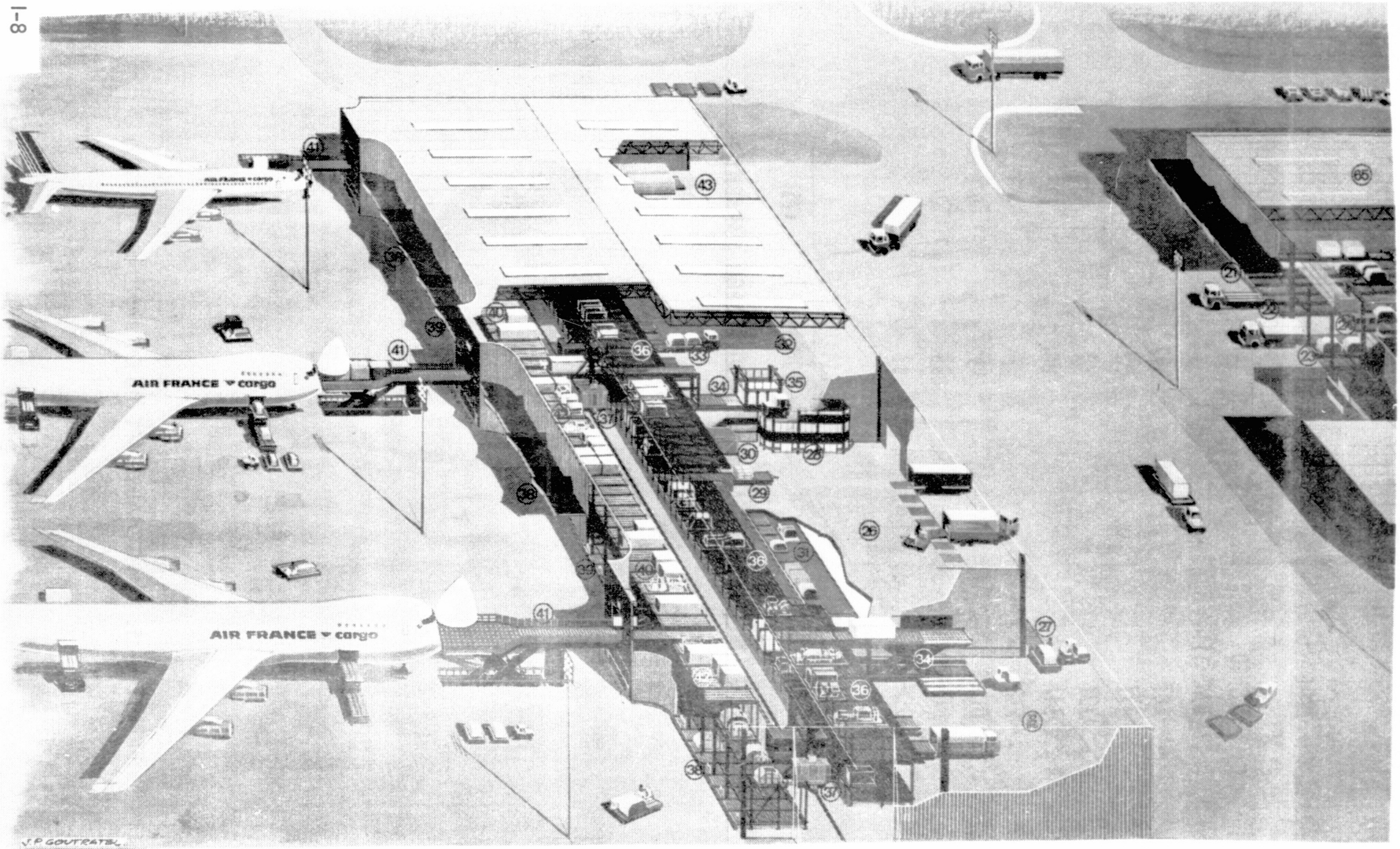


FIGURE I - 6. CARGO TERMINALS

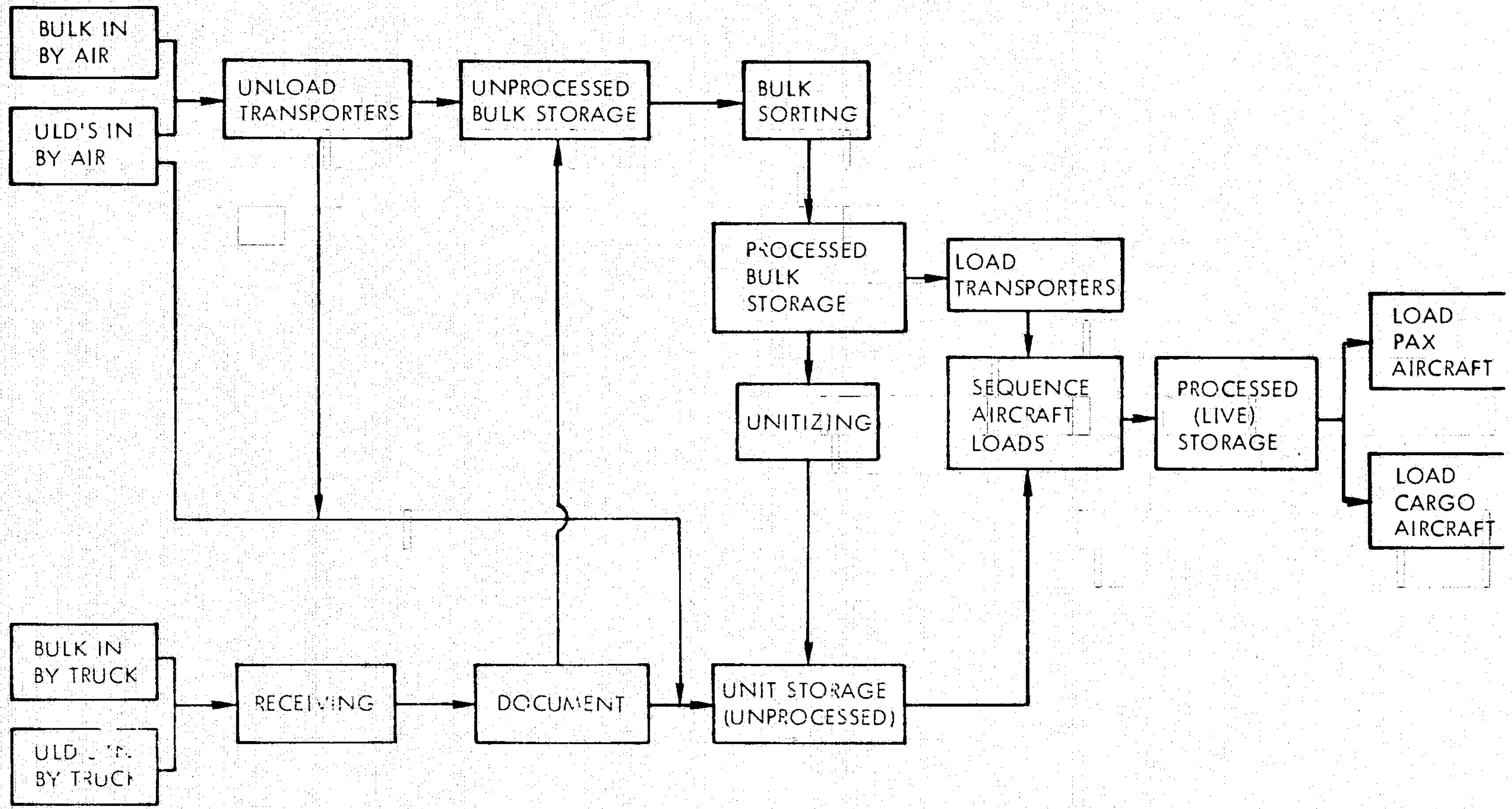


FIGURE I - 7. CARGO TERMINAL OPERATIONS DEPARTURE CARGO

Air Cargo Unit Load Devices (Containers and Pallets) - As mentioned in the preceding subsection, the equipment used for the actual air transportation of goods is generally peculiar to the air mode. Originally, all cargo was bulk loaded, whether in the belly or in the main cabin of the relatively small piston aircraft used at the time. As the size of aircraft used increased - particularly with the advent of jet equipment - and labor costs escalated, mechanization was introduced on a limited scale. At first, flat pallets, on which the cargo was stacked and secured (conforming to the aircraft fuselage contour) by nets were used. This system reduced the number of "pieces" to be loaded or unloaded from the main deck of a cargo aircraft from as many as several hundred to thirteen, for the typical 707 or DC-8.

A further development of this method was the "A" container or "Igloo," which used a structural shell placed over and secured to the pallet base. While this represented an improvement over pallets and nets and did offer some containerization advantages to shippers (protection from weather, security, etc.), this type of container - and similar ones used for widebody bellies - could hardly be considered compatible with surface mode operations. Examples of these types of containers, typical of the majority in use today, are shown in Figures I-8, I-9 and I-10.

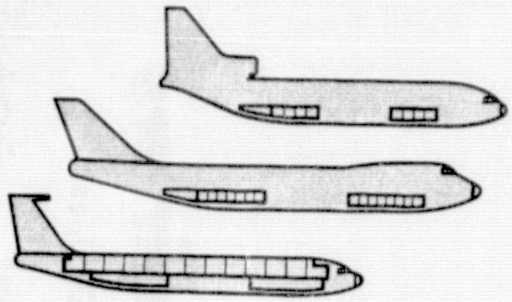
Finally, as shown in Figure I-11, there are a limited number of 8 x 8 feet (2.4 x 2.4-meter) air containers in use today, primarily in connection with 747 freighter/combi operations. These containers are, at least in overall dimensions, compatible with surface modes. Several outstanding problems, remain to be resolved, such as the tradeoff between the structural strength needed for surface containers and the low tare weights desired by the air mode.

The ratio of tare weight to internal volume, usable volume, is a measure for evaluating container design. A ratio of 1.00 to 1.25 pounds per cubic foot (15 to 18.75 kilograms per cubic meter) has been established for air mode containers. Structural containers in current inventory have weight to volume ratios of 1.8 to 2.8 pounds per cubic foot (27 to 42 kilograms per cubic meter). The latest M-2 type B, 8 x 8 x 20-foot (2.4 x 2.4 x 6-meter) air mode container is being delivered with a ratio of about 1.8 pounds per cubic foot (27 kilograms per cubic meter). This container incorporates corner fittings and may be handled in the same manner as marine containers and stacked at least two high. The goal of lower ratios of weight to volume is not likely to be acheved in the near term because of the high cost of the advanced-technology composite material required to significantly reduce weight.

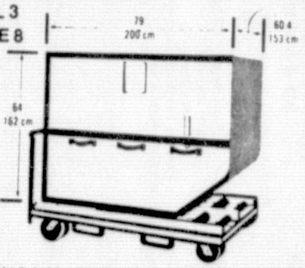
Current Market Environment

This subsection examines traffic flows and capacity availability, commodity movements, and cost/rate structure elements.

carrier owned containers



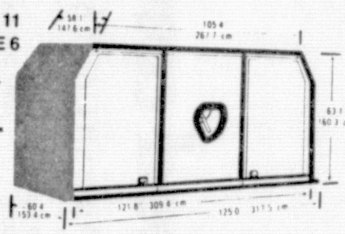
ATA TYPE L 3
IATA TYPE 8



IATA HALF SIZE LOWER DECK STRUCTURAL CONTAINER
IATA RATE CLASSIFICATION NUMBER 8 (ATA TYPE LD3)

Outside Dimensions: 79" x 60.4" x 64" (200.7 x 153.4 x 162.6 cm.)
Inside Dimensions: 75.0" x 56.0" x 60.3" (190.5 x 142.2 x 153.2 cm.)
Door Opening: 57" x 59" (144.8 x 149.9 cm.)
Internal Cube: 153 cubic feet (4.3 cu. meters)
Tare Weight (Average): 370 pounds (168 kgs.)
Maximum Gross Weight: 3500 pounds (1587 kgs.)
Maximum Floor Bearing Weight: 200 lbs./ft² (977 kgs./m²)

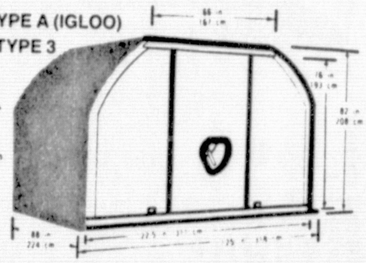
ATA TYPE L 11
IATA TYPE 6



IATA FULL WIDTH LOWER DECK STRUCTURAL CONTAINER
IATA RATE CLASSIFICATION NUMBER 6 (ATA TYPE LD11)

Outside Dimensions: 60.4" x 125" x 63.1" (153.4 x 317.5 x 160.3 cm.)
Inside Dimensions: 56.0" x 119.0" x 62.0" (142.2 x 302.3 x 157.5 cm.)
Door Opening: 121" x 57" (307.3 x 144.8 cm.)
Internal Cube: 241 cu. ft. (6.8 cu. meters)
Tare Weight (Average): 685 lbs. (310.7 kgs.)
Maximum Gross Weight: 6500 lbs. L1011 (2948 kgs.), 7000 lbs. B747 (3175 kgs.)
Maximum Floor Bearing Weight: 200 lbs./ft² (977 kgs./m²)

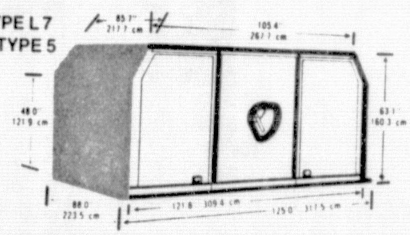
ATA TYPE A (IGLOO)
IATA TYPE 3



IATA FULL 125" STRUCTURAL CONTAINER (IGLOO)
IATA RATE CLASSIFICATION NUMBER 3 (ATA TYPE A)

Outside Dimensions: 88" x 125" x 82" (223.5 x 317.5 x 208.3 cm.)
Inside Dimensions: 83.6" x 120.0" x 80.0" (212.3 x 304.8 x 203.2 cm.)
Door Opening: 121" x 76" (307.3 x 193 cm.)
Internal Cube: 440 cubic feet (12.5 cu. meters)
Tare Weight (Average): 830 pounds (376.5 kgs.)
Maximum Gross Weight: 13,300 pounds (6032.9 kgs.)
Maximum Floor Bearing Weight: 200 lbs./ft² (977 kgs./m²)

ATA TYPE L 7
IATA TYPE 5



IATA FULL SIZE LOWER DECK STRUCTURAL CONTAINER
IATA RATE CLASSIFICATION NUMBER 5 (ATA TYPE LD7)

Outside Dimensions: 88" x 125" x 63.1" (223.5 x 317.5 x 160.3 cm.)
Inside Dimensions: 83.6" x 119.5" x 61.5" (212.3 x 303.5 x 156.2 cm.)
Door Opening: 121" x 57" (307.3 x 144.8 cm.)
Internal Cube: 358 cubic feet (10.1 cu. meters)
Tare Weight (Average): 830 lbs. (376.5 kgs.)
Maximum Gross Weight: 10,200 lbs. (4627 kgs.)
Maximum Floor Bearing Weight: 200 lbs./ft² (977 kgs./m²)

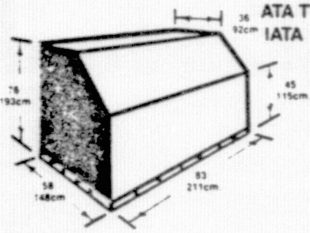
FIGURE I - 8. AIR FREIGHT CONTAINERS

shipper owned containers

IATA Approved Non-Aircraft Unit Load Devices

HALF 125" PALLET SIZE CONTAINER
IATA ID CODE CO 3

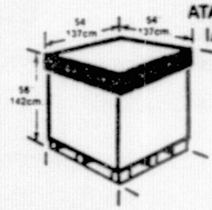
Maximum External Volume: 5.532 cu. meters (195.35 cu. ft.)
Maximum Permissible Gross Weight: 3029 kgs (6686 lbs) (varies according to construction)
Allowable Tare Weight: 133.0 kgs (293 lbs) (or actual whichever is less)



ATA TYPE B
IATA CO 3

LOWER DECK CONTAINER INSERT
IATA ID CODE CO 7

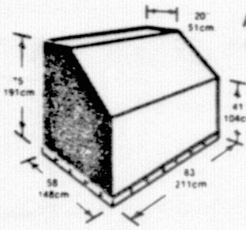
Maximum External Volume: 2.676 cu. meters (94.50 cu. ft.)
Maximum Permissible Gross Weight: 1820 kgs (4050 lbs) (varies according to construction)
Allowable Tare Weight: 64.0 kgs (142 lbs) (or actual whichever is less)



ATA TYPE LDN
IATA CO 7

HALF SIZE INTERCHANGE CONTAINER
IATA ID CODE CO 4

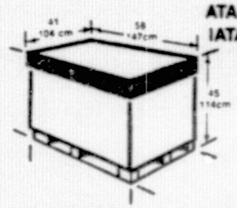
Maximum External Volume: 5.223 cu. meters (184.44 cu. ft.)
Maximum Permissible Gross Weight: 3029 kgs (6686 lbs) (varies according to construction)
Allowable Tare Weight: 125.5 kgs (277 lbs) (or actual whichever is less)



ATA TYPE B
IATA CO 4

QUARTER PALLET SIZE CONTAINER
IATA ID CODE CO 8

Maximum External Volume: 1.754 cu. meters (61.93 cu. ft.)
Maximum Permissible Gross Weight: 1498 kgs (3303 lbs) (varies according to construction)
Allowable Tare Weight: 42.0 kgs (93 lbs) (or actual whichever is less)



ATA TYPE D
IATA CO 8

FIGURE I-9. AIR FREIGHT CONTAINERS

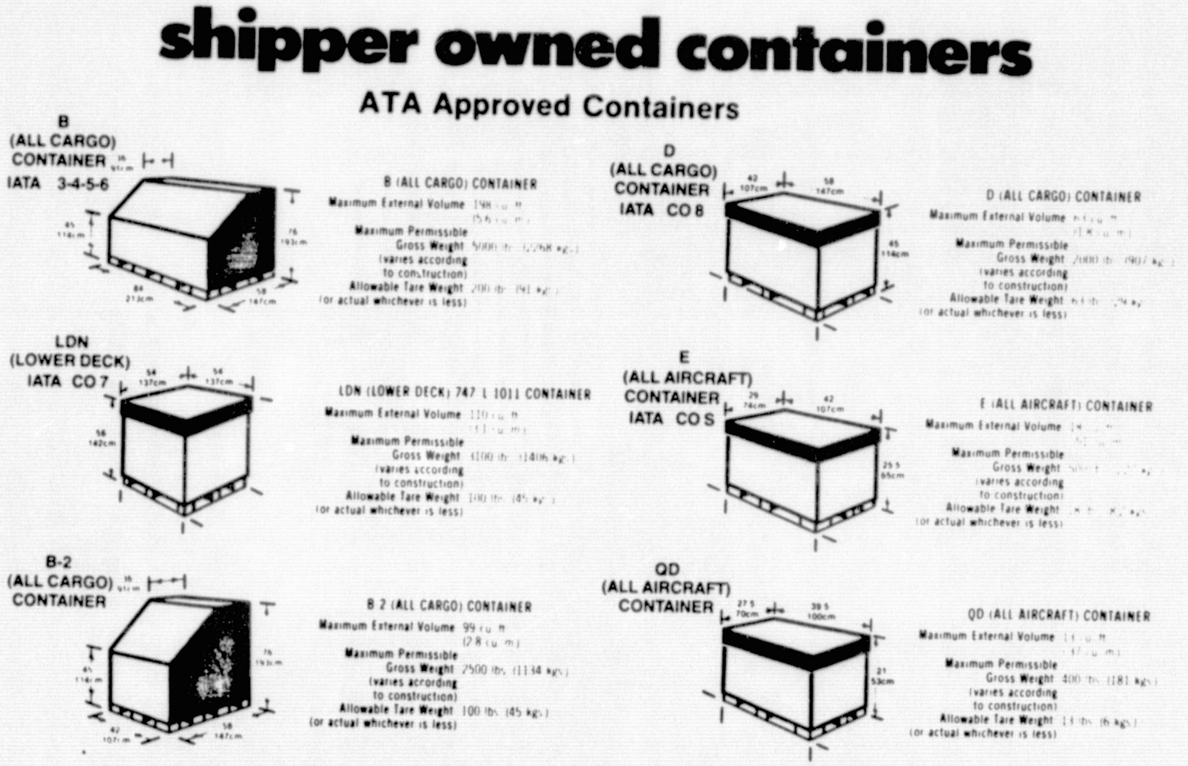


FIGURE I - 10. AIR FREIGHT CONTAINERS

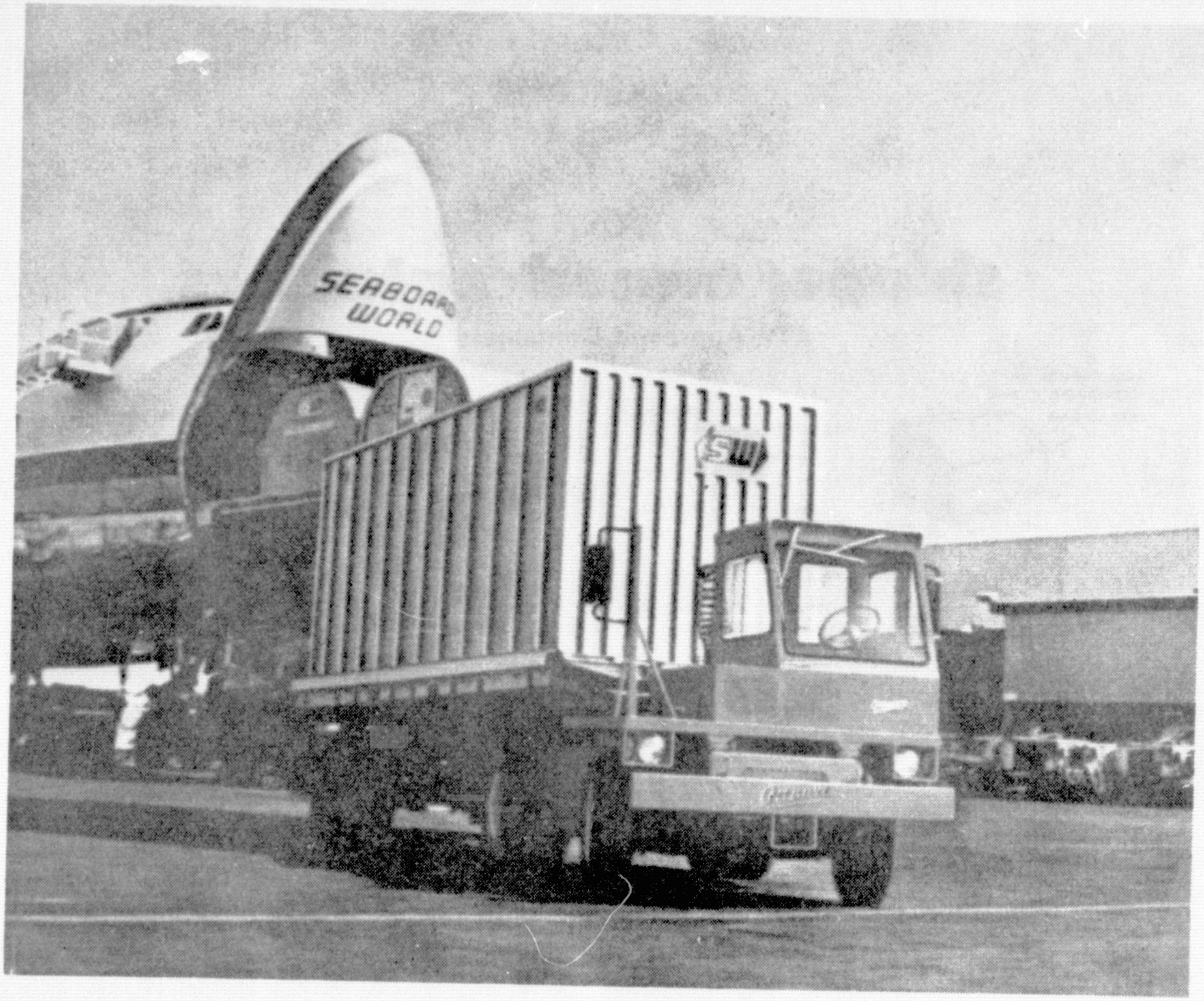


FIGURE I - 11 M-2 (8 x 8 x 20') CONTAINER/747F INTERFACE

Traffic Flows - Figure I-12 displays major international freight traffic flows during 1976; these data are also presented in tabular form in Figure I-13. While the data cover International Air Transportation Association (IATA) members' operations only, these carriers account for the vast majority of air traffic in the free world. It is interesting to note that the ten main international route areas charted account for over ninety percent of all international freight traffic handled by IATA carriers.

Capacity Availability - As shown earlier, one indication of the availability of a substantial amount of cargo lift capability was the number of aircraft which either were or could be configured for freighter or "combi" services. A moderate number of these aircraft are, in fact, used for all-cargo services. Figure I-14 indicates those domestic cities currently receiving scheduled all-cargo services from certificated carriers. While the number of cities is less today than in the past, it is apparent that there are a significant number of freighter service locations, and these locations are fairly widely dispersed. Similar conditions are found in other areas of the world.

In addition to freighters, substantial cargo capacity is also found on the large fleet of "wide-bodied" passenger aircraft, 747's, L-1011's, DC-10's and A300B's, now in service around the world. To gain a perspective of both the magnitude and locations of significant cargo capacity availability, an analysis of cargo schedule data was performed using schedule data contained in the Air Cargo Guide (ref. 1), the standard schedule publication used by the industry. In brief, the following methodology was used for this analysis:

- o The period September 18 to 24, 1977, was selected as a typical week reflecting current operations and avoiding peak or trough activity due to seasonality.

- o Two analyses were made; the number of all freighter and wide-body flights in a given market, and the number of freighter flights only in the market.

- o Markets were ranked, in each category, on the number of direct flights making two stops or less; connections or flights making more than two stops were not tabulated.

- o In addition to the total number of frequencies in each market, tabulations by aircraft type were also made.

The results of analysis are contained in Tables I-1, I-2 and I-3. Tables I-1 and I-2 display the top 50 markets for freighter plus wide-body and freighter only, respectively; Table I-3 summarizes the geographical dispersion inherent in Tables I-1 and I-2.

A number of interesting facts about the capacity available for cargo in the current system can be determined from inspection of Tables I-1 and I-2. As shown in Table I-3, U.S. Domestic operations dominate both lists, having close to 60 percent of each. Short-haul operations represent the next largest

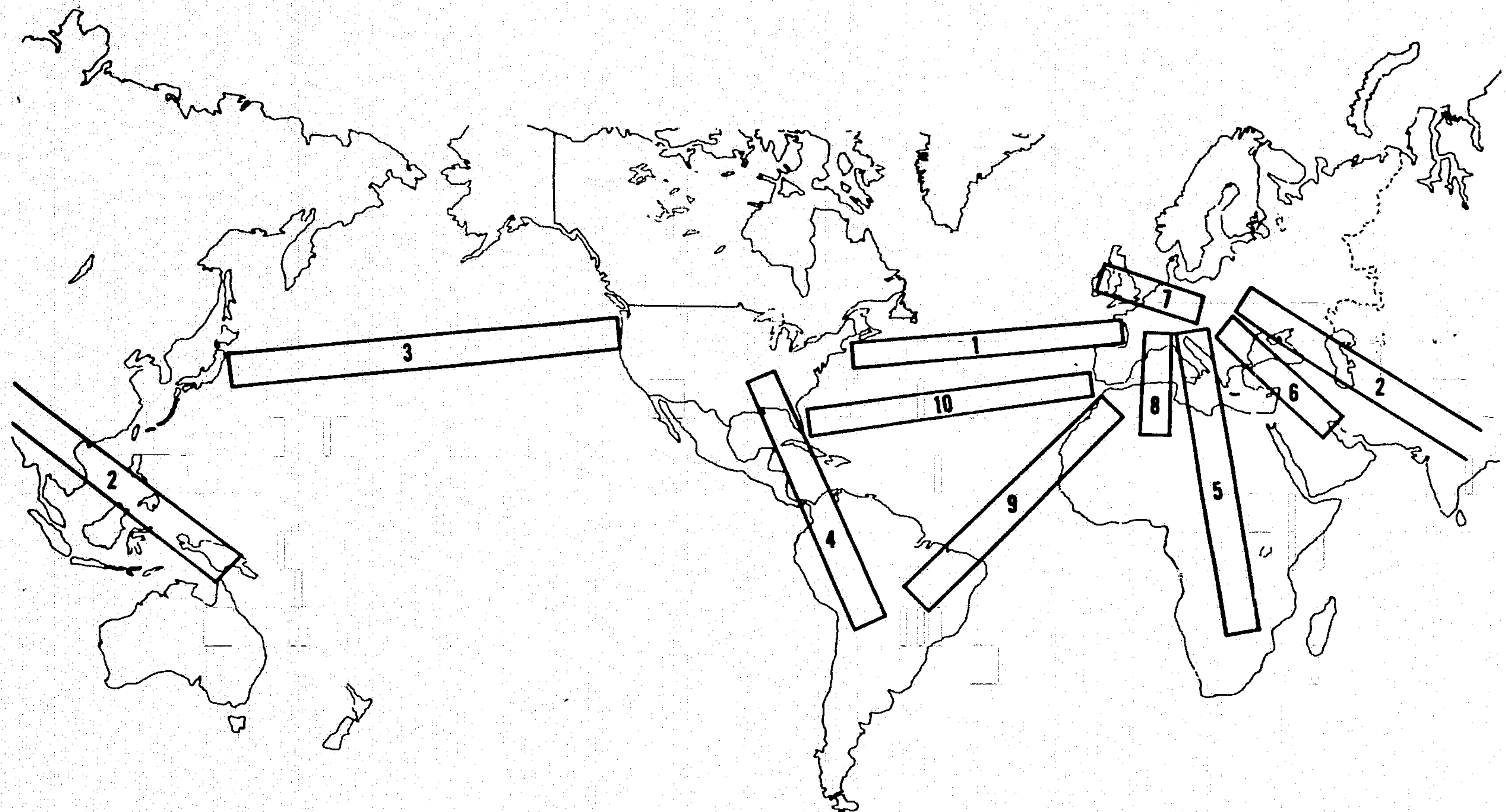


FIGURE I - 12. TOP TEN INTERNATIONAL AIR CARGO ROUTES IATA CARRIERS - 1976

(IATA CARRIERS–1976)

	ROUTE AREA	RTK's (MILLIONS)	PERCENT OF TOTAL
1.	NORTH ATLANTIC	3,231.7	28.0%
2.	EUROPE–FAR EAST/AUSTRALASIA	2,157.2	18.7
3.	NORTH AND MID–PACIFIC	1,681.5	14.6
4.	NORTH–SOUTH AMERICA	621.6	5.4
5.	EUROPE–SOUTHERN AFRICA	617.8	5.4
6.	EUROPE–MIDDLE EAST	601.9	5.2
7.	WITHIN EUROPE	495.2	4.3
8.	EUROPE–NORTHERN AFRICA	477.2	4.1
9.	SOUTH ATLANTIC	424.9	3.7
10.	MID ATLANTIC	254.4	2.2
	OTHER ROUTES	978.9	8.4
	TOTAL	11,542.3	100.0%

FIGURE I - 13. MAJOR INTERNATIONAL AIR CARGO ROUTES

(CERTIFICATED CARRIERS)

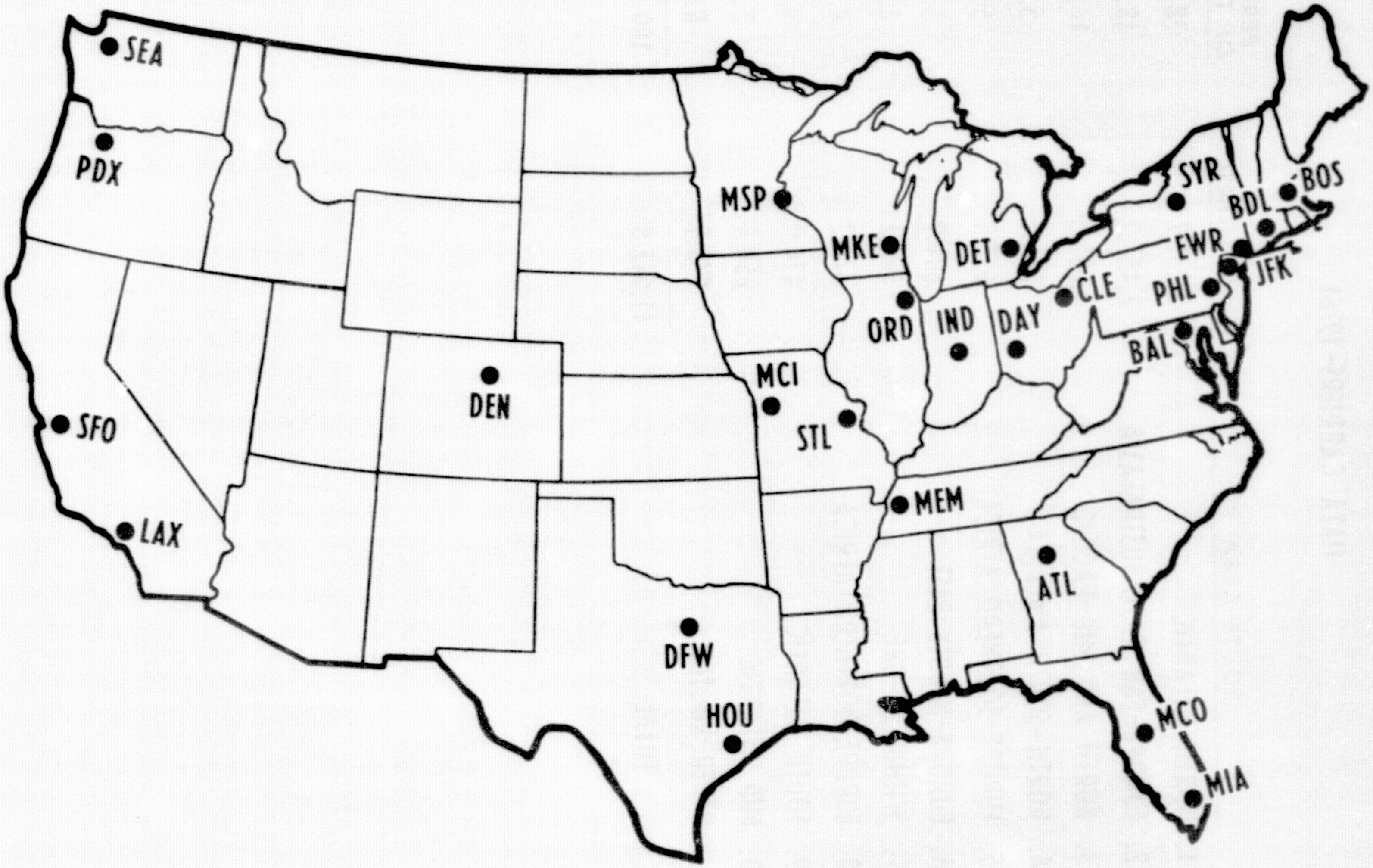


FIGURE I-14. U. S. CITIES WITH FREIGHTER SERVICE

TABLE I-1.

TOP 50 MARKETS - CARGO CAPACITY
FREIGHTER & WIDEBODY AIRCRAFT
(Week of September 18, 1977 - Scheduled)

Rank	Market	Weekly Frequencies	Freighter Service	Remarks
1	HND-CTS	168	No	Japanese domestic
2	ORD-LAX	156	Yes	Prime U.S. route
3	LAX-ORD	150	Yes	Prime U.S. route
4	CTS-HND	147	No	Japanese domestic
5	LAX-HNL	119	Yes	Domestic/International segments
6	HNL-LAX	117	Yes	Domestic/International segments
7	JFK-LAX	110	Yes	Transcontinental
8	SFO-JFK	110	Yes	Transcontinental
9	DTW-ORD	101	Yes	Short haul/connecting link
10	HND-FUK	98	No	Japanese domestic
11	LAX-JFK	98	Yes	Transcontinental
12	FUK-HND	91	No	Japanese domestic
13	LHR-JFK	90	Yes	Top transatlantic market
14	JFK-SFO	86	Yes	Transcontinental
15	ORD-DTW	85	Yes	Short haul/connecting link
16	SFO-ORD	84	Yes	Semi-transcontinental
17	ORD-SEA	83	Yes	Semi-transcontinental
18	ORD-SFO	83	Yes	Semi-transcontinental
19	SFO-HNL	82	Yes	Domestic/international segment
20	LAX-SFO	77	Yes	Short haul/connecting link
21	HND-ANC	75	Yes	N. Pacific (technical stop segment)
22	HNL-SFO	75	Yes	Domestic/international segment
23	JFK-ORD	75	Yes	Primary short haul route
24	ANC-HND	74	Yes	N. Pacific (technical stop segment)
25	HKG-HND	72	Yes	Major regional market (Orient)
26	JFK-LHR	70	Yes	Top transatlantic market
27	LAX-ATL	70	Yes	Southern transcontinental
28	SEA-ORD	70	Yes	Semi-transcontinental
29	SFO-LAX	70	Yes	Short haul/connecting link
30	HND-HKG	68	Yes	Major regional market (Orient)
31	ORD-DEN	67	No	Medium haul market
32	ORD-JFK	66	Yes	Heavy short haul market
33	OSA-HND	63	Yes	Japanese domestic
34	CDG-LHR	62	Yes	Short haul (Europe)
35	ATL-LAX	61	Yes	Southern transcontinental
36	MSP-ORD	61	No	Short haul/connecting link
37	LHR-CDG	60	Yes	Short haul (Europe)
38	ORD-EWR	60	Yes	Short haul market
39	ORD-MSP	60	No	Short haul/connecting link
40	BOS-LAX	59	Yes	Transcontinental
41	DEN-ORD	59	No	Medium haul market
42	FRA-JFK	59	Yes	North Atlantic
43	FRA-LHR	58	Yes	Short haul (Europe)
44	HND-LAX	58	Yes	North Pacific
45	HNL-HND	55	No	North Pacific
46	JFK-SJU	55	Yes	Prime Caribbean market
47	EWR-ORD	54	Yes	Short haul
48	HKG-TPE	54	Yes	Regional (Orient)
49	MCO-ATL	54	Yes	Short haul/connecting link
50	MIA-ATL	54	Yes	Short haul/regional

TABLE I-2.

TOP 50 MARKETS - CARGO CAPACITY
FREIGHTER AIRCRAFT ONLY
(Week of September 18, 1977 - Scheduled)

Rank	Market	Weekly Frequencies	Widebody Freighters	Freighter and Passenger Rank
1	JFK-ORD	47	Yes	23
2	SFO-JFK	46	Yes	8
3	HND-ANC	45	Yes	21
4	ORD-JFK	45	Yes	32
5	ANC-HND	44	Yes	24
6	LAX-SFO	42	Yes	20
7	JFK-LAX	40	Yes	7
8	ORD-LAX	37	Yes	2
9	JFK-SFO	36	Yes	14
10	LAX-JFK	35	Yes	11
11	SFO-LAX	35	Yes	29
12	JFK-DTW	34	Yes	62
13	ARN-CPH	31	No	91
14	FRA-LHR	31	Yes	44
15	SFO-ORD	31	Yes	16
16	LHR-JFK	30	Yes	13
17	ORD-SFO	30	No	18
18	LAX-ORD	27	No	3
19	DTW-ORD	26	Yes	9
20	HNL-OGG	26	No	168
21	BOS-LAX	24	No	40
22	CPH-FRA	23	No	182
23	JFK-BOS	23	Yes	98
24	SFO-HND	23	Yes	73
25	BCN-MAD	22	No	180
26	FRA-JFK	22	Yes	42
27	LHR-FRA	22	No	63
28	VCP-GIG	22	Yes	97
29	BOS-ORD	21	No	70
30	DTW-SFO	21	No	104
31	JFK-DFW	20	Yes	231
32	LIN-FRA	20	No	261
33	ORD-SEA	20	Yes	17
34	OSL-CPH	20	No	262
35	CLE-SFO	19	No	269
36	ANC-LAX	18	Yes	209
37	BRU-FRA	18	Yes	218
38	CPH-ARN	18	No	181
39	TPE-HND	18	Yes	60
40	DTW-LAX	17	No	92
41	HND-SFO	17	Yes	73
42	LAX-BOS	17	No	54
43	ANC-JFK	16	Yes	198
44	DFW-ORD	16	No	325
45	FRA-BCN	16	No	327
46	HND-LAX	16	Yes	45
47	LHR-AMS	16	Yes	172
48	PHL-SFO	16	No	205
49	SEL-HND	16	Yes	52
50	SFO-ANC	16	No	342

TABLE I-3.

DISTRIBUTION OF TOP FIFTY MARKETS - CARGO CAPACITY

Area	Number	Percent of Total
I. Freighter + Widebody		
U.S. Domestic	31	62%
Japan Domestic	5	10
North Pacific	4	8
North Atlantic	3	6
Intra Europe	3	6
Intra Orient	3	6
Caribbean	1	2
	50	100%
II. Freighter Only		
U.S. Domestic	29	58%
Intra Europe	11	22
North Pacific	5	10
North Atlantic	2	4
Intra Orient	2	4
Intra South America	1	2
	50	100%

category in both cases, Intra-Japan for the freighter/wide-body compilation, and Intra-Europe for freighter aircraft only.

The inclusion of the very short-haul Japanese markets in the former deserves comment. With the exception of one market, Osaka-Tokyo, these markets have no scheduled freighter service; their inclusion on the list results solely from the enormous number of wide-body passenger aircraft operated on these routes. Prior to the advent of wide-body aircraft during the last 8 to 10 years, these markets would not have been represented at all. It is significant that they now rank in the top 50 markets, at least in terms of frequency of service. This illustrates the vast potential cargo lift inherent in the operation of wide-bodies aircraft targeted primarily at passenger markets.

Turning to the freighter-only rankings in Table I-2, it is interesting to note that the ranking of these markets does not correspond to those of the combined freighter/wide-body market list. In many cases, there is a wide disparity between the two, e.g., Stockholm-Copenhagen, which ranks 13th when freighters only are considered, but drops to 91st when wide-bodied aircraft are considered in addition to freighters.

Table I-3 indicates that the geographic dispersion of this list is even smaller than that of the freighter/wide-body combination, with two areas, U.S. Domestic and Intra-Europe, accounting for 80 percent of the listings. The substantial showing of the Intra-European routes is interesting due to the short-haul nature of this traffic. While it would be expected that long-haul routes, particularly international ones, would have a heavy incidence in this type of ranking, the presence of numerous short-haul operations, in the U.S. as well as in Europe, indicates the substantial needs for and use of air cargo in the present system for less than continental or trans-oceanic distances.

One other interesting facet of the freighter only listing is the substantial wide-body freighter, 747F, operations. They make up 30 of the 50 segments, including almost all of the long-haul international markets. Some of these occur because of operational requirements rather than market requirements, and carriage of local traffic is not permitted in all cases. Detroit to Chicago is an example of both.

Figure I-15 graphically indicates the large number of all-cargo flights inbound and outbound by specific cities.

Commodity Movements - Traffic or demand data are available from a variety of sources, at various levels of detail and accuracy. These range from broad indicators of national trade flows into and out of various countries to detailed flight segment traffic data compiled by individual carriers.

One source of "industry" data -- the Commodity Transportation Survey of the Census of Transportation produced by the Department of Commerce (ref. 2) -- was selected for examination in micro-level detail in a few selected markets, and for a particular commodity. Although the Commodity Survey of the Transportation Census is hardly an infallible source, as will be discussed in

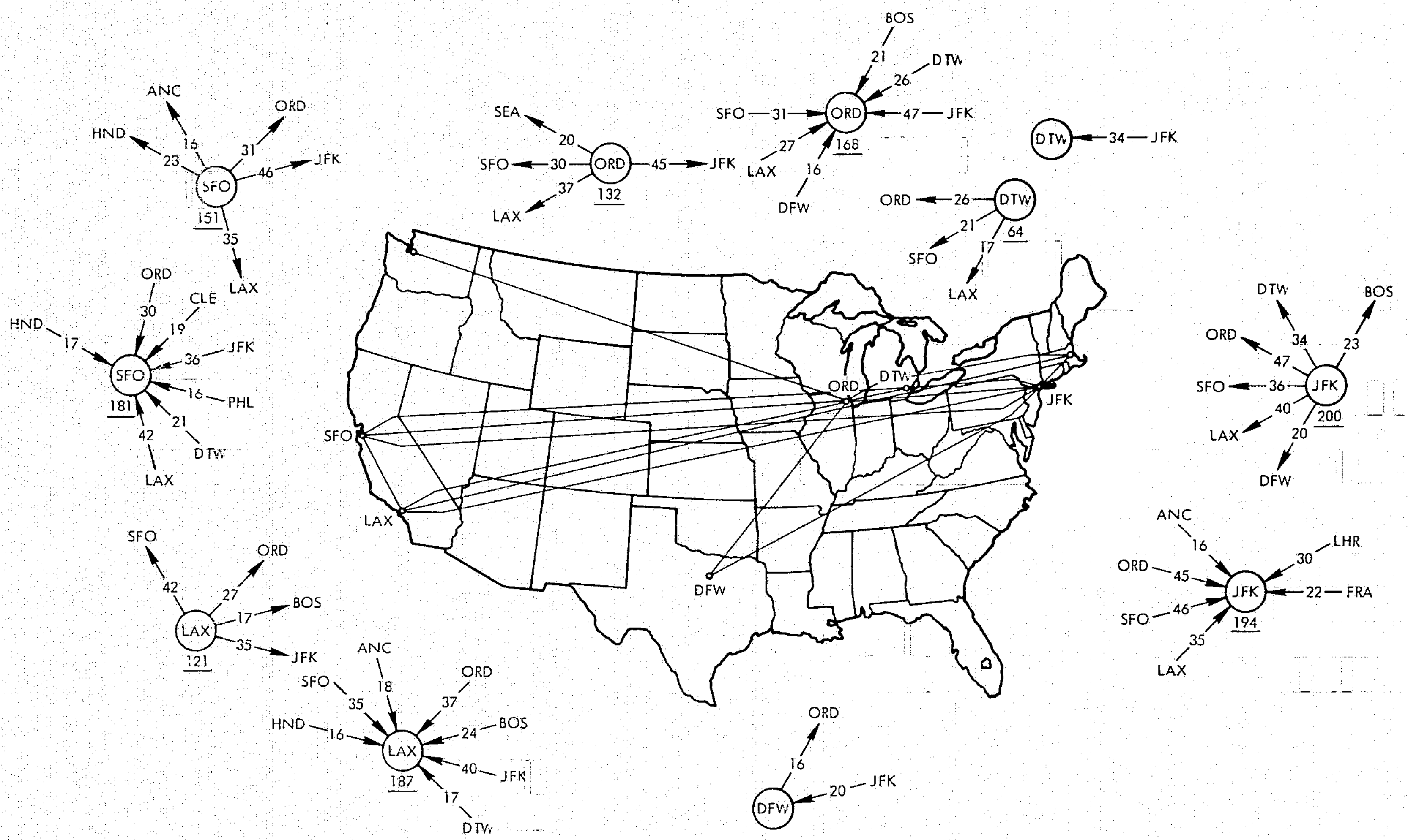


FIGURE I-15. ALL CARGO FREQUENCIES PER WEEK a succeeding subsection, it does offer a reasonable picture of overall domestic commodity flows, and it is about the only data source to address itself to the question of modal splits.

Figure I-16 shows the top five commodities, on the basis of air tonnage, in three markets of differing size and composition. Note the wide diversity of specific commodities, as well as some of the generic groupings, particularly clothing and electronics. The next two Figures, I-17 and I-18, examine the air movements of one of these commodities - men's and boy's clothing - in detail. Here it is interesting to note that, of the top 15 markets, all but one involve two origin "points:" The Standard Metropolitan Statistical Area (SMSA) of Los Angeles - Long Beach, Anaheim - Santa Ana - Garden Grove, San Bernardino - Riverside, Ontario on the west coast, and Allentown - Bethlehem - Easton, Reading in the northeast. The latter area is quite interesting in that neither certificated carrier freighter nor widebody service is offered at the airports serving the cities named; this would seem to indicate that the air movements from this area involved a surface move to a nearby major airport, probably New York or Philadelphia, followed by the actual air carriage.

Traffic Analysis and Route Networks - As is indicated on Table I-4, air freight traffic in the current operating system is of a considerable magnitude for both international (country to country) and domestic (internal) operations. In addition, there has been substantial growth, particularly with regard to international services, during the past five years.

To focus more clearly one some of the components of these general statistics, an analysis has been undertaken of both U.S. domestic and international trade which presently moves via the air mode. Domestic information came from the 1972 Census of Transportation commodity flow data; information on U.S. exports was taken from the U.S. foreign trade data series compiled by the Department of Commerce, using data for October 1976 (ref. 3).

Table I-5 displays the 10 largest routes, in terms of "true" origin and destination, within the U.S. for 1976. This is derived from data submitted by most of the U.S. domestic trunk carriers plus Airlift and Flying Tiger. Traffic carried by Braniff, Delta, Eastern, and Northwest are not included.

This "carrier generated" series of traffic flows can be compared with the Census of Transportation data in Tables I-6 through I-9, where substantial differences can be noted. In the first place, the Census is a sample of manufacturing plants, and is not necessarily restricted to common-carrier air-route networks. Second, data disclosure rules hamper the usefulness of the Census data, particularly at the more discrete, 4- and 5-digit, levels of detail. Finally, some data in the Census material are hard to explain, such as the 4,568 (4,143 metric tons) tons moving by air within the Los Angeles SMSA area at the two-digit level. However, the Census represents virtually the only non-carrier source of information on what is presently moving via the air mode, and tends to confirm some aspects of the carrier data, particularly

(1972 CENSUS OF TRANSPORTATION DATA-4 DIGIT LEVEL)

	NEW YORK-DAYTON	SAN FRANCISCO-NEW YORK	LOS ANGELES-CHICAGO
1.	MISCELLANEOUS PLASTIC PRODUCTS	ELECTRICAL MEASURING INSTRUMENTS	MENS, YOUTHS OR BOYS CLOTHING
2.	WOMENS, MISSES OR CHILDRENS CLOTHING	GLASS CONTAINERS	ELECTRONIC DATA PROCESSING MACHINES
3.	MISCELLANEOUS AIRCRAFT PARTS OR EQUIPMENT NEC	WINES, BRANDY OR BRANDY SPIRITS	INDUSTRIAL PUMPS OR PUMPING EQUIPMENT
4.	NONFERROUS METAL OR INSULATED WIRE	IRON OR STEEL FORGINGS	COSMETICS OR PERFUMES
5.	DRUGS (BIOLOGICAL OR BOTANICAL PRODUCTS)	MISCELLANEOUS ELECTRONIC COMPONENTS	BOLTS,NUTS,SCREWS,RIVETS OR WASHERS

FIGURE I-16. AIR FREIGHT COMMODITY ANALYSIS

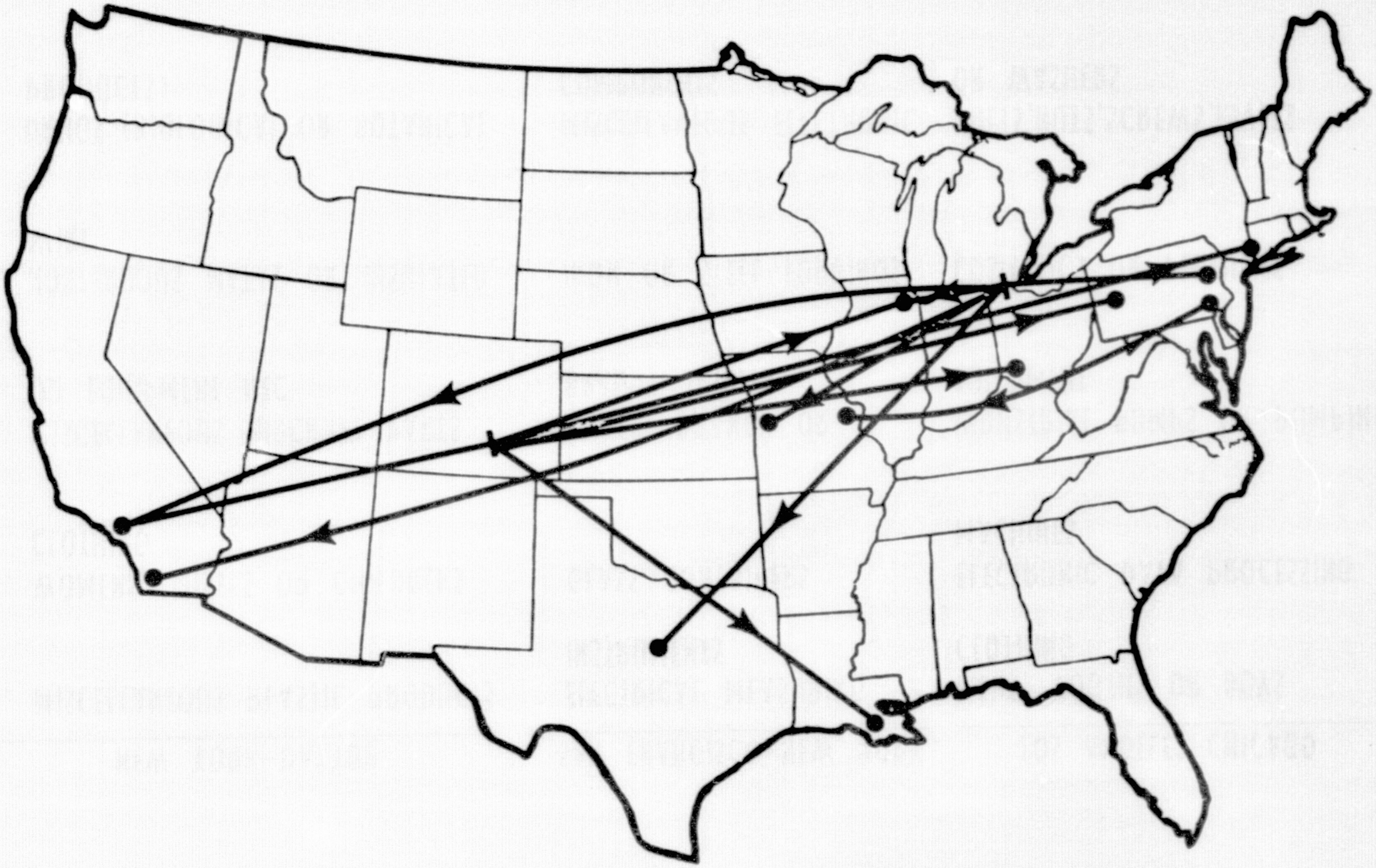


FIGURE 1-17. MAJOR AIR COMMODITY FLOWS - STCC 2311
MENS, YOUTHS OR BOYS CLOTHING

RANK	MARKET	1972 ANNUAL AIR TONS
1.	ALLENTOWN-DALLAS	325.5
2.	LOS ANGELES-CHICAGO	250.3
3.	LOS ANGELES-NEW ORLEANS	247.2
4.	LOS ANGELES-BALANCE OF E. NORTH CENTRAL	204.2
5.	ALLENTOWN-CHICAGO	171.2
6.	LOS ANGELES-NEW YORK	161.2
7.	ALLENTOWN-KANSAS CITY	157.9
8.	LOS ANGELES-PITTSBURGH	155.9
9.	ALLENTOWN-LOS ANGELES	155.8
10.	LOS ANGELES-BALANCE OF PACIFIC	151.2
11.	LOS ANGELES-BALANCE OF ATLANTIC	136.5
12.	ALLENTOWN-SAN DIEGO	134.2
13.	LOS ANGELES-BALANCE OF W. NORTH CENTRAL	133.9
14.	PHILADELPHIA-ST.LOUIS	100.1
15.	LOS ANGELES-CINCINNATI/DAYTON	98.7

FIGURE I-18. AIR COMMODITY FLOWS - STCC 2311 MENS, YOUTHS OR BOYS CLOTHING TOP 15 MARKETS

TABLE I-4. WORLD COMMERCIAL AIR TRANSPORT OPERATIONS

(Excluding USSR)

Freight Traffic in Tonne-Kilometers

Year	Type of Operation (Scheduled International	Domestic	Total
1972	8,240	4,990	13,230
1973	9,850	5,730	15,580
1974	11,030	5,940	16,970
1975	11,300	5,800	17,100
1976	13,000	6,500	19,500

Source: World Air Transport Statistics (IATA) Number Twenty-One, 1976

TABLE I-5. TOP TEN DOMESTIC AIRFREIGHT MARKETS

1976 Annual Data

Rank	City Pair	Tons	Origin	Tons	Destination	Tons
1	LAX-NYC	55,767	NYC	217,095	NYC	184,099
2	SFO-NYC	36,713	NYC	145,245	LAX	144,675
3	LAX-CHI	33,860	CHI	118,656	CHI	136,220
4	NYC-LAX	33,074	SFO	117,854	SFO	92,180
5	NYC-CHI	27,370	DTW	41,255	SEA	36,432
6	CHI-NYC	23,398	BOS	39,868	BOS	35,065
7	CHI-LAX	20,146	PHL	32,608	DEN	34,403
8	NYC-SFO	19,654	CLE	28,443	DTW	32,550
9	SFO-CHI	19,336	SEA	28,368	PHL	27,039
10	DTW-LAX	13,383	DEN	27,190	DFW	22,160

Source: Industry Shared Statistics Program

(McDonnell Douglas Industry On Line Air Freight Program)

TABLE I-6. TOP DOMESTIC AIRFREIGHT MARKETS

1972 Census of Transportation

(2-Digit Level)

Rank	Origin	Destination	Tons
1	PIT	Balance of W.S. Central	25,753
2	CHI	BAL	16,763
3	LAX	NYC	13,937
4	LAX	CHI	12,876
5	SFO	NYC	10,303
6	CHI	DTW	10,023
7	LAX	Balance of E.N. Central	7,564
8	IND	BAL	7,312
9	LAX	MIA	5,977
10	LAX	EWR	5,837
11	LAX	PHL	5,237
12	LAX	LAX	4,568
13	CHI	Balance of E.N.Central	4,376
14	DTW	SFO	4,253
15	LAX	DTW	4,043
16	CHI	CLE	4,026
17	CHI	CHI	3,892
18	CHI	NYC	3,844
19	CHI	MCI	3,810
20	CHI	LAX	3,717

TABLE I-7. TOP DOMESTIC AIRFREIGHT MARKETS

1972 Census of Transportation
(3-Digit Level)

Rank	Origin	Destination	Tons
1	IND	BAL	7,299
2	LAX	NYC	6,943
3	LAX	Balance of E.N. Central	5,666
4	CHI	"	4,164
5	DTW	SFO	3,986
6	LAX	PHL	3,973
7	LAX	Balance of Pacific	2,507
8	CHI	BOS	2,489
9	LAX	DTW	2,391
10	STL	NYC	2,263
11	EWR	Balance of W.N. Central	2,226
12	DTW	MSP	2,206
13	PHL	Balance of Mountain	2,110
14	CHI	SAT	2,056
15	DTW	EWR	1,982
16	CHI	NYC	1,879
17	LAX	LAX	1,871
18	CLE	Balance of E.N. Central	1,804
19	CHI	EWR	1,692
20	NYC	LAX	1,683

TABLE I-8. TOP DOMESTIC AIRFREIGHT MARKETS

1972 Census of Transportation

(4-Digit Level)

Rank	Origin	Destination	Tons
1	CHI	DTW	8,966
2	IND	BAL	7,299
3	DTW	SFO	6,971
4	LAX	Balance of E.N. Central	5,069
5	CHI	MKC	3,673
6	CHI	Balance of E.N. Central	2,694
7	DTW	EWR	2,447
8	LAX	NYC	2,216
9	EWR	Balance of W.N. Central	2,147
10	PHL	Balance of Mountain	2,096
11	LAX	Balance of Pacific	1,993
12	CHI	BOS	1,972
13	CHI	CLE	1,877
14	CLE	CHI	1,687
15	CHI	EWR	1,612
16	NYC	LAX	1,604
17	LAX	LAX	1,590
18	CHI	ATL	1,550
19	CLE	CLE	1,215
20	CLE	LAX	1,201

TABLE I-9. TOP DOMESTIC AIRFREIGHT MARKETS

1972 Census of Transportation

(5-Digit Level)

Rank	Origin	Destination	Tons
1	DEN	LAX	63,040
2	PIT	Balance of W.N. Central	25,753
3	SFO	STL	18,836
4	CHI	BAL	16,763
5	LAX	NYC	13,999
6	LAX	CHI	13,057
7	SFO	NYC	12,108
8	IAH	Balance of Middle Atlantic	10,384
9	CHI	DTW	10,031
10	DTW	SFO	7,970
11	LAX	Balance of E.N. Central	7,747
12	IND	BAL	7,312
13	LAX	MIA	6,005
14	SFO	LAX	5,958
15	LAX	EWR	5,830
16	LAX	PHL	5,251
17	LAX	LAX	4,539
18	SFO	Balance of Pacific	4,471
19	DFW	LAX	4,390
20	CHI	Balance of E.N. Central	4,381

the concentration of traffic at a few points: Angeles, Chicago, New York, and San Francisco.

Another carrier data source is service segment data (ER 586) available from the U.S. Civil Aeronautics Board (ref. 4). Each U.S. certificated air carrier must file a detailed monthly summary of all activities for each scheduled flight segment flown for that month. Approximately 40 to 70 facts are retained, including cargo (freight, mail, and express) transported, enplaned and deplaned for each segment. Although charter and commuter operations are not included, the ER 586 allows for an indepth view of air cargo flow in the U.S. Tables I-10 and Figure I-19 nd I-20 recap cargo tons transported, enplaned and deplaned, respectively, for 1973 through 1977 on stage lengths between 200 and 1700 statute miles, (320 and 2720 km) ranked by cargo volume in each instance.

Some other limitations are obvious. ER 586 only lists airport to airport and not original origin or final destination. In addition, the cargo reported transported for a certain segment represents flow of cargo not true airport origin and destination. However, using the cargo enplaned and deplaned allows for an accurate measure of the importance of a given airport in the U.S. air transportation network.

For international trade from the U.S., traffic is similarly concentrated in a few destinations. Examination of the top 10 destination countries for airfreight in October 1976 reveals that the same 5 countries, with one exception, are represented at all levels of detail, 2- to 5-digit, with only relative shifts taking place between the various levels of detail as shown in Table I-11. It is also interesting to note that, in addition to the expected presence of the large industralized western European nation and Japan, two Latin American countries, Venezuela and Colombia, are significantly represented, as well as Iran, Australia, and Belgium.

After taking this brief look at some of the present air mode's general traffic patterns, the composition of the traffic was examined to learn what commodities are being carried. These data are summarized in Tables I-12 through I-15 for exports, and Tables I-16 through I-19 for domestic movements.

Several general types of commodities seem to dominate both areas, including machinery, motor vehicle equipment, computer-related equipment, and a wide variety of articles manufactured from metal. While clothing is only occasionally mentioned among the exports, it appears at all four levels in the domestic tabulation and heads the list for U.S. imports along with footwear. Similarly, aircraft parts are featured on the export lists, but are not significant on the domestic side. In general, the most frequently mentioned domestic commodities tend to be manufactured and/or processed articles which can be classified as both consumer oriented and industrial; the exports seem to be oriented more heavily toward industrial products, particularly parts and components, whereas domestic leans more toward finished goods and includes significant amounts of agricultural products in a raw or semi-processed state, i.e., fruits, vegetables, and meat.

TABLE I-10. CARGO TONS TRANSPORTED/NONSTOP

RANK	BETWEEN	MILES	1977	1976	1975	1974	1973
1	LAX-ORD	1744	110,959	95,322	86,929	108,903	116,524
2	JFK-ORD	740	99,003	79,579	90,629	89,539	88,338
3	JFK-LAX	2475	96,481	75,364	68,785	87,863	71,612
4	LAX-SFO	337	88,295	69,650	59,437	85,199	77,970
5	ORD-SFO	1846	76,303	79,477	75,893	89,481	88,834
6	ORD-SEA	1720	58,570	64,481	51,033	47,523	46,303
7	HNL-LAX	2556	58,198	56,471	50,797	45,554	39,710
8	BOS-ORD	867	45,511	42,954	42,772	37,339	32,917
9	DTW-ORD	235	44,275	36,997	21,662	38,732	45,348
10	JFK-SFO	2586	44,087	33,585	35,221	32,963	39,774
11	ANO-SEA	1448	39,398	39,950	41,558	34,835	26,942
12	DFW-JFK	1391	34,594	24,283	19,989	22,346	*
13	EWR-ORD	719	29,681	40,295	29,712	33,326	38,804
14	ATL-ORD	606	28,235	24,082	20,908	22,902	25,733
15	DFW-LAX	1235	28,171	25,128	22,019	22,063	*
16	DEN-ORD	900	27,237	27,266	27,216	29,484	27,862
17	DFW-ORD	802	26,470	24,432	21,910	21,068	*
18	ORD-PHL	678	25,994	23,369	23,286	30,205	28,881
19	HNL-SFO	2398	25,958	28,968	25,843	29,680	27,427
20	DTW-SFO	2079	25,218	18,865	13,306	20,066	28,808
21	OLE-ORD	316	24,938	24,032	22,270	25,305	24,833
22	MSP-ORD	334	24,441	24,578	24,713	27,077	25,133
23	ATL-DFW	731	23,575	19,351	14,663	16,326	*
24	DTW-JFK	509	22,774	21,746	16,017	29,951	22,623
25	ATL-MIA	595	22,329	20,012	20,261	22,151	19,923

Source - U. S. Cab ER-586
* DFW Statistics Not Available in 1973

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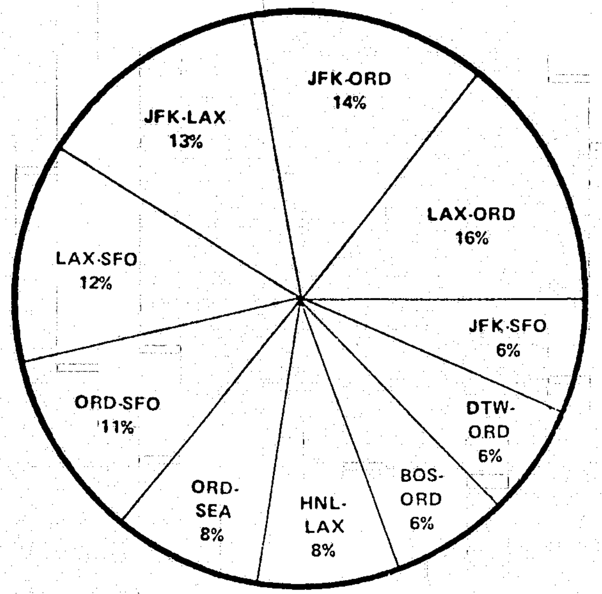
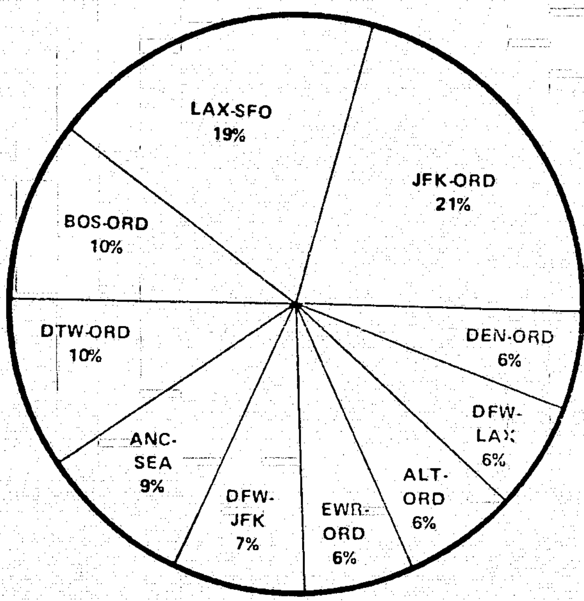
MARKET SHARE OF TOTAL TOP TEN CARGO VOLUME



ALL DISTANCES

44.72% OF TOTAL TOP 50 VOLUME



200-1700 MILES

28.78% OF TOTAL TOP 50 VOLUME

FIGURE I-19. CARGO TONS TRANSPORTED/NONSTOP

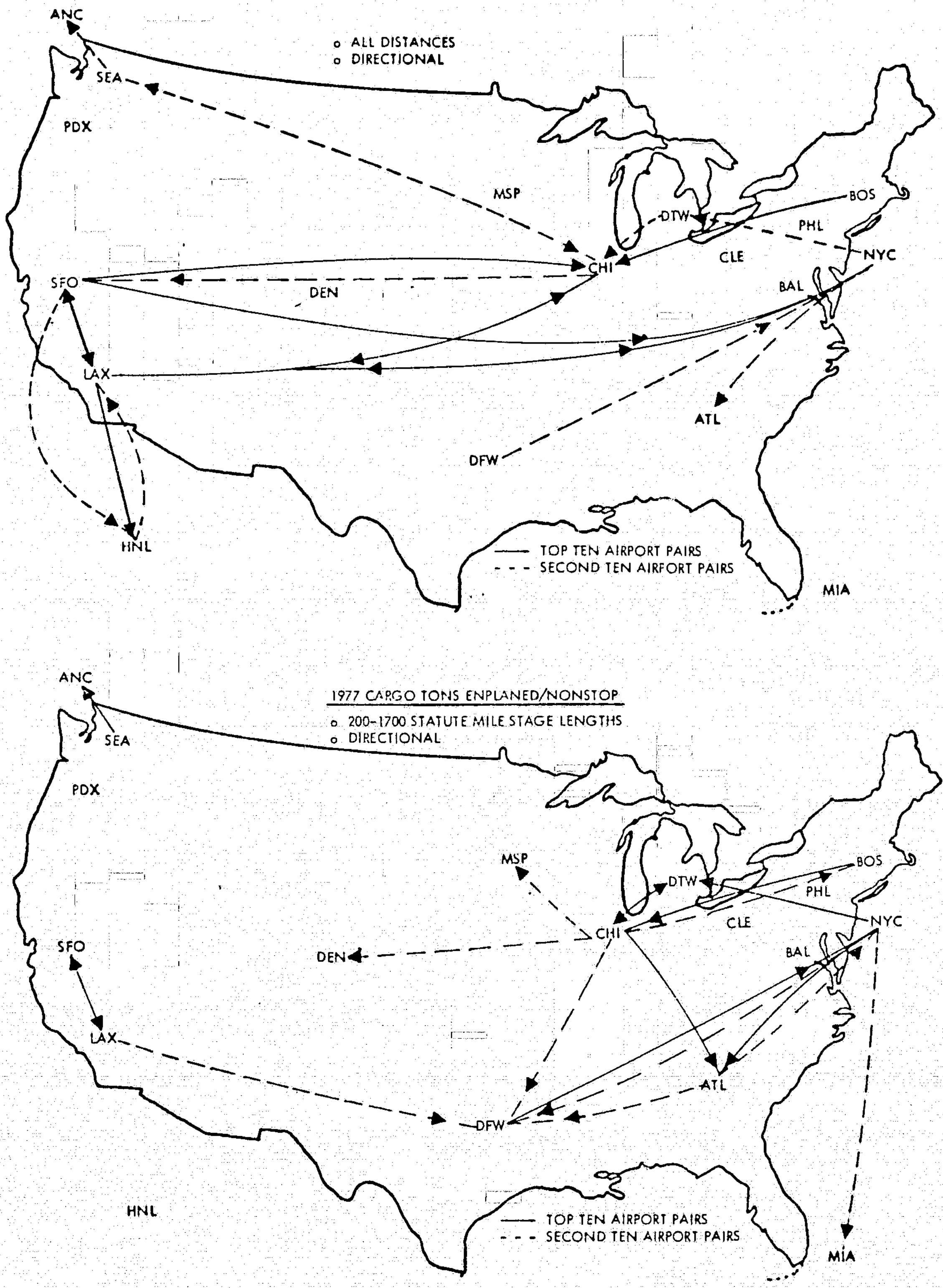


FIGURE 1-20. 1977 CARGO TONS TRANSPORTED/NONSTOP - AIRPORT PAIRS

TABLE I-11. TOP DESTINATIONS - U. S. AIRFREIGHT EXPORTS

Foreign Trade Data - October 1976

Rank	Commodity Level 2-Digit	3-Digit	4-Digit	5-Digit
1	United Kingdom	United Kingdom	France	France
2	Canada	France	United Kingdom	United Kingdom
3	Venezuela	Venezuela	Venezuela	Venezuela
4	W. Germany	Canada	Iran	Iran
5	France	W. Germany	W. Germany	W. Germany
6	Japan	Japan	Canada	Canada
7	Iran	Iran	Japan	Japan
8	Mexico	Belgium	Belgium	Belgium
9	Australia	Mexico	Mexico	Mexico
10	Belgium	Netherlands	Colombia	Colombia

TABLE I-12. TOP AIRFREIGHT COMMODITIES - U. S. EXPORTS

Foreign Trade Data - October 1976

(2-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs[1]
1	Machinery - Nonelectric	3578	112
2	Transport Equipment	4668	104
3	Electrical Machinery, Apparatus, Etc.	4147	91
4	Misc Manufactured Articles	2818	81
5	Professional, Photographic, Etc. Goods	2025	86
6	Manufactures of Metal, NEC	782	57
7	Meat Preparations	573	5
8	Yarn, Fabric & Articles, Textile	411	26
9	Chemical Elements & Compounds	394	22
10	Nonmetallic Mineral Manufactures, NEC	337	14
11	Fruits & Vegetables	294	8
12	Synthetic Resins & Plastic Materials	284	20
13	Spec Transactions not Classed by Kind	255	20
14	Clothing Incl Fur, Knit, Elastic Fabrics, Etc.	255	13
15	Chemical Products & Materials, NEC	223	25

[1] Country destinations

TABLE I-13. TOP AIRFREIGHT COMMODITIES - U. S. EXPORTS

Foreign Trade Data - October 1976

(3-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs[1]
1	Machinery, Appliances & Mach Parts, NEC	3578	92
2	Road Motor Vehicles & Parts, NEC	3138	77
3	Office Machines & Parts	3045	36
4	Elec. Machinery & Apparatus, NEC	1763	52
5	Scientific, Optical, Etc. Apparatus	1713	72
6	Machines for Spec Industries, & Parts	1236	64
7	Aircraft & Spacecraft, & Parts	1228	55
8	Telecommunications Apparatus, & Parts	810	55
9	Power Generating Machinery Exc. Electric	654	60
10	Sound Recorders, Music Instruments, Etc.	639	23
11	Electric Power Machinery, Switchgear & Parts	623	29
12	Printed Matter	611	31
13	Meat - Fresh, Chilled or Frozen	565	4
14	Baby Carriages, Toys, Sports Goods, Etc.	369	18
15	Glass	276	1

[1] Country Destinations

TABLE I-14. TOP AIRFREIGHT COMMODITIES - U. S. EXPORTS

Foreign Trade Data - October 1976

(4-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs[1]
1	Motor Vehicle Parts & Accessories, NEC	2900	74
2	Office Machines & Parts, NEC	2372	32
3	Aircraft, Parts & Accessories NEC	1230	56
4	Machinery & Electrical Appliances, NEC	957	51
5	Construction & Mining Machinery, NEC	935	52
6	Telecommunications Equipment, NEC	696	46
7	Statistical Machinery, NEC	572	20
8	Engines - Internal Combustion Era Aircraft	531	47
9	Meat & Edible Offals, NEC - Fresh or Frozen	514	1
10	Capacitors or Condensers - Fixed	448	24
11	Measuring, Control, Etc. Instruments	448	37
12	Arc Welders	426	11
13	Photo & Motion Picture Equipment & Parts	423	5
14	Phonograph Records & Other Sound Media	422	16
15	Parts & Accessories for Machinery, NEC	390	26

[1] Country Destinations

TABLE I-15. TOP AIRFREIGHT COMMODITIES - U. S. EXPORTS

Foreign Trade Data - October 1976

(5-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs
1	Motor Vehicle Parts Exc Bodies & Stampings	2901	76
2	Parts & Accessories for Electronic Computers	2368	33
3	Aircraft Parts Exc Airships & Balloons	1291	56
4	Misc Machinery & Mechanical Appliances	1023	51
5	Construction & Mining Machinery & Parts	956	55
6	Computer Related & Statistical Machinery	572	20
7	Diesel & Gas Engines & Parts Exc Aircraft	533	48
8	Meat & Edible Offals, Fresh, Chilled or Frozen	514	1
9	Elect Measuring & Controlling Apparatus Exc. Supply Meters	448	24
10	Electron Tubes & Parts, NEC	426	11
11	Phonograph Records & Other Sound Media	422	16
12	Screens, Projection & Copying Equipment NEC	405	5
13	Transmitters, Transceivers & Parts	342	32
14	Electric Apparatus for Electrical Circuits	293	14
15	Glass Envelopes Etc., Clock & Watch Glass	275	1

TABLE I-16. TOP AIRFREIGHT COMMODITIES - DOMESTIC

1972 Census of Transportation

(2-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs
1	Elec Machinery or Equipment	117,678	868
2	Machinery, Except Electrical	102,856	1072
3	Fabricated Metal Products	42,695	621
4	Transportation Equipment	38,269	245
5	Chemicals or Allied Products	33,818	590
6	Misc Prods of Manufacturing	30,146	172
7	Apparel & Other Finished Textile Products	27,417	219
8	Rubber or Misc Plastic Products	15,913	315
9	Instruments or Photographic Goods	14,517	304
10	Primary Metal Products	14,116	288
11	Pulp, Paper or Allied Products	8,888	187
12	Stone, Clay or Glass Products	8,753	184
13	Food or Kindred Products	8,572	151
14	Petroleum Products	4,063	24
15	Furniture or Fixtures	669	28

TABLE I-17. TOP AIRFREIGHT COMMODITIES - DOMESTIC

1972 Census of Transportation
(3-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs
1	Motor Vehicles & Equipment	17,002	110
2	Gen Industrial Machinery & Equipment	14,018	332
3	Radio & Television Receiving Sets	12,971	124
4	Electric Wiring & Lighting Equipment	11,997	213
5	Metal Stampings	11,177	64
6	Industrial Inorganic & Organic Chemicals	10,048	181
7	Office, Computing & Adding Machines	7,983	148
8	Misc. Plastics Products	7,895	131
9	Metalworking Machinery & Equipment	7,101	191
10	Drugs (Biological & Botanical Products)	6,848	182
11	Women's, Misses', Childrens' & Infants' Clothing	6,580	40
12	Construction, Mining Materials Handling Equip.	6,350	248
13	Bolts, Nuts, Screws, Rivets & Washers	5,900	95
14	Electrical Transmission Equipment	4,926	186
15	Soap & Other Detergents	4,565	61

TABLE I-18. TOP AIRFREIGHT COMMODITIES - DOMESTIC

1972 Census of Transportation

(4-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs
1	Motor Vehicle Parts & Access.	41,220	158
2	Metal Stampings	11,183	63
3	Misc Plastics Products	7,973	144
4	Misc Indust Inorganic Chemicals	7,216	54
5	Drugs (Biological & Botanical Products)	6,848	183
6	Womens', Misses', Childrens' & Infants Clothing	6,580	40
7	Industrial Compressors, Pumps, Etc.	6,432	71
8	Bolts, Nuts, Screws, Rivets & Washers	5,968	110
9	Electronic Data Processing Machines	5,810	85
10	Men's, Youth's & Boy's Clothing	3,754	87
11	Plastics Materials	3,324	99
12	Petroleum Refining Products	3,185	19
13	Cosmetics & Perfumes	2,628	39
14	Copper Wire, Strand & Cable	2,480	29
15	Asbestos Products & Asphalt Floor Tile	2,280	11

TABLE I-19. TOP AIRFREIGHT COMMODITIES - DOMESTIC

1972 Census of Transportation
(5-Digit Level)

Rank	Commodity	Tons	Number of Odd Pairs
1	Unclassified	591,164	1475
2	Motor Vehicle Parts	10,693	74
3	Automobile Stampings	7,498	24
4	Womens', Misses, Childrens	6,580	40
5	Industrial Pumps & Pumping Equipment	6,463	57
6	Electronic Data Processing Machines & Equipment	5,820	86
7	Drugs for Human Use	4,164	112
8	Mens', Youths' & Boys' Clothing	3,754	87
9	Plastics Materials	3,543	99
10	Bolts, Nuts, Screws, Rivets & Washers	2,997	53
11	Cosmetics & Perfumes	2,628	39
12	Asphalt Pitches & Tars from Petroleum	2,462	1
13	Unsupported Vinyl & Polyethylene Film	2,163	4
14	Meats & Sausage: Cooked, Cured, Dried	1,635	5
15	Current-Carrying Wiring Devices, NEC	1,562	45

Cost and Rate Structure - Once traffic and capacity are known, it becomes necessary to establish a rate structure, so that the revenues generated by the traffic will equal the costs generated by the provision of the capacity, and - at least in theory - provide for a reasonable return on the capital invested in the enterprise. Summaries of financial results of various cargo operations were examined, as well as the structural aspects of costs and rates which are described here. Data on costs were available from several sources: Two which are particularly useful are published CAB data on U.S. carriers (ref. 5), and IATA Cost Committee studies of international operations (ref. 6). Actual rates are, of course, public information which is available from the applicable tariffs; material on the development of the cargo rate structure has been drawn from the industry experience of TWA's Cargo Pricing department.

The main elements which comprise airline costs are shown in Figure I-21. For convenience, these can be placed in three groups: capacity, or aircraft operating costs, ground handling (non-capactiy) costs, and all other, which consists primarily of administrative expense/overhead. As Figure I-22 shows, one cost problem which has faced the air carriers has been rapid inflation, particularly in the critical areas of fuel and labor.

When the applicable costs have been identified, a rate structure can be developed; Figure I-23 shows the two main philosophical approaches to this task, while Figure I-24 provides rationale for specific commodity rates which are examples of by-product costing.

The disparity between fully allocated (regular all-cargo) rates and by-product (daylight belly) rates is substantial, as shown in Figure I-25. A detailed discussion of cost and rate matters from both a historical as well as a structural point of view, including discussion of current rating practices follows.

Cost Characteristics of Existing Air Cargo Markets

Background - When air freight rates were first established in 1944, there was no foundation of cost experience, and the rates did not properly reflect th varying costs of different sized shipments with a varying number of pieces and varying distances. The original air freight structure was based upon the rates charged for passenger baggage, which itself was based on the passenger fare for the particular segment. In 1946, United Air Lines established a freight rate structure which provided for some taper by distance in recognition of the fact that a portion of the airline expenses was caused by ground handling costs, so that the average yield per mile for short-haul shipments exceeded the yield for longer-haul shipments. The initial rate structure also contained a discount for high-volume shipments in recgnition of the fact that costs per pound were less for a large shipment than for handling smaller shipments. This basic pricing system, derived from passenger fares, lasted - with only minor modifications - until 1961. In 1961, The Flying Tiger Line

- AIRCRAFT (CAPACITY COSTS)
  - FUEL
  - FLIGHT CREWS
  - MAINTENANCE AND OVERHAUL
  - LANDING FEES
  - EQUIPMENT DEPRECIATION/RENTAL
- GROUND HANDLING (NON-CAPACITY COSTS)
  - LABOR
  - TERMINAL RENTAL
  - GROUND HANDLING EQUIPMENT
- OTHER
  - SELLING
  - GENERAL AND ADMINISTRATIVE

FIGURE 1-21. SIGNIFICANT COST ELEMENTS

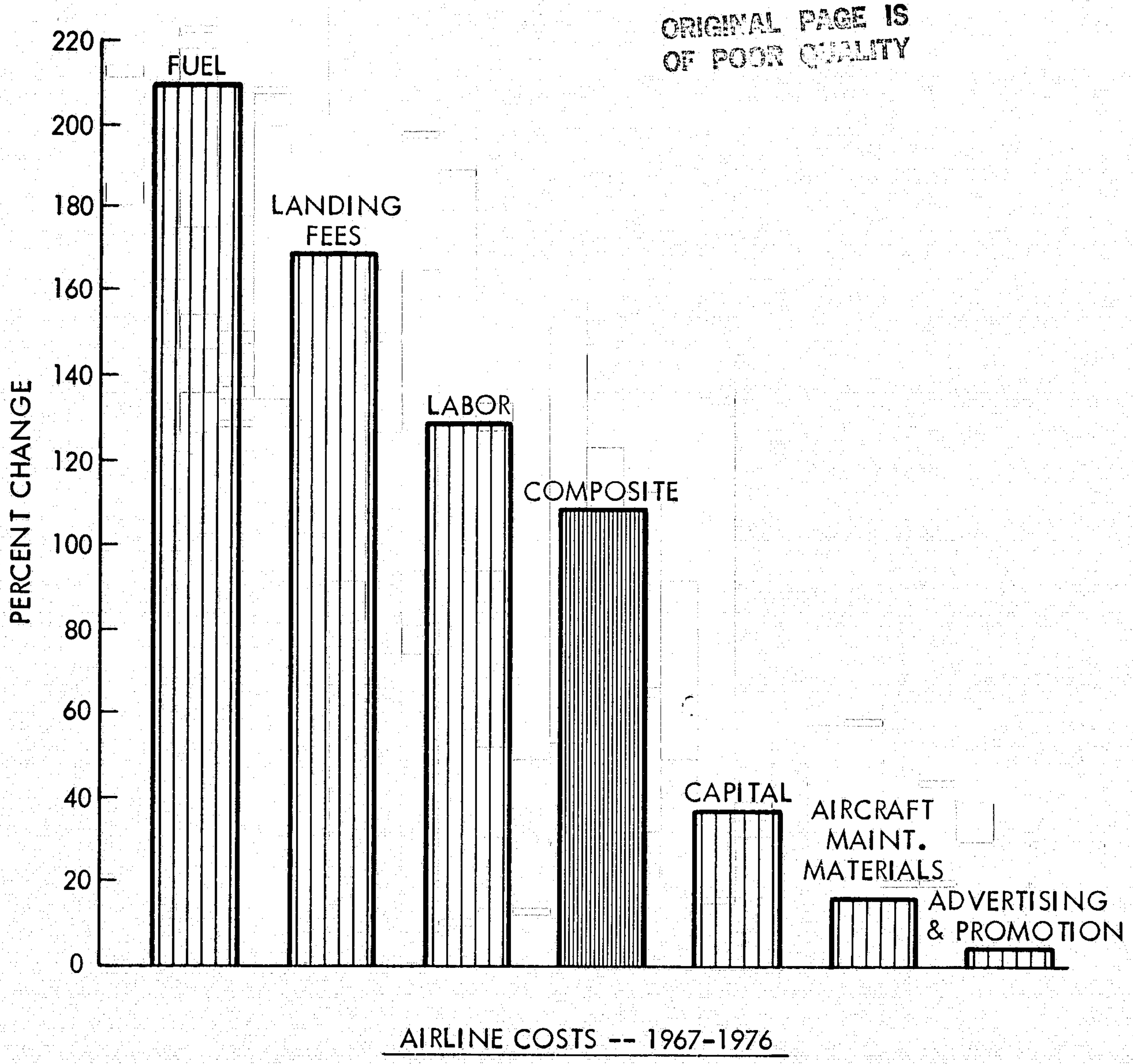


FIGURE I-22. OPERATING COSTS - HISTORICAL TRENDS

FULLY ALLOCATED

- REFLECTS FULL COST OF PROVIDING SERVICE, INCLUDING EQUIPMENT REPLACEMENT
- FAVORED BY FREIGHTER OPERATORS
- GENERALLY PRODUCES PREMIUM RATES

BY-PRODUCT

- REFLECTS ONLY INCREMENTAL COSTS OF PROVIDING CARGO SERVICE ON PASSENGER AIRCRAFT
- VIEWED FAVORABLY BY CARRIERS NOT OPERATING FREIGHTERS
- CAN BE USED TO GENERATE SURFACE COMPETITIVE RATES

FIGURE I-23. FULLY ALLOCATED VS BY-PRODUCT COSTING

- BACKHAUL/BALANCE ONE-WAY TRAFFIC FLOWS
- OFFER RATE INCENTIVE FOR DENSITY
- GENERATE OFF-PEAK TRAFFIC
- DIVERT TRAFFIC FROM SURFACE MODES
- PREVENT DILUTION OF "REGULAR" REVENUES

FIGURE I-24. RATIONALE FOR SPECIFIC COST RATES

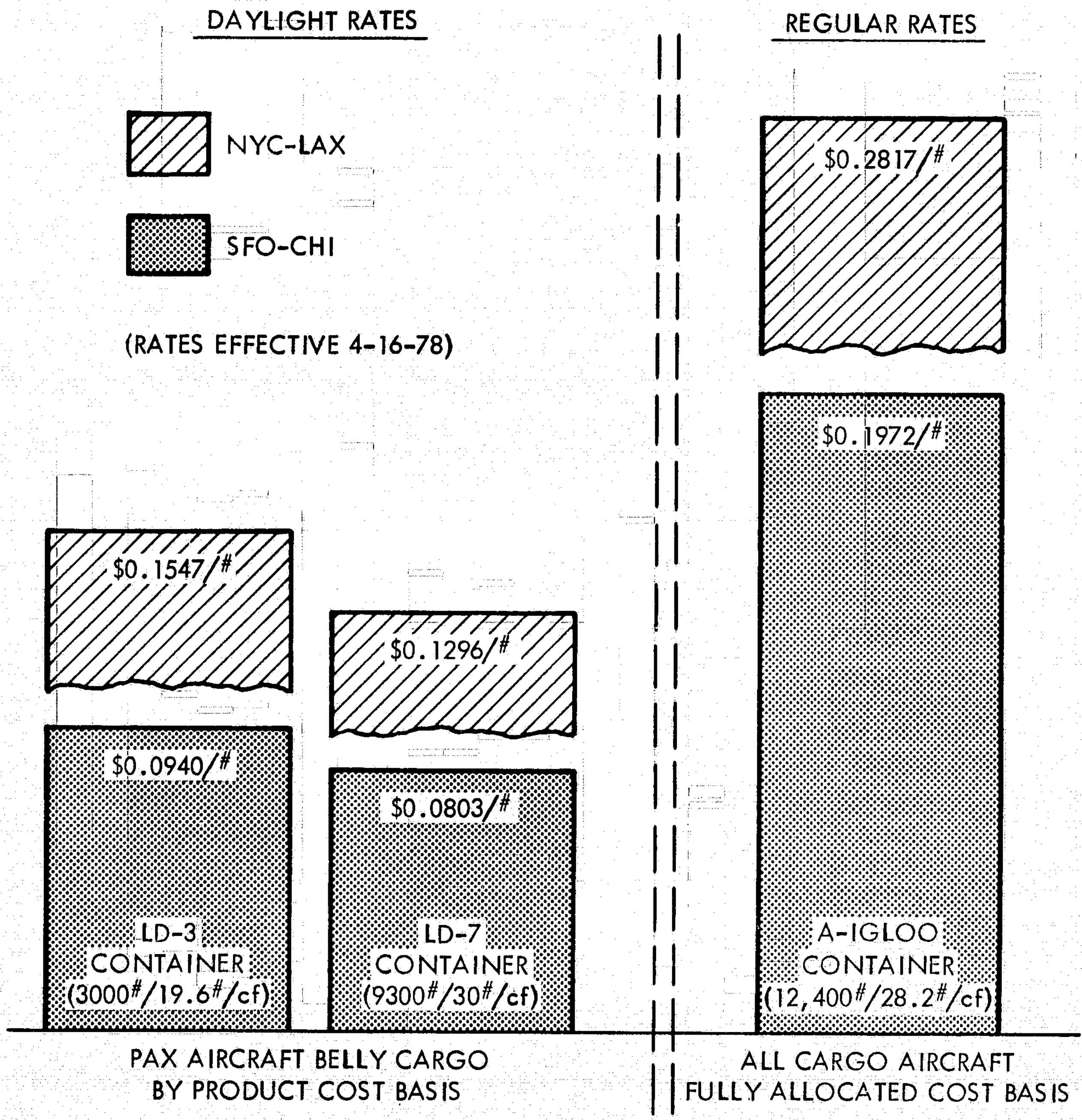


FIGURE I-25. COMPARISON OF DAYLIGHT & REGULAR CONTAINER RATES introduced a freight system which was patterned on the density classification system of motor carriers. Competitors responded to this new system by revising the general commodity rate structure in such a way as to increase the distance taper and to provide weightbreaks for shipments which met a minimum weight requirement of 1000, 2000, 3000, 5000, and 10,000 pounds (455, 909, 1366, 2273, 4545 kg). Again, there was little attempt to relate the rates to the actual cost experience of shipments with varying transportation characteristics. The system of rates adopted in 1961 is, with minor modifications, the same one that applied until recently. The rates have been increased through the years to reflect the increased cost of operation, and some of the high-volume discounts, namely those for 5,000- and 10,000-pound (2273 and 4545 kg) shipments have been eliminated from the rate structure.

Domestic Air Freight Rate Investigation - In recognition of the fact that there was no industry cost basis against which the CAB could judge the reasonableness of rates, in December of 1970 the CAB instituted the Domestic Air Freight Rate Investigation (DAFRI), ref. 7. The principal purposes of the investigation were to establish an industry cost base and develop guidelines against which air freight rates could be judged for reasonableness. Although the case has only recently been concluded, the CAB has for the past four years used the information developed in the investigation as a guide for judging carrier rate increases. As the need for rate increases has accelerated since the fall of 1973, principally due to increases in the price of fuel, the CAB has suspended any rates which exceed the guidelines developed in DAFRI. As a result, the rate structure for domestic air freight has come closer to those costs fixed by the CAB. Generally, long-haul rates, that is, those for distances of 1500 miles (2400 km) or more, are presently at the maximum allowed by the CAB. Short-haul rates, on the other hand, are still priced below the CAB's guidelines, but the gap continues to narrow as carrier increases are processed.

In DAFRI, the CAB examined costs in two main categories: non-capacity costs and capacity costs.

Non-capacity costs are those costs which are incurred by the carrier for the ground handling portion of transportation. They include the labor costs incurred at the terminal, such as the time required to accept a shipment, process shipments through the terminal, and load the traffic on board the aircraft. In addition, it includes the cost of equipment and facilities and sales expense.

Capacity expense, on the other hand, involves those costs associated with flying the freight from origin to destination. It includes items such as landing fees, fuel expense, crew pay, aircraft maintenance, and other flying operations.

The non-capacity costs were developed by commissioning a consultant, the Parsons group, to measure work flows at selected terminals. These man-minutes were then assigned to the principal cost-causative factors: shipments, pieces, or pounds. It was found through their study that these three elements are the principal reasons why the cost of handling a shipment varies. For example, costs of certain functions, such as preparation of an airbill, are essentially the same for each shipment irrespective of the size or number of pieces. Other costs, such as labeling, vary with the number of pieces. The cost of moving traffic from the warehouse to the aircraft varies principally with the number of pounds moved.

After the man-minutes were determined and assigned to their cost-causative factors, the total industry ground-handling terms were developed for all domestic shipments, pieces, and pounds tendered. A cost per man-minute was then developed, based on ground handling costs for the air industry. With this information, the CAB has been able to establish average ground-handling costs for any shipment tendered to a carrier. Further, these costs can be, and are, updated as the cost experience of the industry changes. The CAB does this by reviewing quarterly cost and traffic submissions by carriers to determine the percentage increase or decrease experienced from the base period (year 1972).

Capacity costs have been developed based on the all-cargo cost experience of carriers. The CAB decided to use the cost experience for freighter operations only, essentially for two reasons:

1. The determination of freighter cost is much more accurate than the determination of costs for combination lift. Since combination aircraft usually are operated primarily for the purpose of carrying passengers and cargo can be considered a by-product of this operation, considerable judgmental elements are involved in assigning a share of joint costs to the cargo operation. Therefore, the costs for cargo in combination aircraft is open to interpretation, and there is no consensus as to the proper method for allocating costs to these operations.

2. The CAB recognizes the need for the freighter operations of carriers to earn a reasonable profit. Otherwise, carriers will not provide the all-cargo schedules which are required to satisfy the freight demand of today's shippers or of the future.

Freighter capacity costs were developed for the base year 1972 at the average loads experienced by the industry during this period. The capacity costs consist of two elements: departure-related (such as landing fees) and line-haul-related (such as fuel, pilot pay, and maintenance of the aircraft). These costs, too, are updated from year to year by the CAB, so that current cost experience is used. This, also is developed from quarterly reports to the CAB which show each carier's capacity costs and revenue ton-miles. The most recent experience is compared with the base period (year 1972) and adjusted as required.

<u>Example of CAB Costing Methodology</u> - Now that the industry cost base has been established, the CAB has a useful tool for measuring the reasonableness of any freight rate which is proposed by an air carrier. The maximum rate which will be allowed for a particular segment is determined as follows:

1. The non-capacity costs for a shipment consisting of three pieces and weighing 100 pounds (45.5 kg) is determined by combining the current cost per shipment, at $4.53, and the cost for three pieces, at $1.74 per piece, or $5.22, and the cost for 100 pounds (45.5 kg), at $8.42 per 100 pounds (45.5 kg). The ground-handling or non-capacity costs for this shipment are thereby determined to be $18.17.

2. The capacity cost for a 100-pound (45.5 kg) shipment traveling 1000 miles (1600 km) is determined by combining the cost per departure, at 0.00818 cents per pound mile, or $8.18 per 100 pounds (45.5 kg) for 1000 miles (1600 km). The capacity costs are thereby determined to be $14.46.

3. The total cost per shipment is the combination of the non-capacity cost, $18.17 and the capacity cost, $14.46 or $32.63 per 100 pounds (45.5 kg). The mathematics of this methodology are shown in Figure I-26.

As noted above, during the past several years the CAB has used this methodology to review the reasonableness of any rates filed by carriers. Since this was a period of unprecedented cost increases, due primarily to increases in the price of fuel, the airline rate structure now in effect generally reflects the maximum cost allowed under this formula. In particular, long-haul shipments, namely those of 1000 miles (1600 km) and over, are at the maximum formula permitted by the CAB. Short-haul segments have not yet achieved the maximum allowable by the CAB, but the spread has been considerably narrowed during this period. Figure I-27 is a copy of the CAB's cost data for the latest period available: the year ending March 31, 1977.

Characteristics of the Current Rate Structure - The rate structure that is was in effect at the start of cargo "deregulation" differs from that which had been effective before the Board adopted this costing methodology in two main areas:

1. The current rate structure reflects a larger taper for distance than the one which formerly applied. Since non-capacity costs represent a considerable portion of total airlne expenditures, the taper between short-haul and long-haul shipments has been widened. As the rate structure moves closer in line with the CAB'S findings, this taper will be widened still further.

2. There is far less of a pricing differential between small size and high volume shipments. Since the costs assigned to shipments ($4.53) are a relatively small portion of the total expense, the rate differential for shipments of small sizes versus shipments of larger sizes is much smaller than it previously was. For example, the per shipment expense of $4.53 expresed in terms of cost per pound (kilogram) amounts to 4.5 cents for a 100-pound (45.5 kg) shipment, 0.45 cents for a 1000-pound (45.5 kg) shipment, and 0.045 cents for a 10,000-pound (4545 kg) shipment.

NON-CAPACITY COSTS

COST PER SHIPMENT	$4.53/SHIPMENT	$ 4.53
COST PER PIECE	$1.74/PIECE X 3 PIECES	$ 5.22
COST PER POUND	$0.0818/LB X 100 LBS.	$ 8.42
TOTAL NON-CAPACITY (GROUND-HANDLING) COSTS		$18.17

CAPACITY COSTS

COST PER DEPARTURE	$0.0628/LB. X 100 LBS.	$ 6.28
LINE HAUL ELEMENT	$0.0818/LB. X 100 LBS	$ 8.18
TOTAL CAPACITY (AIRCRAFT) COSTS		$14.46

TOTAL COST

NON-CAPACITY COSTS	$17.93
CAPACITY COSTS	$14.46
	$32.63

FIGURE I-26. COST OF 3-PIECE, 100 POUND SHIPMENT FOR 1000 MILES
CAB METHODOLOGY

12 MONTHS ENDED MARCH 31, 1977

TYPE OF TRAFFIC	Capacity Line Haul Cost Per Pound Mile (Per 1.49 Kg-Km)	Terminal Charge: Non-Capacity Cost Per Shipment	Terminal Charge: Non-Capacity Cost Per Piece	Terminal Charge: Per Cwt. (Per 45.5 Kg) Capacity Portion	Terminal Charge: Per Cwt. (Per 45.5 Kg) Non-Capacity Portion	Terminal Charge: Per Cwt. (Per 45.5 Kg) Total
Regular Bulk Freight	.00818¢	$4.53	$1.74	$6.28	$8.42	$14.70
Environmentally Controlled and Hazardous	.00818	8.12	1.74	6.28	7.48	13.76
Valuable	.00818	13.94	1.74	6.28	7.48	13.76
Live Animals	.00818	12.54	0.97	6.28	6.51	12.79
Human Remains	.00818	4.53	9.73	6.28	6.53	12.81
Non-Bypass Type Containers						
B, B-2	.00818	4.53	1.52	6.28	7.21	13.49
LD-N	.00818	4.53	1.52	6.28	7.44	13.72
D	.00818	4.53	1.52	6.28	7.32	13.60
E, QD	.00818	4.53	1.62	6.28	7.78	14.06

Bypass Type Continers	Capacity Line Haul Cost Per Cubic Foot Mile (0.455 Cubic Meter - Km)	Capacity Line Haul Cost Per Pound Mile 1/ (.724 Kg-Km)	Terminal Charge: Non-Capacity Cost Per Shipment	Terminal Charge: Non-Capacity Cost Per Container	Terminal Charge: Capacity Cost Per Cubic Foot (Per .0283 Cu M.	Terminal Charge: Capacity Cost Per Pound 1/ (Per 1.600 Kg)
A-1, A-2, A-3	.07220¢	.00646¢	$4.53	$187.52	55.50¢	4.96¢
LD-1, LD-3	.07220	.00646	4.53	105.23	55.50	4.96
LD-7	.07220	.00646	4.53	200.52	55.50	4.96
LD-W	.07220	.00646	4.53	62.64	55.50	4.96
LD-5, LD-11 (278 cu. ft.)	.07220	.00646	4.53	149.74	55.50	4.96
LD-6	.07220	.00646	4.53	169.93	55.50	4.96
LD-11 (257 cu. ft.)	.07220	.00646	4.53	140.35	55.50	4.96
LD-12	.07220	.00646	4.53	210.71	55.50	4.96
M-1	.07220	.00646	4.53	242.12	55.50	4.96
RD-7	.07220	.00546	4.53	189.64	55.50	4.96

1/ Excess weight charges for densities above 11.17 pounds; derived by dividing the rates per cubic foot-mile and per cubic foot by 11.17.

FIGURE I-27. STRUCTURE ELEMENTS USED IN BUREAU'S COST-BASED RATES

In practice, this translates to a cost-related rate differential of less than 4 mils per pound for a shipment weighing 10,000 pounds (4545 kg) compared with a shipment weighing 1000 pounds (455 kg), assuming the same number of pieces per cwt. Such differentials are insignificant based upon the overall airfreight rate levels and lend little cost support to high volume discounts. Previously carriers had often priced high weightbreak shipments on a much wider spread as a method for developing high volume shipments and stimulating the air cargo market. The current rate structure still contains shipment spreads which are in excess of those indicated by the costing formula. The future is likely to see a further reduction in the spread of rates for high volume shipments.

International Pricing - Unlike the domestic pricing arena, there has been no similar development of a sophisticated cost base with respect to international rates. There is a question as to whether there is any useful purpose to be gained from the development of a comparable costing formula for international rates. First of all, international rates are typically settled through IATA negotiations. At these IATA negotiations, the implementation of rates often depends upon social or political influences rather than on strictly economic factors. For example, many foreign-flag operators are more concerned with stimulating trade from their particular country than in the profitability of carrying such traffic. Since many are subsidized by their governments, the losses incurred through the carriage of freight can be recouped through government subsidies. Second, there is little likelihood that a meaningful cost base could be developed. The many different carriers operating a particular route are faced with different economic conditions in their homelands, varying currency relationships, and differences in cost experience. There is some doubt that an industry-based average cost would have any validity for an individual segment. Third, unlike domestic transportation which achieves a mix of short-haul and long-haul transportation, international transportaion normally is trans-ocean and necessarily is long-haul in nature. Thus the segregation of costs into non-capacity and capacity, and further development of capacity costs to those that are departure-related versus line-haul-related, has substantially less meaning for international transportation than for domestic transportation.

In recent years, the IATA Cost Committee has devoted some effort to developing all-cargo costs for the various world areas. The cost data that they work with is not the universe of carrier cost experience, since there is no requirement that IATA carriers submit these costs to the committee. Typically, about 50 percent of the carriers operating a route will report costs to IATA. However, generally the carriers which do report costs are the larger carriers and represent a major portion of the traffic for a particular area.

The latest IATA cost study segregates carrier costs into eight major categories, and it is possible to determine the split between capacity and non-capacity costs. However, there has been no effort by the IATA Cost Committee to assign the non-capacity expenses to shipments, pounds, or pieces, nor the capacity costs to those that are departure-related versus those which are line-haul-related. Thus, the development of this cost data is of very little help in determining whether the structure of the air freight rates, as opposed to the level of the air freight rates, is cost-based.

The results of the 1976/77 operations, IATA examines yearly data for the period ending September 30 of each year, show that all-cargo operations for various areas were from 5 percent below to 45 percent below the level needed to recover full economic costs. The Transatlantic and Transpacific rate levels were 30 and 37 percent, respectively, below full economic costs. These results were achieved despite the attainment of load factors roughly comparable with those experienced for U.S. domestic routes, 50 percent load factor on the North Atlantic versus 55 percent load factor on domestic routes. It is apparent, therefore, that substantial yield increases would be required for carriers to achieve profitable operations at typical load factors experienced on international routes.

While there have been no studies comparable to the Parsons study with respect to assigning costs on a shipment, pound, and piece basis, it is quite likely that the cost experience of the U.S. domestic carrier industry would form a reasonable basis for international operations, with the exceptions of allocations to shipments. In international operations, additional cost is associated with preparation of airwaybills, review of customs documents, and clearance of shipments through customs. For that reason, the $4.53 charge per shipment on domestic routes is likely to understate the per-shipment cost for international shipments. On the other hand, it is probable that the findings of the Parsons study, with regard to allocation of charges for pieces and weight, would be valid for international shipments, since terminal work flows are approximately the same, regardless of whether the shipment is domestic or international in character. The higher costs for shipment-related functions in international traffic mean that a cost-based rate structure would involve higher spreads between the rates for low-volume and high-volume shipments.

Based on a special IATA study that was conducted about three years ago, it is estimated that the per-shipment costs for international traffic approximate $25 per shipment. Thus, a $25 charge per hundredweight (cwt) (45.5 kg) needs to be built into the 100-pound (45.5 kg) rate structure; this would decline to $2.50 per cwt. (45.5 kg) for a 1000-pound shipment (455 kg), and to 25 cents per cwt. for a 10,000-pound (4545 kg) shipment. The spread between a 100-pound (45.5 kg) shipment and a 1000-pound (455 kg) shipment should be considerably greater for an international segment than for a domestic shipment. On the other hand, once a shipment, either domestic or international, exceeds 1000 pounds (455 kg) in weight, the cost-related differences which accrue to shipments of even greater weight are relatively insignificant. Using the above example, the total cost difference dependent upon shipment size between a 1000-pound (455 kg) shipment and a 10,000 pound (4545 kg) shipment is only $2.25 per 100 pounds (45.5 kg). The effective reduction in cost then should translate to a rate reduction of about 2 cents per pound (0.45 kg).

On transatlantic routs, many carriers have been seeking to implement high weightbreak reductions which far exceed these amounts. This is due in part to a desire to offer a promotional rate which may stimulate additional air business, and in part also to the desire of some carriers to segment the market in such a way that they will be able to gain a bigger share by virtue of their capacity offered.

During the past 10 years or longer, high weightbreak offerings have been the paramount source of contention between transatlantic carriers as to how an effective rate structure should be developed. During th last year, these differences became so pronounced that the IATA agreement was terminated. This circumstance has permitted carriers to make unilateral tariff fillings which can become effective upon approval of the U.S. and foreign government involved. The result of the open rate status coupled with the desire of the U.S. CAB to foster rate competition has been the implementation of numerous reductions for specific commodity container and high weightbreak rates, particularly on westbound transatlantic segments.

Further discussion on pricing as a result of deregulation is presented in the "Institutional Controls" subsection.

Current Air Mode Selection/Air Eligibility Commodity Characteristics

Following the discussion of air market economics, is it appropriate to look at some of the reasons behind the generation of air traffic flows. This is examined from the point of view of attempting to find specific criteria which might determine, or at least influence, movement via the air mode, using available published data sources and material recently developed by the Department of Transportation.

A number of criteria are thought to influence the selection of the air mode versus surface carriage, including:

- o Perishability
- o Value
- o Density
- o Shipment size and weight
- o Fragility
- o Market growth rates and time sensitivity

Various commodities presently moving by air can be cited as examples of one or more of the above general charactristics, e.g., cut flowers (perishability, value per pound, low density); fashion goods (time sensitivity, value); and others. These factors help to cause the majority of air cargo tonnage today to be composed of shipments generally characterized by "smallness," relatively high unit value, of some fragility/perishability, low density, and/or of an emergency nature.

After reviewing these traditional criteria such as density, value, perishability, etc. in a general manner, it was decided to use an analytical approach in an attempt to confirm the applicability of the aforementioned criteria, as well as to uncover any additional facts which might be of use in determining potential air eligibility.

To summarize briefly, the methodology employed was to merge two data sources, ref. 2 and the Commodity Attribute File developed by the Transportation Systems Center of the Department of Trasportation (ref. 8). It was anticipated that once that was accomplished, data from the Census could then be correlated with that contained in the Attribute File, and regression techniques could be used to determine if and to what extent any correlations existed. Finally, any strong correlative factors which were discovered could then be used to determine appropriate commodities/origin-destination pairs where air penetration was now low, but might be stimulated due to favorable commodity and/or route characteristics. The methodology is diagrammed in Figures I-28 and I-29.

Since the Census, and some of the difficulties in using it, has been reviewed previously this Section; no further description of this source is provided here. The Commodity Attribute File includes the following data:

- 5-Digit STCC (Standard Transportation Commodity Code) Number
- Density
- Value per unit of weight
- Physical state (solid, liquid, gas, or particulate)
- Special handling requirements (including requirements for freezing temperature, temperature control, shock control, other special handling)
- Shelf life

These factors, plus one other inherent in the Census O&D data - the average distance hauled - were then arranged into a general model of the following form to examine air eligibility factors, so that a multiple regression analysis could be performed: % Air Penetration =

k (a constant) +

f_1 (value/weight ratio) +

f_2 (density) +

f_3 (average distance hauled) +

f_4 (shelf life - dummy variable) +

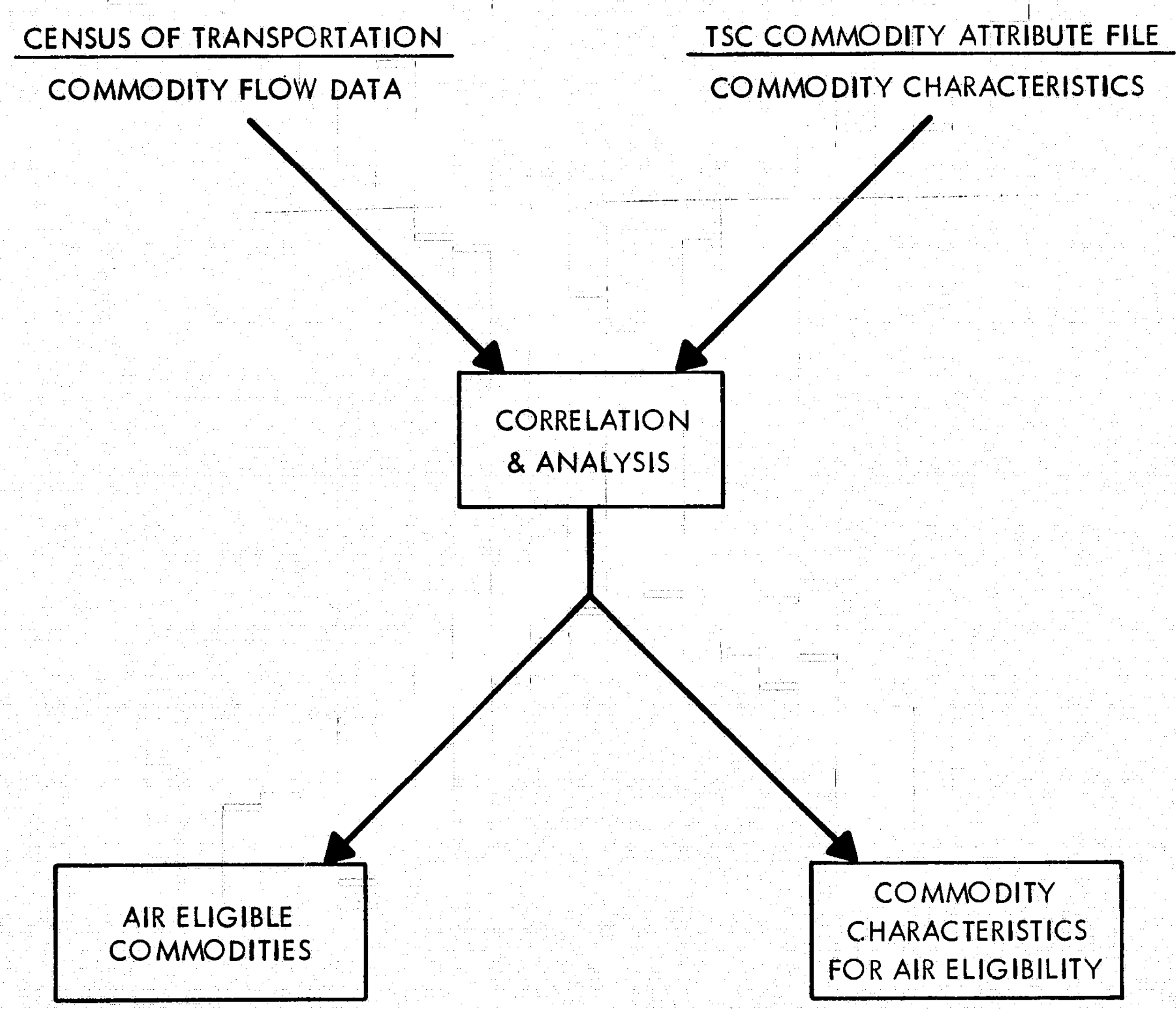


FIGURE I-28. AIR ELIGIBILITY ANALYSIS

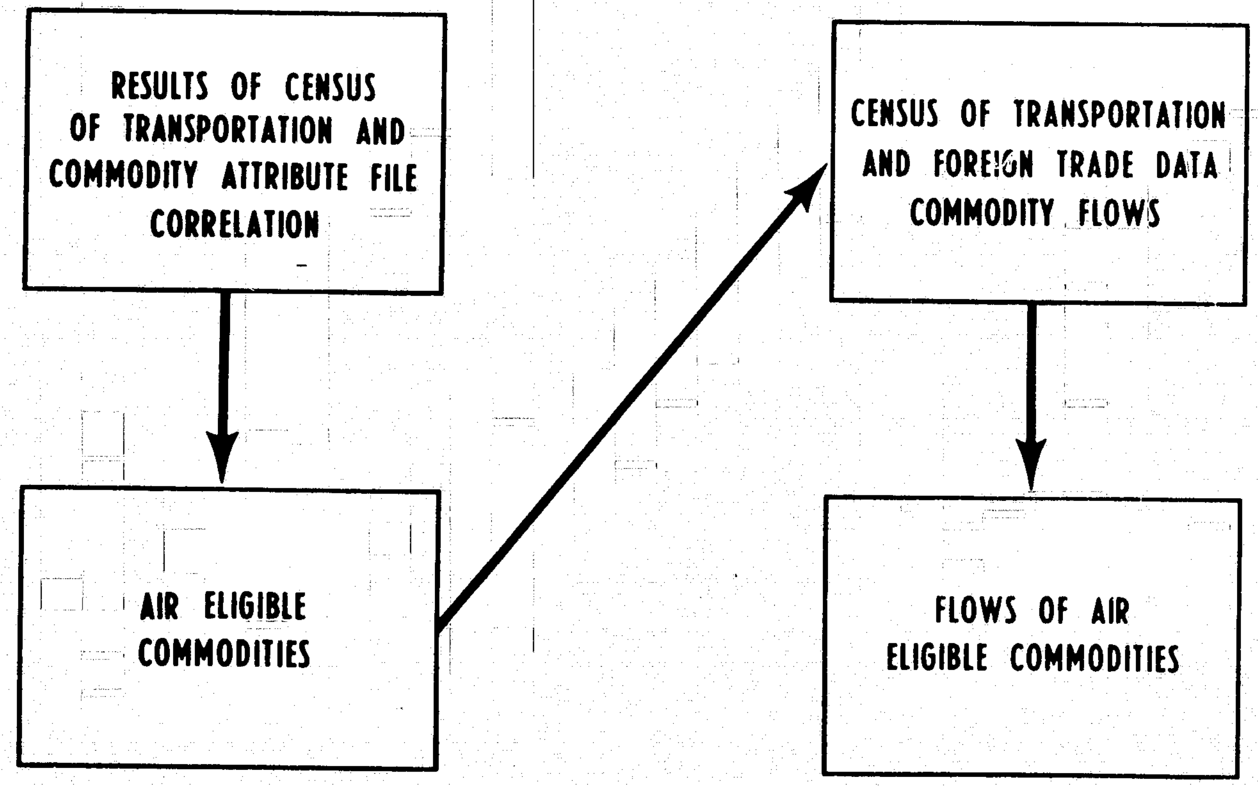


FIGURE 1-29. AIR ELIGIBILITY ANALYSIS - METHODOLOGY

f_5 (average shipment size - determined by dividing total tons by number of shipments) +

f_6 (state of the commodity - dummy variable) +

f_7 (special handling requirements - dummy variable)

Use of the multiple regression analysis allows the determination of the relative contributions of each of the variables toward the selection of the air mode, since the variables are to be entered one by one, beginning with the variable which shows the highest correlation with the dependent variable, air penetration.

Application of this concept proved to be less than successful for two reasons. First, due to the disclosure/suppression problems inherent in the census data, only a relatively small number of commodities at the 5-digit level were available to be matched to the Commodity Attribute File. Second, those available for analysis showed generally inconclusive results, such as density versus air penetration, Figure I-30, and unit value versus air penetration, Figure I-31. Distance for air shipments versus air penetration, Figure I-32, showed marginally better results, although there was a great concentration of points along the horizontal axis in the scatter diagram. Finally, a cross-correlation - unit value versus density, Figure I-33 - also showed little but clustering around the vertical axis.

Several factors would be responsible for the lack of results from this approach, including problems associated with the data inherent in the Census, such as failure to achieve a true "cross-section" of data at the 5-digit level due to the disclosure rules or the possibility that air eligibility "factors" are more general trends rather than specific items which can be subjected to analytical methods to yield high correlation to modal choice. Since this is a rather complex subject beyond the intent and scope of the current project, no further analysis along these lines was attempted.

Lack of success with this approach obviously precludes using the results of this analytical process to determine areas amenable to penetration by air mode. Traditional market research methods use by carriers to perform this task generally start with an assessment of traffic volumes, by commodity, moving between O&D pairs, using the Census, Foreign Trade Data, etc., with commodities being selected based on the traditional factors of density, value, and perishability as adapted to the particular carrier's situation. Following this step, the carrier then makes a determination of shippers/receivers near the origin/destination points and follows this with sales contacts with the shippers/receivers to determine realistic potential volumes.

This approach is rather complex, and since it is oriented towards use in individual markets rather than towards the system as a whole, it would be of only limited value to perform this type of research in this analysis.

1972 CENSUS/COMMODITY ATTRIBUTE FILE CORRELATION

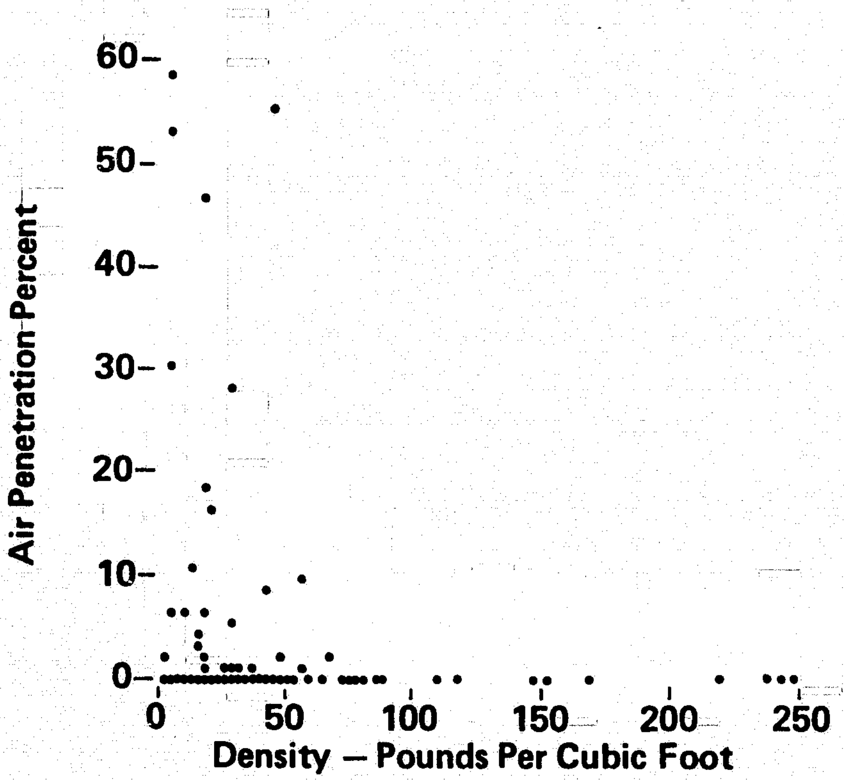


FIGURE I-30. AIR PENETRATION ANALYSIS - DENSITY

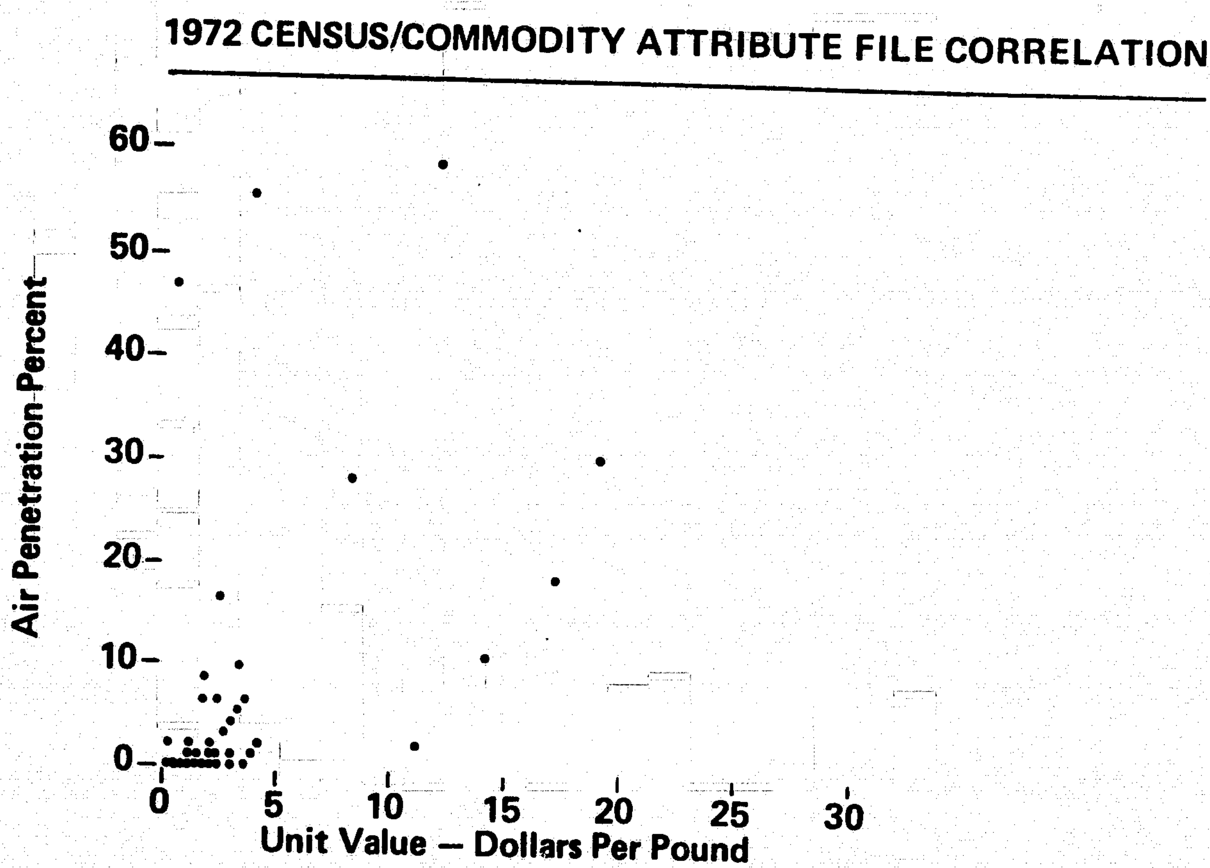


FIGURE I-31. AIR PENETRATION ANALYSIS - UNITE VALUE

1972 CENSUS/COMMODITY ATTRIBUTE FILE CORRELATION

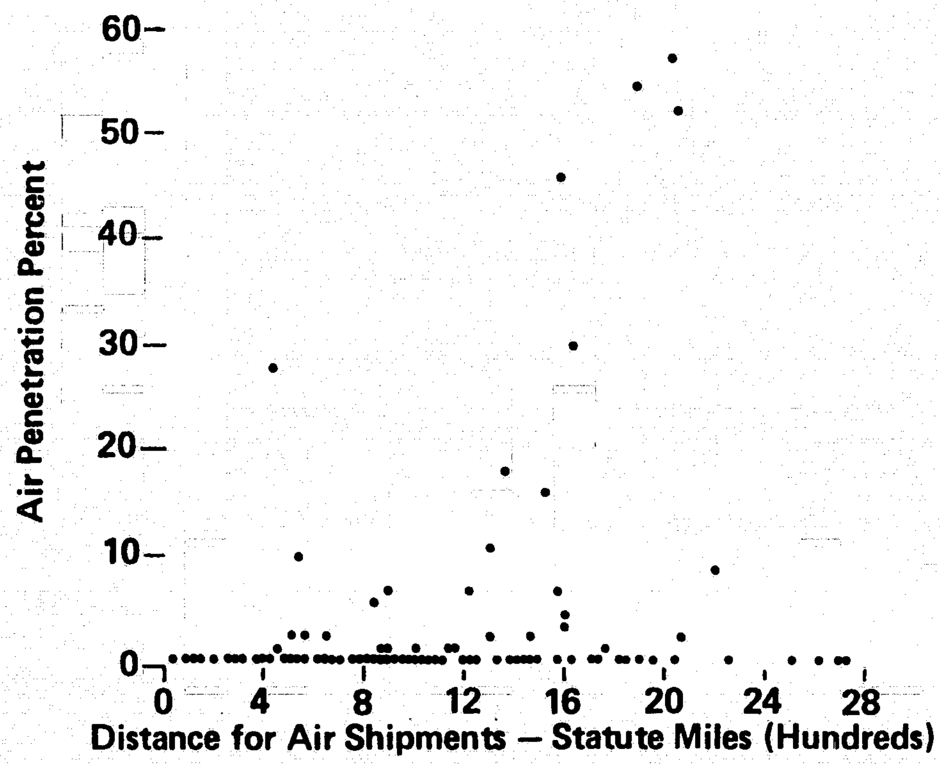


FIGURE I-32. AIR PENETRATION ANALYSIS - DISTANCE FOR AIR SHIPMENTS

1972 CENSUS/COMMODITY ATTRIBUTE FILE CORRELATION

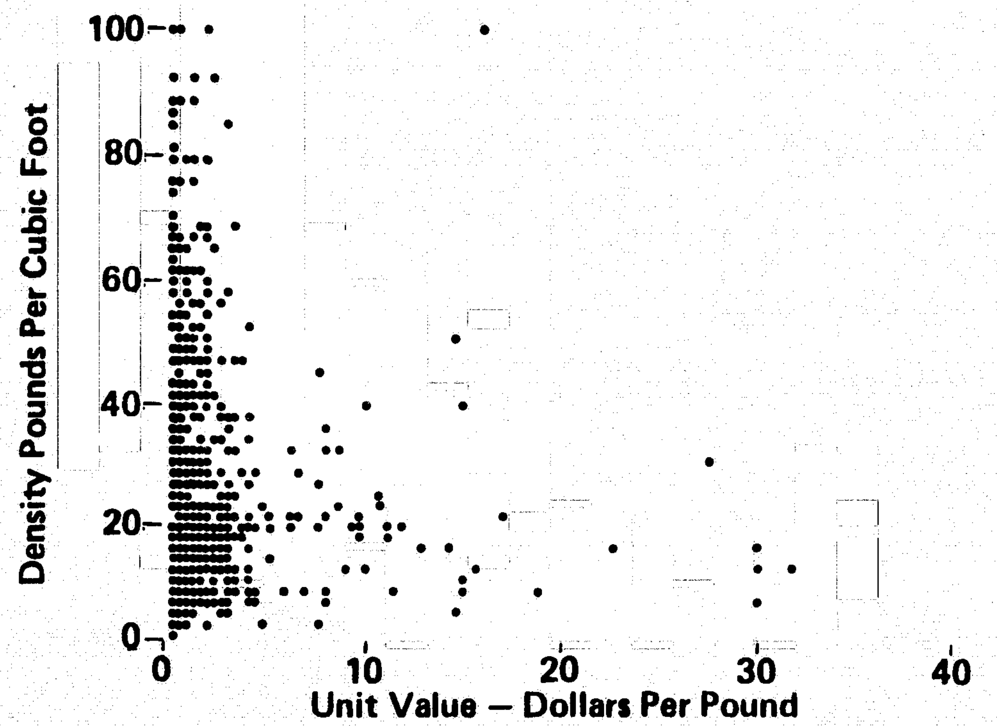


FIGURE I-33. CROSS CORRELATION - UNIT VALUE VS DENSITY

Analysis of generalized commodity groupings using factors such as density, perishability, if known, and others, can be of some value in determining potential air penetration, although the accuracy of results generated by this method is questionable, since it does not take into account real-world market factors, distribution patterns, etc. In addition, unless the work is done at a discrete commodity, e.g., 5-digit STCC level, where data voids often exist due to disclosure requirements, the commodity descriptions are often not precise enough to positively identify true air potential tonnage.

Prior to completing this discussion, one key term - density - and its use in determining market potential should be mentioned. While greater density is beneficial, different factors apply depending on whether the air carriage is to be performed in an all-cargo aircraft or in the belly of a passenger airplane. In the former, density considerably above the design density of the aircraft actually impairs space utilization in that the aircraft "weights out" before all the volume is utilized. While this is not generally a problem currently, since most freighters have design densities at or above the level of the prevailing traffic, it could become a problem in the future were a considerably lower density build into a new design. On passenger aircraft this is less of a problem, for two reasons: (1) density in the main deck of the airplane is low due to poor cube utilization in the passenger compartment: and (2) space utilization in the belly can be subordinated to revenue potential. If density incentives are necessary to fill otherwise unused belly space and it is priced on an incremental basis, then some traffic diverted from surface is better than none, even if it uses weight capacity out of proportion to the space it occupies.

The Potential Air Commodity Identification issued by the Cargo Analysis and Development Unit of Boeing in March 1977 (ref. 9) also examined air freight eligibility. This study examined five factors: value per kilogram, density, fragility, market time sensitivity, and market growth.

For each commodity examined, a "factor score" was assigned based on certain parameters. Factor scores were grouped into three categories: high, medium, and low, with values ranging from 20 to 5 points, respectively. Thus an "air eligibility score" could be derived for each commodity for which data was available, with a high score indicating greater air eligibility.

This Method yielded significantly better results than the use of a single factor, such as value. Use of the methodology is, of course, somewhat subjective, particularly in assigning factor scores to fragility and market time sensitivity, although Boeing notes that "no significant improvement over the original system was detected" by applying different factor weighting and point score systems.

This is an interesting and logical approach, but one for which Boeing states that "more recent and more detailed statistics are required" in order to be of the greatest possible use. In addition absolute validation of this type of tool is not feasible, since even the best-developed air market may contain commodities which have not been fully penetrated. When a commodity's air penetration lies below the expected level predicted by this method, it is not known whether the deviation is due to imperfection in the evaluation method or to incomplete market development. Hence, it was decided to use the methodology only as a preliminary evaluation tool.

Comparison of Current Air/Surface Modes

To assess not only the characteristics of the present air cargo system, but also to discover how the present air system relates to its surface competition, a survey approach was devised to compare air and surface operations on five routes:

New York - San Francisco (Typical Transcontinental Route)

Chicago - Los Angeles (Major Production Center/Long Haul Route)

New York - Dayton (Short-Haul Freighter Route)

New York - London (Prime North Atlantic Route

New York - Tokyo (Prime Transpacific Route)

These routes were chosen to provide a good cross-section of operational and market factors, for both international and domestic operations. All of these routes presently have scheduled all-cargo air service, as well as numerous surface carriage options.

The survey methodology was selected to include the "real world" operating experience of the carriers actually operating on a given route, both air and surface. The air-surface comparison methodology encompasses route selection, commodity selection, carrier selection and contact, distribution of survey questionnaires, analysis, and preparation of results. The main factors surveyed are listed on Figure I-34, a sample questionnaire may be found in Appendix I-A.

To ensure that air would be reasonably represented, specific commodities were chosen for which air has achieved some penetration in that particular market, as shown in Table I-20. This was done to establish that the commodities in question could be, and are, actually transported by air. Data on modal splits were obtained from the Census of Transportation for domestic, and the Department of Commerce Foreign Trade Data, 1976, for international.

Following this, the questionnaire requesting various types of service and rate information was devised and sent to approximately 20 carriers, representing the air, rail, truck and ocean shipping modes as appropriate to the routes in question. Where possible, questionnaires were sent to more than one carrier of each mode on each route, to ensure that enough data were obtained to analyze each route.

RATES

- TYPICAL SHIPMENT SIZES
- AVAILABILITY OF CONTAINER RATES
- DELIVERY

SERVICE

- TRANSIT TIME: LINE-HAUL AND DOOR-TO-DOOR
- USE OF CONTAINERS
- FREQUENCY OF SERVICE
- CLAIMS RATIO
- CAUSES OF DELAY

FIGURE 1-34. AIR-SURFACE COMPARISON
MAJOR FACTORS SURVEYED

TABLE I-20. AIR SURFACE COMPARISON ROUTES SURVEYED

DOMESTIC ROUTES

COMMODITY	RAIL	TRUCK	AIR
1. New York - San Francisco			
Non-addictive drugs	13.2%	86.3%	0.5%
Leather luggage/suitcases	0.5	55.9	21.1
2. Chicago - Los Angeles			
Cable, copper covered, insulated	18.7%	41.8%	23.5%
Misc. fabricated rubber products	6.3	86.5	6.9
3. New York - Dayton			
Knit clothing	1.8%	70.8%	2.9%
Cosmetic & Toilet preparations	57.7	41.9	0.2

INTERNATIONAL ROUTES

	OCEAN	AIR
1. New York - London		
Records/pre-recorded tapes	50.2%	49.8%
Medical/surgical/vet. instruments	43.5	56.5
2. New York - Tokyo		
Regenerated cellulose, except rayon	46.3%	53.7%
Groundwood paper, uncoated	54.7	45.3

C-2

As is often the case, however, obtaining all the information needed by means of the survey questionnaire method proved to be difficult, even after initial agreements to participate, and several follow-ups. Enough data was received to reasonably analyze four of the routes; the fifth, New York - Tokyo, had to be eliminated due to lack of data on the surface modes. The results of the others are presented in Tables I-21 to I-24 and are briefly summarized below.

1. New York - San Francisco

   Air mode delivery is considerably faster than both truck and rail, although air rates are about triple those of motor carriers, and close to four times the rail tarrif, however, rail competition does not effectively exist below 20,000- to 30,000-pound (9091 - 13636 kg) shipments. Obtaining the rates quoted for air at the 3,000- and 20,000-pound (1364 and 9091 kg) levels requires the use of shipper-loaded air mode containers. Truck, as is general practice, includes door-to-door service in the basic price; air rates are for airport to airport movement only. Minimum pick-up and delivery charges for air are included as supplemental information.

2. Chicago - Los Angeles

   Again, air mode delivery is superior to the surface modes in transit time, although the advantage is reduced due to the lesser distance comared with the New York-San Francisco market. Air is still the high-cost mode, although the rate disparity is only about two-to-one at the largest shipment size, plus a small pick-up/delivery charge for air. Again, rail is competitive only at the highest weight.

3. New York - Dayton

   On this short-haul route, the time advantage of air versus truck is seriously eroded compared with the longer routes, although the truck line haul is double the air time. Rail data were not available for this market, but judging by the longer hauls previously discussed plus the numerous reports of extremely poor rail service in the Northeast, particularly involving the major eastern cities, it should be safe to assume that rail service in this market is relatively inexpensive but rather time-consuming.

   Air rates are still considerably greater than those for truck but for one commodity, clothing, the air container rate is only about 50 percent more than truck, which converts to less than $3.00/per hundred weight (45.5 kg). This lower rate differential reflects the rate structures of both modes, which consist of terminal costs plus line-haul costs, the latter being very high for the air mode. As distances lengthen, the higher line-haul costs are a disadvantage to the air mode, at least if costed on a fully allocated basis. The opposite is true as trip distances shorten, with terminal costs, which

TABLE I-21. ROUTE: NEW YORK TO SAN FRANCISCO

SERVICE FACTORS

	AIR	RAIL	TRUCK
Line Haul Time	1-2 days	5 days	6-8 days
Pickup/Delivery (Total)	1-2 days	0 (Rail Siding)	1-2 days
Carrier Scheduled Services Per Week (1)	10	7	Unk
Use of Containers	See below	Trailer (TOFC)	No
Door-to-Door Service	No	Yes (Siding)	Yes

RATES PER POUND

	AIR	RAIL	TRUCK
1. Non-Addictive Drugs			
500 #	\$0.4745 (4)	\$ -	\$0.1536
3,000#	0.4135/0.3928 (2)(5)	-	0.1244
20,000#	0.2750 (2)(6)	0.0766 (3)	0.0885
2. Leather Luggage/Suitcases			
500 #	\$0.4745 (4)	\$ -	\$0.2569
3,000 #	0.4135/0.3928 (2)(5)	-	0.2038
20,000#	0.2750 (2)(6)	0.0766 (3)	0.1309

(1) Freighter services only for air carrier

(2) Container rate

(3) Rate for 30,000 lb trailer

(4) Pickup and delivery charges of \$0.1115 to be added

(5) Pickup and delivery charges of \$0.0710 to be added

(6) Pickup and delivery charges of \$0.0388 to be added

TABLE I-22. ROUTE: CHICAGO TO LOS ANGELES

SERVICE FACTORS

	AIR	RAIL	TRUCK
Line Haul Time	1 day	3 days	4-6 days
Pickup/Delivery (Total)	1-2 days	0 (rail siding)	1-2 days
Carrier Scheduled Service Per Week(1)	5	7	UNK
Use of Containers	See below	Trailer (TOFC)	See below
Door-to-Door Service	No	Yes (Siding)	Yes

RATES PER POUND

	AIR	RAIL	TRUCK
1. Cable, Copper Covered, Insulated			
500#	\$0.3110(4)	\$ -	\$0.1177
3000#	0.2635(5)	-	0.0955
20,000#	0.1660(2)(6)	0.0746(3)	0.0736(2)
2. Miscellaneous, Fabricated Rubber Products			
500#	\$0.3110(4)	\$ -	\$0.1500
3000#	0.2635(5)	-	0.1191
20,000#	0.1660(6)	0.0746(3)	0.0934(2)

(1) Freighter services only for air carrier

(2) Container rate

(3) Rate for 40,000 lb trailer

(4) Pickup and delivery charges of \$0.0690 to be added

(5) Pickup and delivery charges of \$0.0360 to be added

(6) Pickup and delivery charges of \$0.0104 to be added

TABLE I-23. ROUTE: NEW YORK TO DAYTON

SERVICE FACTORS

	AIR	RAIL	TRUCK
Line Haul Time	1 day	NA	2
Pickup/Delivery (Total)	1-2 days	NA	2-3
Carrier Scheduled Services Per Week	5	NA	5
Use of Containers	See below	NA	See below
Door-to-Door Services	No	NA	Yes

RATES PER POUND

	AIR	RAIL	TRUCK
1. Knit Clothing			
500#	$0.2345(3)	NA	$0.1080
3,000#	0.1600/0.1213(2)(4)	NA	0.0834
20,000	0.0803(2)(5)	NA	0.0582(2)
2. Cosmetic & Toilet Preparations			
500#	$0.2345(3)	NA	$0.0928
3,000#	0.1600/0.1213(2)(4)	NA	0.0717
20,000#	0.0803(2)(5)	NA	0.0349(2)

(1) Freighter services only for air carrier

(2) Container rate

(3) Pickup and delivery charges of $0.0975 to be added

(4) Pickup and delivery charges of $0.0406 to be added

(5) Pickup and delivery charges of $0.0130 to be added

TABLE I-24. ROUTE: NEW YORK TO LONDON

SERVICE FACTORS

	AIR	OCEAN
Line Haul Time	1-2 days	6 days
Pickup/Delivery (Total)	1-2 days	1-2 days
Customs Clearance	1 day(4)	1 day
Carrier Scheduled Services Per Week(1)	5	2
Use of Containers	See below	Yes (containership)
Door-to-Door Service	No	No

RATES PER POUND

	AIR	OCEAN
1. Records/Pre-Recorded Tapes		
500#	\$0.6000(5)	\$0.1516(3)
3,000#	0.4392(2)(6)	0.1516(3)
20,000#	0.4400(7)	0.1516(2)
2. Medical/Surgical/Veterinary Instruments		
500#	\$0.6000(5)	\$0.1070(3)
3,000#	0.4392(2)(6)	0.1070(3)
20,000#	0.4400(7)	0.1070(2)

(1) Freighter services only for air carrier

(2) Container rate

(3) Stuff/strip charge of \$0.088/lb except for 20,000 lb container

(4) Items often precleared; require no processing after arrival

(5) Pickup charges of \$0.0720 to be added

(6) Pickup charges of \$0.0253 to be added

(7) Pickup charges of \$0.0180 to be added

should be relatively the same, being the limiting factor in the modal cost comparison. However, the truck rates include pick-up and delivery, whereas the basic air tariff does not. Pick-up and delivery charges must be added to the air tariff, and the pick-up/delivery charges at the two smaller shipment sizes adds considerably to the rate disparity between the two modes.

4. New York - London

This long-haul international route shows the superiority of air with regard to line-haul transit time and the advantage of the surface ocean carrier with regard to price. Pick-up and delivery costs are about the same:

The ocean rate does not include full pick-up and delivery to port sites. In addition, at less than full container volumes there is a charge for container stuffing/stripping. Air rates, of course, are for airport-to-airport; the minimum pick-up rate for New York is shown for information. The delivery rate for London is not shown due to the need for customs clearance, which is usually handled by an agent/broker, and may or may not be included/priced together with the delivery service.

In addition to the service factors previously considered, customs clearance is another item to be concerned with since this is an international route. Neither mode seems to have a clear advantage here, although the LACES system in use at Heathrow Airport often allows inbound air cargo to be precleared, meaning that it can be immediately delivered to the consignee, without further action by U.K. customs.

The four markets examined tended to bear out a truism about air versus surface shipping: air is more expensive but offers much faster transit times. However, it is quite apparent that surface modes also strive to give rapid line-haul times and that, particularly on short routes, air may lose some or all of its advantage if pick-up and delivery and/or processing is not accomplished efficiently.

Air did consistently prove to be of higher cost than the competing surface modes, although some significant "narrowing of the gap" could be noted in some instances, particularly for the higher weight shipments. The terminal-to-terminal cost of air, including pick-up and delivery must be taken into account before a completely accurate comparison can be made with surface rates, which generally include all door-to-door costs in the rate structure.

Current Air Cargo Terminal Operations

One of the most extensive portions of this analysis of current air cargo operations is the assessment of the effect of terminal operations on the air mode. This was accomplished in four stages:

- Use of published reports and background material
- Written surveys of significant traffic and operating data at selected airports
- Field visits to these airports, to verify and discuss survey data, as well as other, more general cargo-related developments and projections
- Use of TWA and other industry expertise, particularly in evaluating areas such as mechanization and containerization.

Frost and Sullivan stated in their 1977 air cargo report (ref. 10), "...it must be kept in mind that terminal operations are highly labor intensive. From a study made some years ago (1968), it appeared, on the basis of data made available by eight domestic trunk carriers, that in those terminals which handled a large amount of freight per month, 86 percent of the total air cargo handling expense represented the cost of labor ....nearly half the payment received by the carrier is required to cover terminal costs alone."

In 1967, an early evaluation of air freight terminal labor costs (ref. 11) showed the advantages of handling large shipments of limited pieces, the largest of which would be a single (ULD) piece.

Weight Per Shipment (lb)	Weight Per Shipment (kg)	No. of Pieces	Terminal Labor Cost Per Ton (Per 90.91 kg)
100	45.45	5.2	$47.50
500	227.27	4.3	$12.40
1,000	454.54	3.2	$ 8.00
10,000	4545.45	1.0	$ 1.16

The single 10,000-pound shipment is a heavy "A" container consolidated off airport.

More recently, Frost and Sullivan reported in a "broad brush" fashion without regard to shipment size but with reference to terminal flows and aircraft type: "For terminals with a volume above the threshold of 2000 tons (1820 metric tons) a month, total ground handling cost probably by now runs to between $40.00 and $50.00 a ton (0.91 metric ton) on all-cargo aircraft and wide-bodied passenger/cargo jets and may be as much as $60.00 to $70.00 a ton (0.91 metric ton) on narrow-bodied combination jets. With the former aircraft, in-terminal costs average about 60 percent of the total but for the latter the ratio is reversed. These figures are, of course, averages and, as such, conceal many differences between individual terminals and circumstances of particular operations. Where containerization has proceeded far, the aircraft loading costs, and therefore the total ground handling costs, are notably lower. Moreover, the carrier may experience significantly lower in-terminal costs if a large proportion of the traffic is tendered in containers...."

Description of Current Cargo Facilities at Selected Airports

The airport survey procedure encompassed a number of elements. The first was the selection of the airports. The airport survey selection criteria included consideration for both domestic and foreign operation, a cross-section of size of operation (small/medium/large), a cross-section of level of mechanization/automation, a look at new airports, and an assessment of the cargo orientation of the airport. The selection criteria served to provide both a balance and a diversity in the sample group. Figure I-35 lists those locations selected together with their relative sizes and date the location was visited and the cargo terminal information sought at each airport site. The data received from the surveys are recorded in Figure I-36. The airport survey procedure called for a written survey questionnaire to be filled out and an on-site visit/interview with each selected airport authority. The on-site survey included an inspection of several carrier facilities and a discussion of significant operating factors and problems with hose carriers. A carrier questionnaire was prepared, but due to the proprietary nature of much of the requested data, its purpose was not satisfactorily served. Appendix I-B represents a sample copy of the written questionnaire sent in advance of the visit to each location.

Each airport is briefly described below.

- Kennedy International (New York)

  This large, well-known facility contains one of the largest air cargo operations in the world. Extensive freighter and widebody services are available to most major areas of the world. Due to its proximity to a heavily urbanized area, space for expansion is at a premium, and some segments of neighboring communities oppose further expansion of oeprations and/or have suggested curtailment of some current operations, including night flying.

- O'Hare International (Chicago)

  This airport is the largest, in traffic terms, in the world. It is the stage for significant international, as well as extensive domestic operations. Little room for growth is available in current cargo

CITY AIRPORT	RELATIVE SIZE	ON-SITE SURVEY (1977)
DOMESTIC		
NEW YORK (KENNEDY)	LARGE	AUGUST
CHICAGO (O'HARE)	LARGE	AUGUST
LOS ANGELES	LARGE	AUGUST
DALLAS/FT. WORTH	LARGE POTENTIAL	AUGUST
BALTIMORE	MEDIUM	AUGUST
MIAMI	MEDIUM	AUGUST
DAYTON	SMALL	AUGUST
INTERNATIONAL		
LONDON (HEATHROW)	LARGE	AUGUST
FRANKFURT	LARGE	AUGUST
PARIS (CHARLES DE GAULLE)	LARGE	SEPTEMBER
AMSTERDAM	LARGE	SEPTEMBER

FACILITIES

- o TERMINAL AREA
- o ACCESSIBILITY
- o SPECIAL FACILITIES (HIGH VALUE/REFRIGERATION/BONDED STORAGE, ETC.)
- o AIRCRAFT/TERMINAL INTERFACES
- o SURFACE MODE/TERMINAL INTERFACES
- o CONSOLIDATED VS INDIVIDUAL TERMINALS

FREIGHT FLOW CHARACTERISTICS

- o ANNUAL VOLUME
- o RATIOS
  - BELLY TO TOTAL
  - UNITIZED TO TOTAL
  - PALLETIZED VS CONTAINERIZED
  - SHIPPER UNITIZED (TO TOTAL)
- o INTERLINE
- o SHIPMENT SIZE (S)

EQUIPMENT

- o ULD HANDLING EQUIPMENT
- o SORTING/UNITIZATION
  - MECHANIZATION/AUTOMATION
- o DOCUMENTATION

OTHER

- o CUSTOMS
- o SECURITY
- o OPERATING CONSTRAINTS

FIGURE I-35. AIRPORT SURVEYS

	Number of Cargo Flts/Wk.		Ratio Belly To Total Cargo	% Unitized	% Shipper Unitized	% In 8' X 8' (2.4m X 2.4m) Units	Number Cargo Gates	Annual Cargo Flow				% Domestic	% Intnl.	Number of Carriers	
								Sched.		Total					
	Sched.	Unsched.						Tons (000)	Metric Tons (000)	Tons (000)	Metric Tons (000)			Sched.	Total
EUPOREAN															
Schiphol	180	90	50/80	80%	10%	Very Low	4-6	200	180	260	234	0	100%	49	
Heathrow	320	20	53%	-	-	-	30			416	374.4	3.2	96.8		74
Orly	79	6	-	-	-	-	9	136.6	122.9	139.3	125.4	11	89	61	
Chas. DeGaulle	179	6	-	-	-	-	13	239.6	215.6	247	222.3	2.3	97.7	30	
Frankfurt	421	24	42%	70	2	3%-5%	8	525.6	473.0	552.7	497.4	14.6	85.4	63	247 Charter
DOMESTIC U.S.															
Balt.-Wash.	156	N/A	33.3%	-	-	-	3			48.3	43.5	N/A	N/A		20
O'Hare	176			-	-	-		828.3	745.5	-		77%	13%	41	
Dayton	5			40	10	0	2	31.4	28.6			80%	20	6	
Dallas-Ft. Worth			40%	-	-	-	14	78	70.2	80	72	98	2	12	
Los Angeles	455		55%	-	-	-	20	-		763	686.7	-	-	38	
JFK	600		-	-	-	-	50			1030	927	38	62	53	
Miami	-	-	80%	-	-	-	20	290	261	371.7	334.5	32	68	65	

FIGURE I-36 AIRPORT SURVEY DATA

area, although currently unutilized space elsewhere offers good growth potential.

- o Los Angeles International

  This is a large international and domestic operation, particularly important as an interchange/break-bulk point for transpacific cargo. There are some operational restrictions due to noise problems and aircraft weight restrictions to/from certain terminals. Expansion possibilities are limited due to the location.

- o Dallas - Ft. Worth Regional

  A new (1974) large airport in a rapidly growing area. Some freighter service, including 747Fs. Large potential for development of international traffic and service. Few if any problems with expansion or environmental factors.

- o Miami International

  A large cargo operation, primarily oriented toward Latin-American market. Conventional handling facilities. Numerous freigther services, including 747F.

- o Baltimore-Washington International - Figure I-37 and I-38

  A medium-sized operation including freighter service by United. Airport operator aggressive about encouraging development of air cargo throughout region.

- o James M. Cox (Dayton)

  Small operation, but in the heart of heavy manufacturing region. Freighter service to east/west coasts by TWA; also "hub" of Emery Air Freight cargo charter operation. Limited freight handling facilities.

- o Frankfurt/Main

  Large cargo operation, including extensive use of mechanization/automation. Main carrier, Lufthansa, was first with 747F. Extensive cargo handling facilities. Restrictions include runway/frequency limitations and night curfew.

- o Schiphol (Amsterdam)

  Moderate to large location emphasizing international operations. One of the main interchange points for traffic from North America to Africa/Middle East, etc. Main carrier, KLM, is one of primary 747 "Combi" operators.

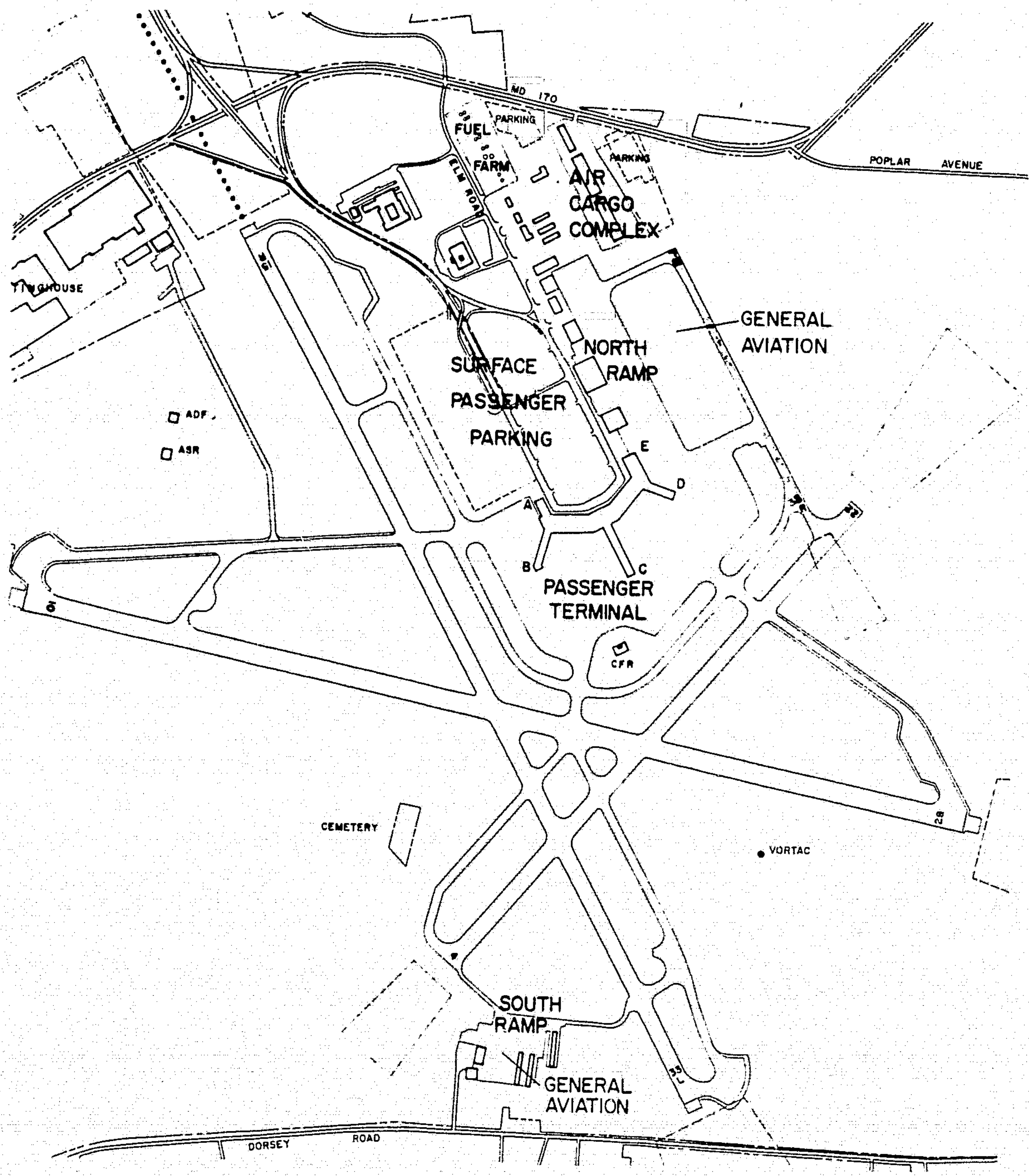


FIGURE I- 37. BALTIMORE-WASHINGTON INTERNATIONAL AIRPORT LAYOUT

ANNUAL CARGO TONS	69,909
NUMBER OF RUNWAYS/LONGEST	4/9500 FT.
NUMBER OF CARRIERS	20
TOTAL WEEKLY ALL-CARGO FLIGHTS	156
WEEKLY INTERNATIONAL ALL-CARGO FLIGHTS	-
NUMBER OF CARGO AIRCRAFT GATE POSITIONS	6
LANDING FEE (B-707)	$75
LARGEST AIRCRAFT-SCHEDULED SERVICE	L-1011
DISTANCE FROM CITY	10 MILES (BALTIMORE) 30 MILES (WASHINGTON)

FIGURE I- 38. BALTIMORE-WASHINGTON INTERNATIONAL AIRPORT DATA

- Charles de Gaulle (Paris)

  A new facility, opened in 1974. Still only partially developed. Large freight area with much room for expansion. Due to rural location, one of few major airports in Europe without a curfew. Air France, based here, is a major 747F operator.

- Heathrow (London) - Figures I-39 and I-40

  Very large international operation, particularly geared to North Atlantic and Middle East markets. Space badly limited, for both terminal space and aircraft parking positions, with little room for expansion. Night curfew for almost all operations.

Current Automated Cargo Facilities

Labor represents a significant portion of airport operations and ground handling costs and has suffered from a high rate of inflation in recent years. As a result, automation has been looked to as a means of reducing the dependence on labor and of ameliorating the worsening economics involved.

The objective of the investigation of automation is to evaluate the effect of automation/mechanization on the ground handling costs of cargo movement. Trade-off of equipment investment versus labor costs was considered, and the reliability of the mechanical equipment has been assessed. The importance of reliability of the cargo facility equipment cannot be overemphasized.

Not all areas of a cargo terminal are amenable to automation of operations. Prime terminal functions susceptible to automation are sorting, storage, and documentation. Automation for unitization, the operation of actually stuffing the box, is unlikely due to the general heterogeneity of the packages moving through the system.

During the 1960's, many air carriers needed to expand their cargo terminals in order to take care of the surge of business that was stimulated through the introduction of modern jet aircraft. Many carriers, in designing these new terminals, incorporated various forms of mechanization as a way to reduce labor costs. Several terminals of the major carriers at JFK airport in New York and at major gateway points in Europe were designed to employ a variety of such mechanized techniques.

Because these on-airport ground handling and terminal costs were so expensive and labor intensive there were great expectations for automation. Frost and Sullivan state: "The experience of the last five years, however, fails to support this expectation." Some highly automated, high-volume facilities both domestic and foreign had much difficulty in opening and only after several years of "de-bugging" the equipment did they become fully

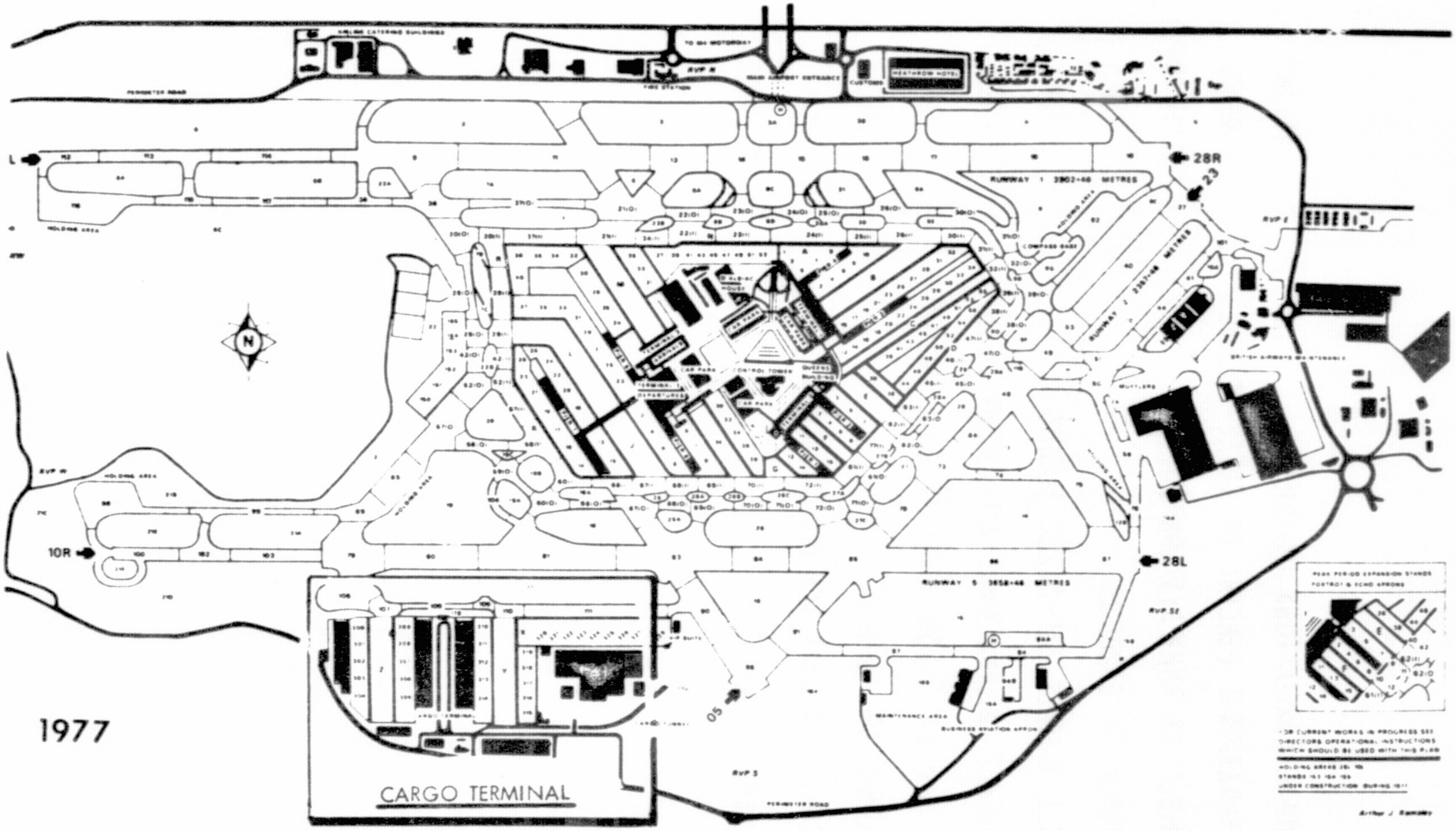


FIGURE 1- 39. HEATHROW (LONDON) AIRPORT LAYOUT

ANNUAL CARGO TONS (METRIC)	416,000
INTERNATIONAL PERCENT OF TOTAL TRAFFIC	96.8%
NUMBER OF RUNWAYS/LONGEST	3/12,800 FT.
NUMBER OF CARRIERS	74
TOTAL WEEKLY ALL-CARGO FLIGHTS	320
MONTHLY INTERNATIONAL ALL-CARGO FLIGHTS	1,120
NUMBER OF CARGO AIRCRAFT GATE POSITIONS	30
LANDING FEE (B-707)	$500
LARGEST AIRCRAFT-SCHEDULED SERVICE	B-747
DISTANCE FROM CITY	15 MILES

FIGURE I-40. HEATHROW (LONDON) AIRPORT DATA operational. The most difficulty befell the high volume international carrier terminals where automated storage machinery broke down creating serious and costly problems in the handling and storing of bulk and containerized freight.

In summary, automation has failed for two reasons: first, technical, e.g., problems that involved the handling of nonuniform packages and the sophistication required to operate and maintain the system on a daily basis; and second, financial, e.g., the investment and operating costs were far greater than the savings that were realized.

The ground handling of loose cargo, tendered mainly in small shipments, will continue to be a labor-intensive activity; only containerized cargo is suited to automated/mechanized handling. Therefore, many of the carriers have completely abandoned the automated and highly mechanized processes and have reverted to the hand processing of packages through their terminals. The elaborate sorting and storage systems generally did not operate successfully, nor did they in fact save the amount of labor costs which were estimated. Many in the industry now feel that the most practical terminal is a large, covered space with a minimum of columns.

A good example of the use of hand processing occurs in the Federal Express sorting hub at Memphis. In what is probably the largest volume of small air-freight shipments handled on a daily basis, Federal makes use of large amounts of low-cost labor (in conjunction with a relatively simple conveyor belt system) rather than an elaborate automated system with its attendant capital costs and performance problems. That this method works is testified to by Federal's outstanding growth, performance, and records.

The Parsons work flow study has attempted to quantify the differences between manual terminal operations and conveyor terminal operations. The use of conveyor belts is shown in the Parsons study to result in a savings of about 4 percent in man-minutes for terminal handling of an average size shipment. For example, a bulk shipment consisting of 6.2 pieces and 256 pounds (116.36 kg) required 30.9 man-minutes of time in a conveyor terminal and 32 man-minutes of time in a manual operation. Cost savings of this nature are not significant, especially when offset by the increased procurement, installation and maintenance cost of a mechanized system. In addition, where the use of such mechanized devices causes delays in the delivery of traffic to the customer as the result of breakdowns or improper routing of the freight to a designated terminal area, the overall service standard suffers and business can be lost. Table I-25 breaks out the Parson's man-minutes for the discussed bulk shipment operations.

Again, from Frost and Sullivan: "If, therefore, real progress is to be made toward reducing terminal costs by automation, it will depend upon the trend toward containerization. Once loose cargo has been consolidated into containers or onto pallets, mechanization, even if not true automation, becomes not only cost effective but essential....and....that automation is not a cost effective way of improving the efficiency with which loose cargo is handled; and, lastly, that automation or more correctly mechanization, that is

TABLE I-25. PARSON'S MEASURED MAN-MINUTES PER SHIPMENT

	Manual	Conveyor	Time Savings
Bulk/Bulk Freight			
(1 shpmt/6.20 pcs/256.4 lbs.)			
Widebody - Origin/Destination	33.674	32.326	4%
- Transfer	19.917	19.390	
Bulk/Container Freight			
(1 shpmt/6.20 pcs/256.4 lbs.)			
Widebody - Origin/Destination	30.760	28.401	7.6%
- Transfer	17.004	15.466	
Container/Container Freight			
(1 shpmt/1 cont./1836 lbs.)			
Widebody - Origin/Destination	67.374		
- Transfer	52.344		
Bulk/Bulk Freight			
(1 shpmt/6.20 pcs/256.4 lbs.)			
Cargojet - Origin/Destination	32.026	30.915	3.5%
- Transfer	18.270	17.980	
Bulk/Container Freight			
(1 shpmt/6.20 pcs/256.4 lbs.)			
Cargojet - Origin/Destination	30.409	29.061	4.4%
- Transfer	16.653	16.126	
Container/Container Freight			
(1 shpmt/1 cont./1836 lbs.)			
Cargojet - Origin/Destination	106.760		
- Transfer	91.730		

taking place and that is cost-effective is associated with and dependent upon, containerization.... Containerization could indeed permit a major reduction in the overall cost of air transportation if the shipper could load his freight into containers and tender it to the carriers in this form and if the carriers could deliver it to the ultimate consignee still in the container."

This states the case for off-airport unitization and deunitization - for shipper stuffing and stripping - and encourages the tendering of terminal bypass containers with intermodal capability. Routine large-volume shippers are obviously needed to reap the benefits of substantially increased mechanization/automation and the only one where automation can be beneficial regardless of containerization.

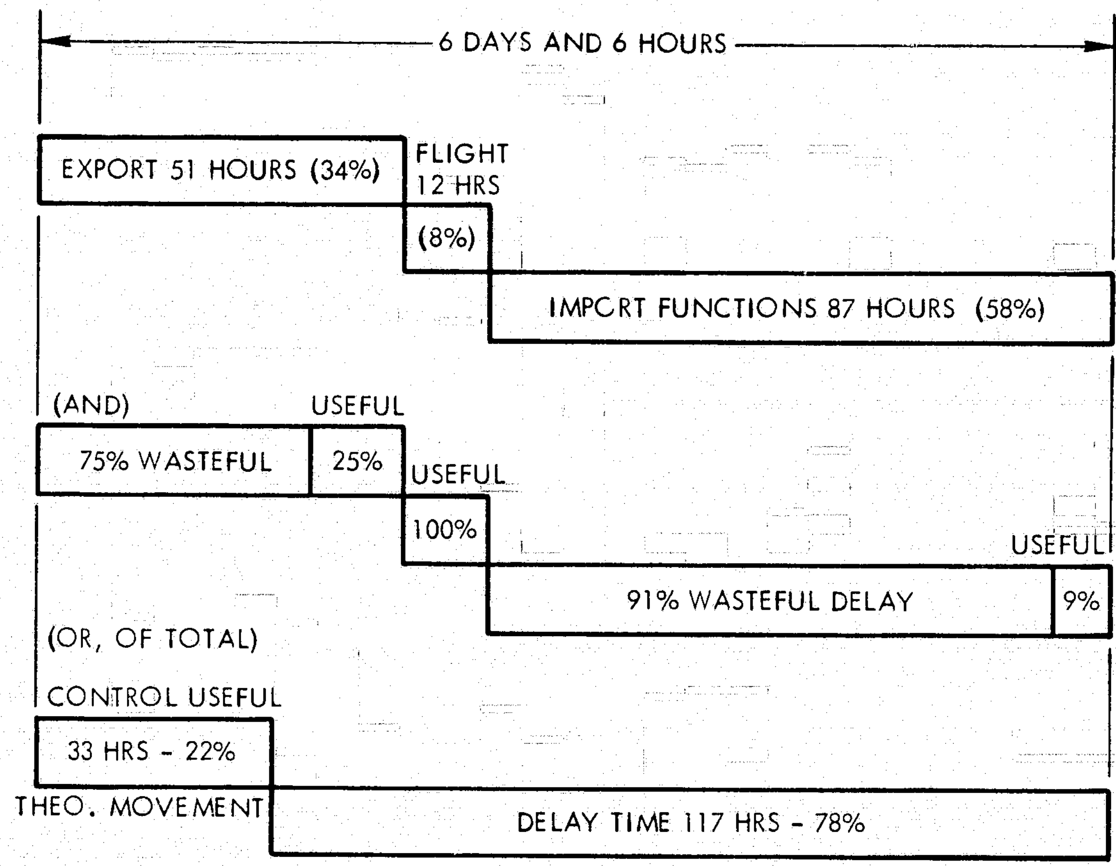
Air cargo documentation is another terminal cost and time-consumer. As stated in the IATA Cargo Automation Research Report (CART) in 1975 (ref. 12), "The average international air freight shipment was taking six days to move from shipper to consignee and the average cost of ground handling at major world airports has reached US $120 a metric ton, half of which was being spent on information processing. And, yes, the expanded use of electronic data processing could help improve both of these costly situations." IATA was saying that their own member (most major free-world) carriers were providing poor international service, and that their ground handling costs were rising rapidly.

In ref. 12, the movement delay analysis (Figure I-41) for international shipments showed that, in the average 6-day, 6-hour total movement time, only 33 hours or 22 percent was found to be useful productive time. In the bar graph, the total time span of 150 hours is variously broken out to show useful and delay increments. The table below the bar graph shows the breakdown of the 117 hours of delay by participant.

Not all reasons for delay can be eliminated, but all are capable of being reduced. The general reasons for delay are:

- Limited resources (48.1 hr - 32 percent)
- Participant misalignment (37.8 hr - 25 percent)
- Lack of information (31.1 hr - 21 percent)

Further, as stated in ref. 12, "The total information processing cost for manpower and materials which can be associated with the movement of one international consignment from shipper to consignee was found to be just under US $18.00 per consignment. The manpower cost to prepare and handle the relevant documents account for 97 percent (US $17.32) of the total, while purchase costs of the documents themselves account for only 3 percent (US $0.5586) of this total.... Carriers' information processing costs are the highest of all (modes) in the transport cycle, and the Air Waybill is the single most expensive document."



THE 117 HOURS OF DELAY IS FURTHER BORKEN DOWN :

RANK	PARTICIPANT	HOURS DELAY	% OF TOTAL DELAY	THROUGHPUT % OF TOTAL
1	BROKER	35.6	31	24
2	TRUCKER	21.2	18	14
3	IMPORT CARRIER	19.4	17	13
4	EXPORT AGENT	17.7	15	12
5	EXPORT CARRIER	12.1	10	8
6	TRANSFER CARRIER	8.1	7	6
7	IMPORT CUSTOMS	2.7	2	1
8	EXPORT CUSTOMS	-	-	-
		117	100%	78%

FIGURE I-41. IATA CART MOVEMENT DELAY ANALYSIS

The CART (ref. 12) findings were "The results of an extensive Cost/Benefit Analysis on a typical (proposed) Cargo Information Processing and Exchange system showed a 37 percent per annum Return on Investment." A paced evolutionary implementation was recommended. And with respect to sensitivity: "Even an unfavorable economic climate, which resulted in only a 5 percent growth in air freight tonnage and no growth in the number of shipments, still yielded a 12 percent ROI."

Electronic data processing/documentation can, in addition to its basic function, also handle the following: ULD control, cargo space allocation, interline billing and settlement, automated central prorate, and/or automated bank settlement plan. Documentation is one piece of the ground handling/terminal cost of cargo which can be appreciably helped by automation. It is beneficial at the smallest package/smallest shipment end of the air cargo spectrum where it is most needed. Many carriers are already operating very sophisticated and very satisfactory computerized documentation systems in countries where such is possible. Some international carrier systems are already integrated with customs.

Unit load Devices vs Random Loads

Another area in which cost savings can be achieved involves the manner in which cargo is loaded into the aircraft - either in bulk, or using some of unit load device/containers.

Container shipments are defined as those shipments which are precontainerized by the customer. Such operations include the use of carrier-owned containers which are air-worthy, such as the M-2, M-1, Type A, LD-11, LD-7, and LD-3, or as shipper-owned containers which must be further processed by the carrier before loading on an aircraft. Shipper-owned containers include Types D, B, QD, etc.

Domestic - The domestic air freight rate investigation showed that, in 1972, slightly over 17 percent of the total airfreight weight was precontainerized by shippers. This percentage included the traffic of all local service, trunk, and all-cargo carriers.

The percentage of containerized traffic for trunk and all-cargo carriers is somewhat higher. For the year ended June 30, 1973, the CAB data show that approximately 25 percent of the traffic for these carriers was tendered in containers.

More recent data compiled by the ATA show that, in 1976, about 27 percent of the traffic handled by trunk and all-cargo carriers was containerized. Since containers generally move for longer distances than bulk traffic, it is estimated that between 30 and 35 percent of revenue ton-miles are in fact containerized.

It should be noted that the overall traffic includes small-size shipments which do not qualify for a containerized program. The aircraft containers are designed to containerize traffic with a minimum weight of 1000 pounds (454 kg)) or more. The most often-used aircraft container, the Type A container, is designed for loads of 3200 pounds (1454 kg) or more (to 13,300 pounds (6045 kg) to gross weight), and the new 8 x 8-foot M-1 and M-2 containers, which are being used in wide-body freighter operations, are designed for loads of 8250 pounds (3750 kg) or more to 12,500/15,000 and 25,000 pounds (5681/6818 and 11363 kg) gross weight.

The non-aircraft containers, namely those supplied by shippers, are designed for shipments carrying as little as 100 pounds (45.5 kg), but the use of these non-aircraft containers has not been nearly as successful as the use of aircraft containers. As reported in the DAFRI findings, approximately 80 percent of total container movements for the trunk and all-cargo carriers was tendered in aircraft containers.

International - Unfortunately, the situation for containerization on international routes is not as clear. No industry statistics have been compiled to show the relative use of containers versus bulk traffice.

The comments of the carriers represented at the IATA conferences indicate a wide range of container usage. some carriers reported insignificant containerization, while others reported that a majority of their traffic was pre-containerized by shippers. Overall, it appears that on trans-Atlantic routes, at least, the international container program has been less successful than in domestic operations. One major carrier, TWA, carries about 12 percent of its traffic as containerized lift. This is approximately one-third the level achieved in domestic operations.

For international operations, it appears that the aircraft containers have far greater use than the non-aircraft containers. The aircraft containers account for approximately 85 percent of the total container movements, again based on TWA's experience.

The ULD's when compared to random (bulk) loads have lower handling costs and affort greater protection for the cargo. Against this, the ULD's require a capital outlay and maintenance, effect a tare weight penalty where applicable, and are not necessarily sized to match the shipment. The random loads must process through the terminal, whereas the ULD may frequently bypass the terminal.

Table I-26 summarizes the trade-offs between ULD's and bulk loading.

The Parson's report, which provided much substantive data used in the CAB's Domestic Air Freight Rate Investigation, offers numerous containerization observations and some revealing statistical data:

"It became evident during the survey that weight was not the most significant cost-causative factor.... For example the element processing of

TABLE 1-26. CONTAINERIZED VERSUS RANDOM CARGO

Random (Non-Containerized)	Containerized (By-Pass)
Receiving/Acceptance:	
1. Individual piece verification	1. Not applicable (one piece)
2. Consignee label/address verification each piece	2. Not applicable (One address)
3. Shipment weight verification - handle each piece	3. Not applicable (One weight)
4. Inspection of shipment pieces to assure adherence to tariff requirements	4. Not applicable (One box)
5. High labor intensity and cost regardless of equipment	5. Low labor cost, ramp and aircraft loading
Documentation:	
1. Lot labelling for each piece of shipment	1. Routing tag for one piece
2. Multiple shipment documents must be received and processed	2. One shipping document receipted and processed
3. Complete air bill prep frequently	3. Completed airbill presented with container
Processing/Handling:	
1. Individual shipment pieces cannot be protected by seal or locks	1. Shipment safe in locked/sealed container
2. Shipment must be multiply handled from receiving thru sortation, bulk storage, consolidation, unit storage, etc.	2. Container taken directly from receiving to staging area for aircraft loading
3. Multiple lot shipment must be handled at one time to assure forwarding as one lot	3. Not applicable to container load.
4. Shipment cannot be stored outdoors in inclement weather	4. Container can be stored outdoors in inclement weather
5. Shipment may be containerized or palletized using on-airport facilities and manpower	5. Not applicable on-airport

TABLE I-26 CONTINUED

Carriage/Transport	
1. Shipment more susceptible to hold-off for higher priority traffic when boarding to be on pax flight	1. Container better assured of forwarding. Unitized freight can be loaded more readily in "last minute" space
2. Bulk loaded or palletized freight more susceptible to shifting in turbulent weather flight	2. Shipment(s) better contained in structural container
3. Shipment recovery much less rapid - requires break bulk	3. Recovery is rapid
4. Transfer to customer on an individual piece basis requiring verification against air bill.	4. Rapid unencumbered one-piece transfer to consignee at destination.
Treatment:	
1. Shipment subject to unintentional breakdown of highly mechanized freight facilities causing time delays.	1. Due to size of containers, facilities provide highly reliable and/or redundant container handling equipment.

airbills would be the same regardless of how many pieces or size of pieces; therefore, this element is shipment oriented. The element calling for the loading of pieces to a container from a platform cart can only be accomplished by physically handling each piece; therefore, this element is piece-oriented since the time will vary directly with each piece handled.

"Unitized freight observed during the survey consisted of A containers or pallets, LD-3 and LD-7 containers for wide-body aircraft, LD-W containers for narrow-body aircraft, and a wide variety of other containers, treated as large bulk items for this study.

"....Shipper-unitized containers are handled by various bypass systems if they are LD or A-type containers. Shipper unitized containers do not require handling through the normal processes and require far less labor expenditures than carrier unitized freight..... Bypass systems for containers offer the most efficient use of manpower and equipment for shipper-unitized containers if the system can route the container directly to the freighter aircraft or to the ramp for the transport to combination aircraft."

From the foregoing it muust be noted that the Parson's study did not include the larger 8 x 8 M-1 or -2 containers, nor did it cover the wide-body 747F all-cargo aircraft. However, data presented in the report can be further processed to show man-minutes per weight and cost per weight. Figures I-42 and I-43 show these times and costs for the various cargoes, and include a projection of where the non-included larger shipments, shipper-unitized, might fall. The curves projected to cover shipper unitized unit weights greater than those for the A-igloo show that further time and cost reductions can be expected with these larger units, and that beyond the M-1 container size, the curve is very flat.

Non-capacity terminal cost data for various bypass containers as provided in Figure I-44 show a decided cost advantage for the larger volume containers. The plot in Figure I-44 shows an M-1 container is handled on airport at 44 percent of the cost of an LD-W and at 56 percent of the cost of the LD-1 and -3's.

Using Parson's data as presented in Appendix L of the Domestic Air Freight Rate Investigation, - "Cost of Carrier Unloading of Cargo Shipped in Various Type of Containers - 1974," when the carrier accomplishes the stripping (break bulk)) of the containers, the following relationships to the total unloading cost existed:

TYPE CONTAINER	% OF TOTAL MAN-MINUTES PER POUND (0.45 kg) CARGO Unload/Strip Container	Unload Aircraft
A	61	39
LD-7	52	48
LD-3	55	45
LD-W	43	57

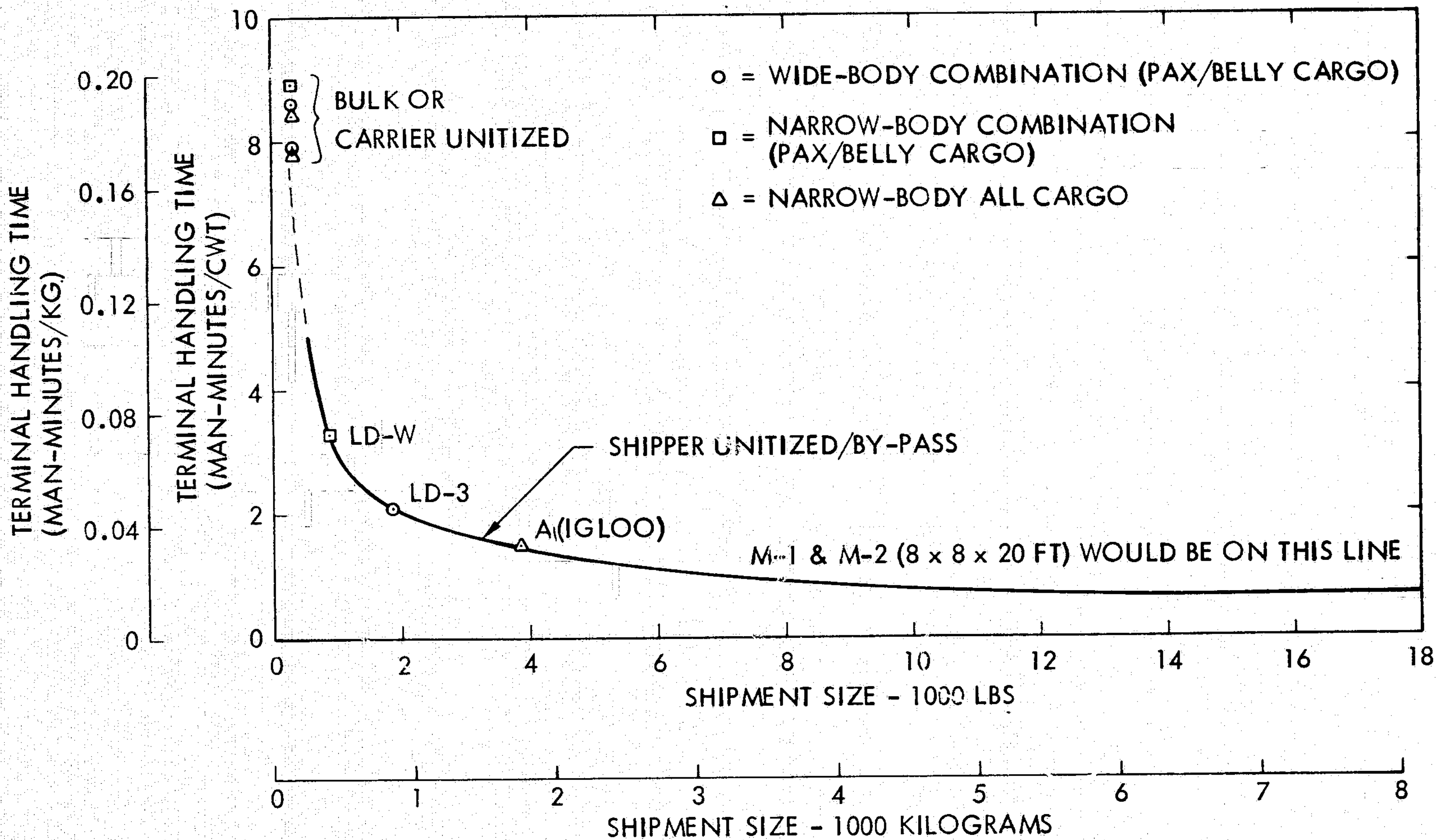


FIGURE I-42. AVERAGE SHIPMENT PROCESS TIME - OUTBOUND HANDLING

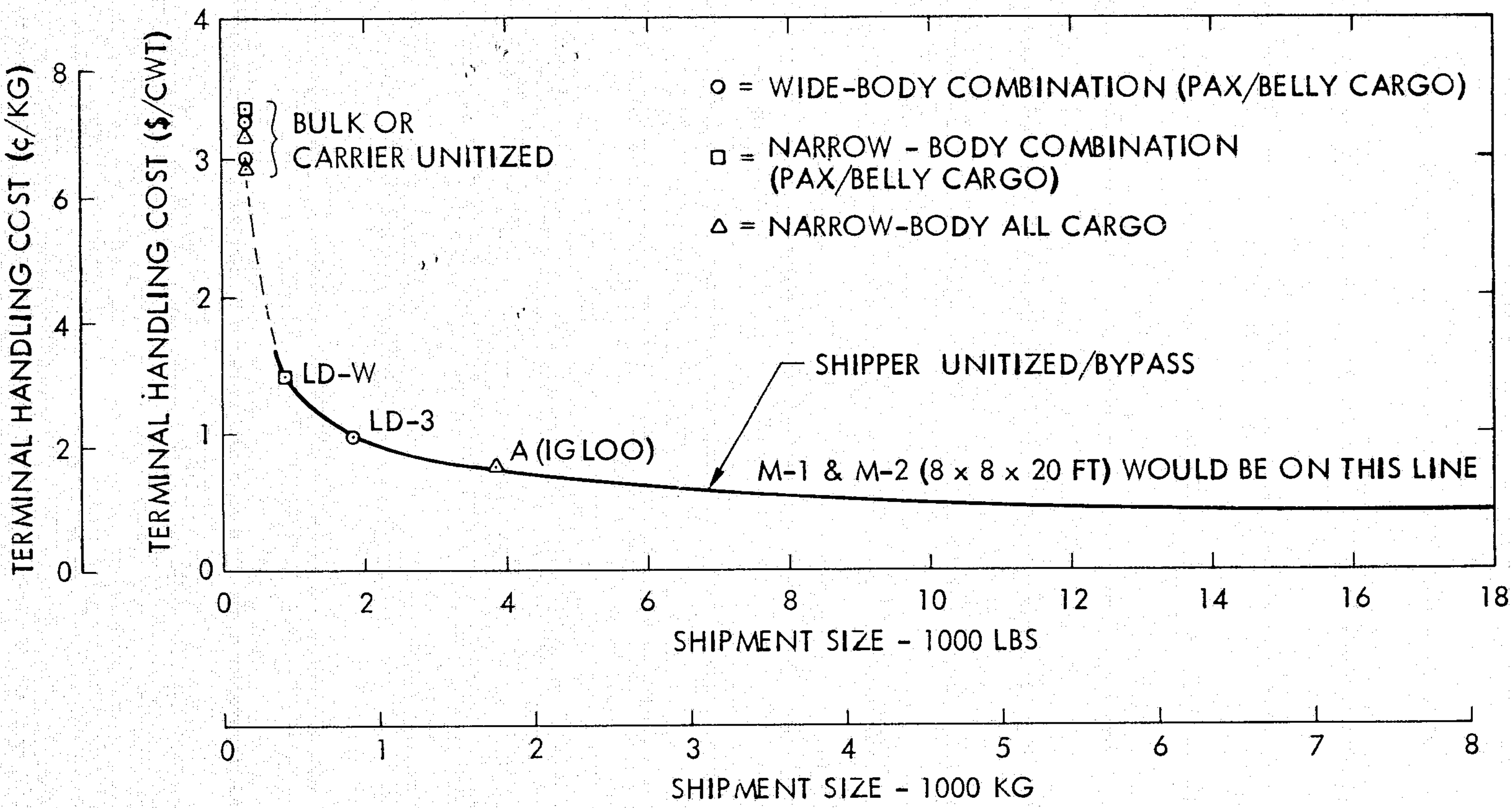


FIGURE I - 43. AVERAGE SHIPMENT PROCESS COST - OUTBOUND HANDLING

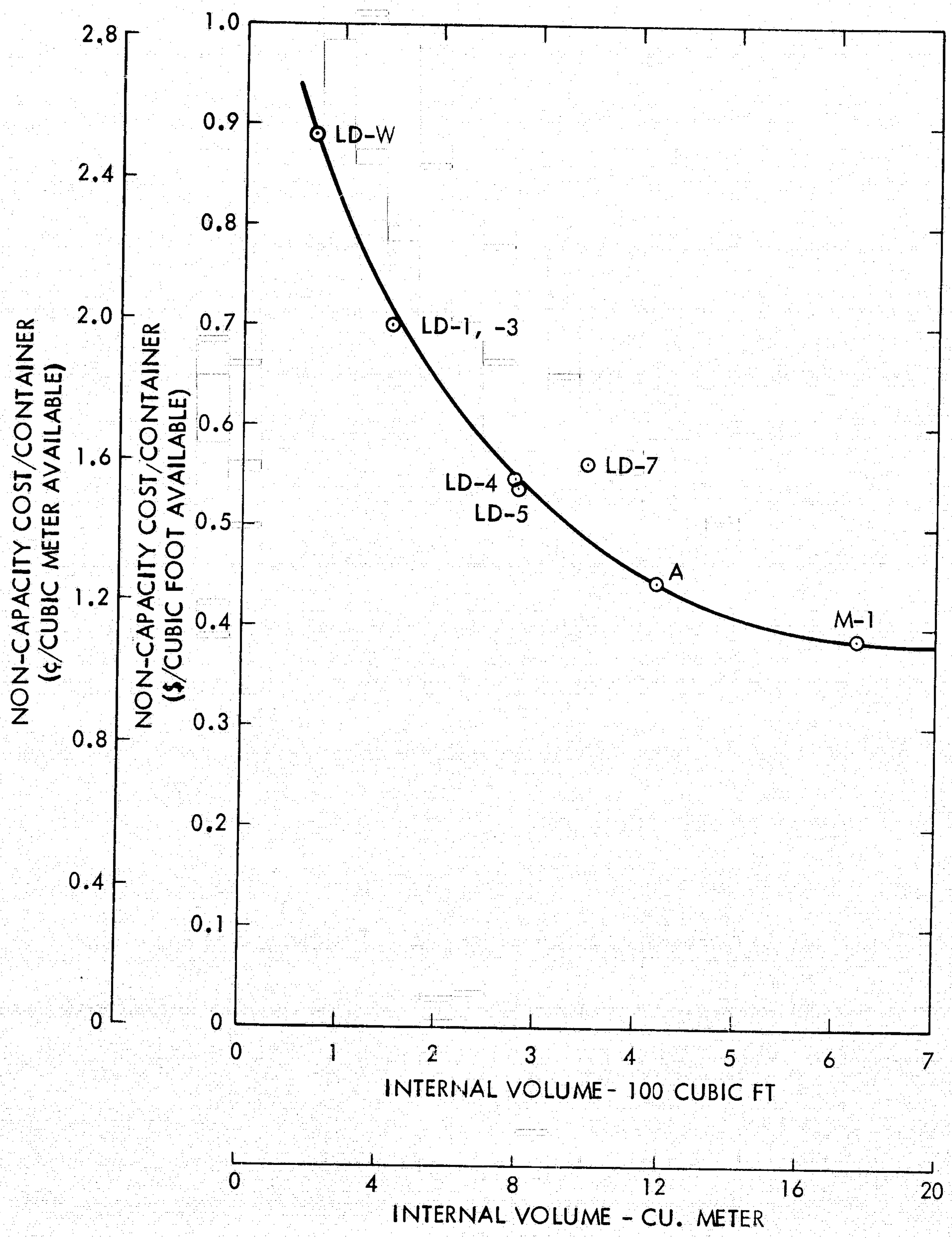


FIGURE I-44. TERMINAL CHARGE BYPASS CONTAINER NON-CAPACITY COST

In general, the larger the container the proportionately less effort required to load/unload it aboard the aircraft, and the larger the proportion of the total carrier effort expended upon the deconsolidation (in this instance) phase.

With respect to the actual loading/unloading of the aircraft and the ramp handling equipment costs will generally increase as the need for faster aircraft turnarounds is evidenced. However, for those existing terminals surveyed by Parsons, the equipment and facility costs (1973) were rather small, $0.0007 per pound (0.45 kg) for equipment and $0.0018 per pound (0.45 kg) for the facility, compared with the labor costs.

The somewhat unique 747 freighter/M-2 container interface equipment is more representative of a future "advanced" system. Representative equipment costs (in 1977 dollars) are here estimated to be $5000 per ISO chassis, $20,000 per year tractor, $80,000 to $175,000 per scissors or post loader, and $80,000 to $200,000 for straddle/ toplift equipment. A minimum bypass station outfitting of ground handling equipment for a one-aircraft turnaround could be expected to cost some $400,000 to $500,000. It is more likely that an average terminal set-up would equal twice that estimate. These capital expense estimates do not include costs for in-terminal functions such as small shipment receiving, sortation, consolidation operations, and administrative functions which are assumed to already be in place.

Palletized vs Containerized

Palletization denotes cargo bulk loaded on an aircraft pallet (usually 88 x 125 inches/2.24 x 3.18 meters), usually contoured to the shape of the aircraft, and held by a restraining net. Containerization, on the other hand, denotes the use of a rigid aircraft container, usually contoured to the interior shape of the airfract. Such containers commonly carry such designations as Type A (igloo), Type LD-7, Type LD-11, and Type LD-3.

There are several trade-off factors in making the decision whether to containerize or palletize traffic. Container traffic has the following advantages:

- o Since the containers are already contoured to the aircraft configuration, traffic can be more quickly loaded than when palletized.
- o More traffic can usually be loaded into a container than on a pallet, since the limits of the contour can more readily be determined.
- o Containers offer better protection from weather.
- o Containers are more effective in preventing theft or pilferage.

- Less damage is likely to occur to containerized freight because of the extra protection provided.

- Containers do not require the placement and removal of plastic film and netting which increases the cost and labor for each "bulk loaded" pallet.

On the other hand, there are several disadvantages connected with the use of containers. For example:

- The cost of purchasing containers greatly exceeds the cost for a pallet with net.

- Maintenance of containers, due to damage, loss of doors, etc., is an extra cost factor.

- Since containers weigh more than pallets, the cost of flying the container is greater, due to the extra fuel required to lift the extra weight. The extra tare weight sometimes reduces payload, especially on long haul segments, e.g. transpacific routes where flights often weigh-out.

- Containers require more warehouse storage space.

While there are no data compiled which would quantify the trade-offs involved in containerization versus palletization, the domestic carriers have generally concluded independently that containerization offers greater benefits to themselves and the shipping public than does palletization. A notable exception to this is on trans-Pacific routes where the long flight segments and high density traffic frequently result in weight-limited operations. Carriers have moved toward the use of pallets with nets rather than containers on these segments.

Effect of Range on Ground Cargo Handling Cost

The terminal or station costs of cargo handling whether actual or computed by the Domestic Air Freight Rate Investigation are essentially a constant with respect ot range in any total cost computation. Figure I-45 was prepared using carrier data for 707-320C/DC-8-50 type aircraft with early 1978 costs. The curves in Figure I-45 show that station cost as a percentage of total cost decreases significantly with increasing ranges.

In general, the field visits tended to corroborate existing data sources, including the Frost & Sullivan and Parsons studies. While the use of M-2, 8 x 8-foot (2.4 x 2.4-meter), container and handling systems was noted at most of the larger facilities, the sophistication of the facilities to handle this

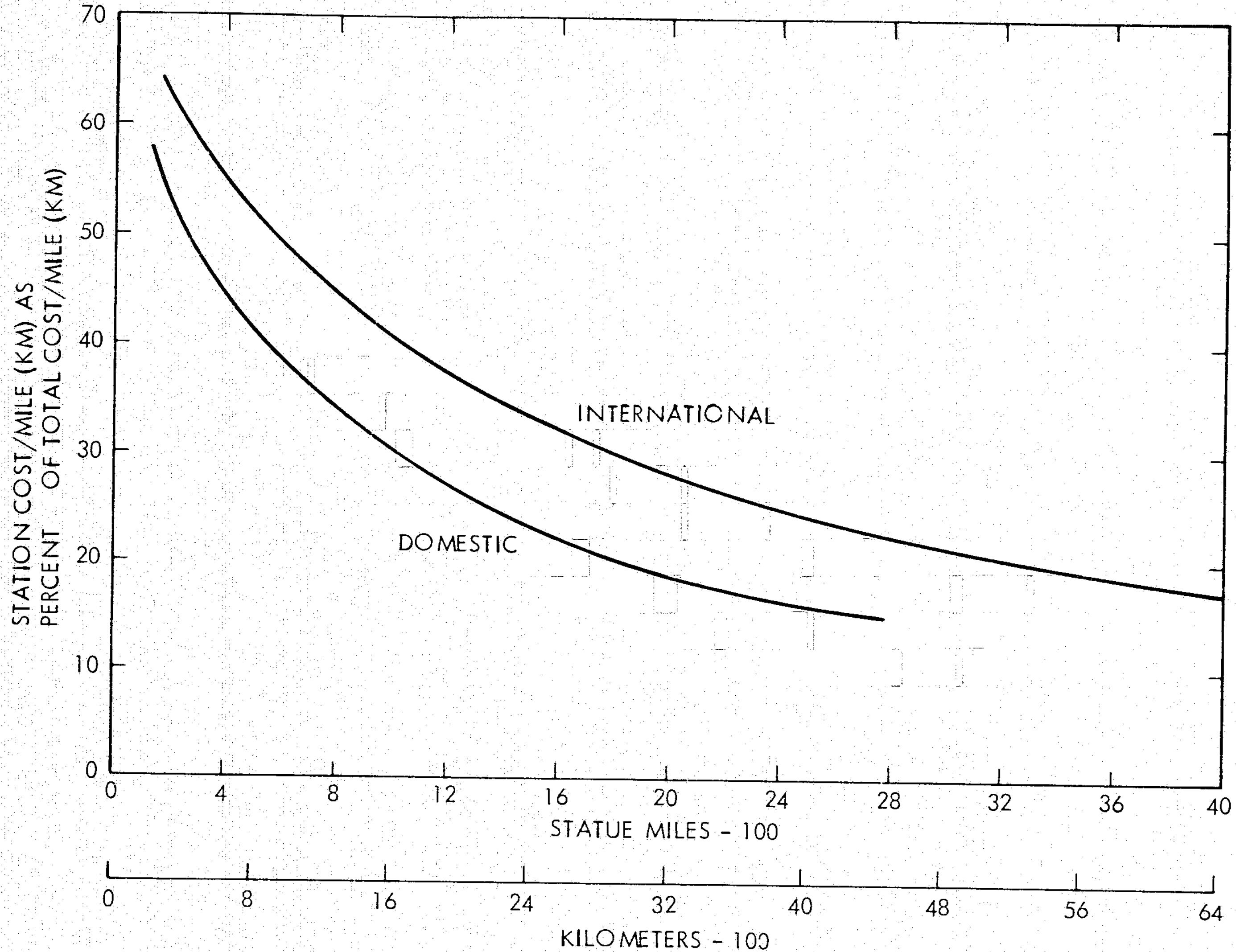


FIGURE I-45. EFFECT OF RANGE ON STATION COSTS AS PERCENT OF TOTAL COST type of container varied widely. A safe description of the average would be rudimentary: they are able to accomplish the task.

This lack of change over the years in the current air cargo system is due to the incidence, if not virtual dependence, on "conventional" elements, e.g. aircraft, containers, handling systems, etc. While the 8 x 8-foot (2.4 x 2.4-meter) container portion of the system is carrying significant tonnage at least in selected markets, older equipment still predominates, and in fact, is likely to do so for some time to come. Inasmuch as this is true, the system will continue to have the appearance of little change, at least until the economics of the newer system can be put to full use.

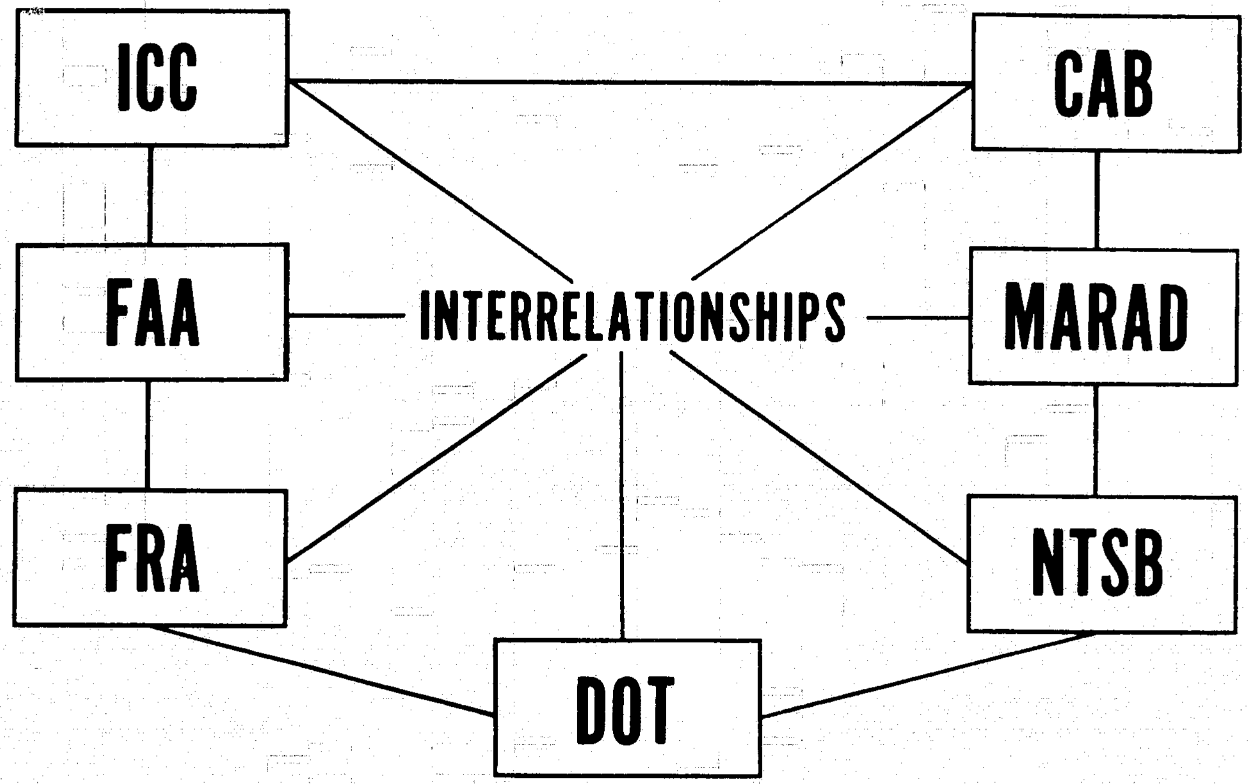
Finally, one other factor was noted. That is the increasing degree of saturation to which most of the larger locations visited are subjected, particularly at peak hours and seasons. In many cases this is accompanied by similar pressures on the passenger operations which tend to dominate most airports, and it is apparent that this will soon be a very serious problem for belly cargo operations, if not already.

Institutional Controls and Other Influences

In addition to the economic and operating factors previously discussed, a number of governmental agencies outside the industry have direct effects on the nature of the current air cargo system. These governmental influences are imposed by both U.S. and foreign governments as well as city and state administrations.

Governmental regulation or control affects economic, safety, operating procedures, route authority, environment and ecology, and international operations of the carriers. Route control provides carrier certification and may additionally involve operating restrictions, permissive or mandatory authority, and international relations. Tariff control is basically economic and may require very complex filings by the carrier; where foreign governments are involved, the proceedings may be considerably more time-consuming. IATA tariff construction is manifestly tedious and much less than satisfactory results are achieved. Both domestic and international proceedings are frequently lengthy; regulatory lag is common. Domestically, air cargo deregulation has served to streamline a previously burdensome system and can be said to mitigate filing action lags and delays. Figure I-46 shows some of the more significant governmental inter-relationships causing regulatory influences.

Domestic - The U.S. domestic air carrier industry has been subject to regulation since 1938. Under the Civil Aeronautics Board's administration, air carriers have been subject to tight route controls and pricing controls. In recent years, the CAB has conducted extensive investigations on the public need for authorizing additional cities on carrier routes and has generally



ICC - (Interstate Commerce Commission) approves routes and regulates economics (rates) of the regular common motor carriers and railroads.

FAA - (Federal Aviation Administration) establishes design and operation requirements for all private sector aircraft; certifies all private and commercial aircraft; establishes requirements and development equipment for airports.

FRA - (Federal Railway Administration) promotes railway commerce and administers the railway subsidy program.

CAB - (Civil Aeronautics Board) regulates economic aspects of U.S. air carrier operations and of foreign common carrier operations to and from the U.S.

MARAD - (Maritime Administration) administers airplane subsidy program and promotes marine commerce.

NTSB - (National Transportation Safety Board) autonomous board which investigates major transportation accidents.

DOT - (Department of Transportation) develops national policies to provide fast, safe, efficient, convenient and economical transportation.

FIGURE I-46. REGULATORY AGENCIES

expanded air carrier service through awarding additional route segments to carriers which already hold certificates.

In the area of pricing, the CAB has taken an increasing part in determining the proper passenger fares and cargo rates to be assessed by the carriers. Their detailed investigations on passenger pricing issues, cargo rates, liability provisions, mail rates, and the like, have made the airlines subject to explicit price controls in their operations.

Within the last year, a definite move toward deregulation of the air industry has become manifest. This was partly the result of Presidential directive and the activities of consumer groups. In addition, Mr. Robson, former Chairman of the CAB, openly advocated a deregulation of the air cargo industry. The deregulation efforts are concentrated upon two principal facets: (1) that the Board should approve greater carrier competition by allowing free entry of new carriers into markets, or of existing carriers into new markets, and (2) that the airline should be allowed to price with greater freedom. Most deregulation proposals advocate the use of a suspension-free range in prices, so that any adjustments within that range would be free of suspension. The adoption of deregulation proposals along the lines being advanced could substantially alter the make-up of the domestic air industry. While the most significant impact would be upon passenger operations, freight operations would also be considerably impacted. In many respects, the proposals for deregulation of freight operations are considerably more radical than those proposed for passenger operations.

Some of the specific areas which would be impacted by the adoption of a deregulation bill are more fully discussed in the following subsections.

International - The deregulation efforts for the domestic market have little counterpart in international circles. While the Civil Aeronautics Board has maintained a position of allowing carriers to reduce rates on international routes with very little interference, the attitude of Board is not mirrored in the actions of foreign governments. Most foreign governments are guided to a large extent by the representations of their national flag carrier, and approve or disapprove rates depending upon their effect on the national flag carrier. The overall result has been that foreign-flag carriers have been successful in gaining the approval of the Civil Aeronautics Board on any pricing concepts which they advocate to the Board for their approval. On the other hand, the American-flag carriers have been rather unsuccessful in implementing rates which do not have the concurrence of the foreign-flag carrier at the destination point.

In addition, many of the foreign governments have a much different view on free market entry than does the U.S. CAB or the U.S. government. The foreign carriers have for many years operated with pooling agreements in non-U.S. markets. These pooling agreements are very effective in limiting capacity and insuring high load factors for the carriers operating the routes. The foreign governments would in many cases be receptive to similar pooling agreements or capacity restraints on U.S. routes but have not been able to convince the U.S.

government of the merits of such arrangements. Apparently for this reason, the deregulation preposals that have been advanced by the U.S. government are generally limited to the domestic arena. They recognize that a similar deregulation concept for international routes would be very difficult or impossible to achieve under the current bilateral agreements and with the attitude of the foreign governments which generally favor limited market entry.

Availability and Cost of Airline Capital

There is little doubt that the current method of regulation has facilitated the ability of the airlines to secure capital for financing of aircraft and terminals. Under the current system of regulation, the certificated carriers are, in fact, guaranteed the right to operate certain routes with a limited amount of competition. Under the free entry regulations being proposed by the current bills under consideration, it is likely that new carriers would enter some markets. The most probable markets to be entered would be the prime markets where there is heavy demand. The result of this additional competition would make it less likely that lenders would be willing to finance the capital projects of the carriers for future needs. Testimony to this effect was given at one of the Senate Deregulation Hearings by members of the banking community. The past years of airline experience have produced unsatisfactory profit results and the addition of new carriers, particularly in prime markets, is likely to seriously worsen those results. It appears that capital available to carriers in the future will become more expensive because of the greater risks involved on the part of the financial community.

Fuel Availability and Cost

The immediate result of deregulation would be an increased number of carriers and flights in prime markets. The result of the additional capacity, in the short term at least, would be lower load factors for all carriers and an increase in the fuel requirements of the carriers serving a particular route. While the longer-term result of deregulation might be to cause some carriers, who experience unsatisfactory results, to drop out of the market, it is quite likely that, in an entrepreneural society such as ours, additional carriers will test markets where another carrier drops out. The long-term results are likely to be an increase in fuel requirements because of deregulation.

The nature of the airline business is such that larger market shares are won by carriers who schedule more frequent departures in a particular market. Thus, the addition of new carriers in the market does not normally result in the cancellation of flights by competitors, but rather results in an increase in flights by competitors, so that more frequent and convenient departures can be offered to the shipping public. The result of this type of action is to carry approximately the same number of passengers on a greater number of flights, with subsequent increases in fuel usage. While the airfreight market is not as dependent upon flight frequencies as is the passenger market, there is some marketing benefit to having multiple flights in a particular market. Thus, the current deregulation proposals are likely to have a similar effect for cargo transportation.

Curfews/Operating Limitations

Curfews on night flights out of airports are primarily the result of aircraft engine noise. Neighborhoods around airports complain that the "noise" from aircraft prevent them from sleeping. This problem can be solved by a limited number of actions, but first an understanding of noise-related disturbance factors is warranted. Sleep disturbance factors related to noise characteristics (ref. 13), for example, are:

- o noise level loudness
- o frequency spectrum
- o time duration of the above
- o number of disturbances

There are sleep disturbance factors that are related directly to noise as indicated below:

- o Type of sleep disturbance
  - Prevents from goin to sleep
  - Awakens from sleep
- o Age
  - Boys: 1 percent awakened in aircraft noise test
  - Middle-age men: 18 percent
  - Old men: 32 percent
- o Sex
  - Middle-age women, 42 percent; men, 18 percent

- o Other
  - Time of night (least disturbance - middle 1/3)
  - Social background
  - Adaptation to noise
  - State of health

In general, people react to aircraft noise levels as would be expected: the louder the noise the more complaints. There have been numerous studies initiated by government, cities, and states to establish acceptable criteria for sleep noise levels. However, criteria for "acceptable" sleeping noise levels have not been officially established by law.

FAR-36 established noise levels for schedule airline operations. These levels are considerably higher than those being considered today as acceptable for curfew-free operating levels. The problem of lowering noise levels can be attacked in the areas of better construction techniques of houses and office buildings and in lowering aircraft noise. The latter is an area of technology which must be pursued beyond that available today.

The restriction of night operations is a comparatively recent development in noise abatement that could severely constrain the growth in air cargo operations worldwide. Curfews on night operations have been imposed or threatened both in the U.S. and overseas as part of a pattern of growing public resistance to airport noise. San Diego is the only U.S. airport that currently imposes a night curfew for all jet aircraft. Limited restrictions are in force at Washington National, and measures to curtail late-night operations are under consideration in other localities.

Imposition of these restrictions has been more extensive outside the U.S. In Western Europe and other parts of the world, limited, partial, and total curfews are in effect, or being considered. From Osaka, Japan, where a complete night curfew is in effect, to Athens, Greece, where new noise control procedures bar fuel stops between midnight and 5:00 a.m. and discourage charter operations after midnight, restrictions are being imposed.

Most large airports of the world have experienced a substantial growth in traffic over the past few years, and in many cases, a growth of population in noise-impacted areas around airports. This has resulted in a relatively strong public reaction against what is seen as a technological intrusion into residential areas.

The effects of curfews on the operations of the airlines are potentially serious. Essentially, the curtailment of nighttime operations at airports imposes an additional constraint on the carriers' already limited scheduling flexibility. This can best be illustrated by considering long-range west to east flights. For instance, if curfews were in effect on both East and West coasts between midnight and 7:00 a.m., no non-stop eastbound flights could take off between 4:00 p.m. and 11:00 p.m. or between midnight and 7:00 a.m. To take another example, if a night curfew were imposed at JFK International Airport, and the summer night curfew at London were made year-round, the takeoff and landing times available for eastbound trans-Atlantic flights would be only 3 or 4 hours a day. Obviously, a curfew at a single location like San Diego has a limited and largely localized effect. Schedules can be modified so that aircraft which would normally be used on night flights are moved out of that location and are not immobilized. On the other hand, if curfews spread, the impact will be cumulative and would impose serious constraints on airline scheduling.

For example, a 2300 to 0700 (local time) curfew at London would preclude takeoffs from New York to the U.K. between the hours of 1100 to 1900, assuming seven hours flying time and the standard 5-hour time difference. Note that this precludes any operations during one-third of each day, 8 out of 24 hours. If both cities had the same local time curfew, the problem is compounded. Since none of the restricted departure period at New York coincides with the arrival curfew at London, fully two-thirds of the day, 16 out of every 24 hours, will be closed to New York-London flights. Operations out of New York would be limited to two "windows": from 0700 to 1100 and from 1900 to 2300.

Due to the greater affect of time-zone changes on eastbound as opposed to westbound flights, this example does tend to overstate the difficulties of scheduling around curfews to a moderate extent. However, mitigating against this is the fact that many flights have an itinerary which involves more than a single segment; if several of the points served have relatively lengthy daily curfews, scheduling can almost become an exercise in futility, with equipment forced to lay over at one or more points to accommodate a flight to one or more curfews. This, of course, is quite wasteful in economic terms (underutilization of resources), and it defeats the primary advantage of air transport: speed.

On the domestic scene, a good example of some of the problems generated by curfews is provided by recent developments at Boston's Logan Airport. In large measure due to community pressure, an agreement was reached whereby the carriers serving Logan would not schedule older, noisy (non FAR part 36) aircraft to depart from Logan after 1:00 a.m. in 1977. In 1978 the hour was advanced to midnight, thereby directly affecting the three main all-cargo operations (TWA, Flying Tiger and American) which were and are scheduled o depart between 12:30 and 1:00 a.m. for points in the Midwest and on the West Coast. The material in Appendix I-C identifies various aspects of the exemption process required in the Boston hearings whereby the three flights in question were enabled to continue operating during the restricted hours. The material is quite detailed concerning the effects of moving the services even a small amount of time, and serves to illustrate many of the difficulties inherent in curfews as they concern cargo operations. In addition, it should also be noted that Boston is a coastal point, where flights often originate within an hour or so of midnight. If the scene is shifted to a point in the middle portion of the country, such as Chicago or St. Louis, it is easy to see that there is virtually no chance to adjust schedules, as flights from one coast to another tend to transit the Midwest between 2:00 and 5:00 a.m.

A 1972 survey by the Airport Operators Council International gives an indication of the volume of traffic that moves at night and would be directly affected by spreading curfews. One finding was that, at major U.S. airports, some 50 million passengers arrived or departed between the hours of 10:00 p.m. and 7:00 a.m. - about 25 percent of all passengers traveling. A comparison of passenger vs cargo flights between 11 p.m. and 5 a.m. in 1975 is shown in Figure I-47. In addition, a sizeable majority of all U.S. airfreight and mail moved in and out of airports during those hours. So far as air cargo transportation is concerned, the main impact of curfews would, of course, be on domestic all-cargo flights. These services are considered inadequate by many shippers and forwarders. Extensive rescheduling of domestic all-cargo flights to daytime hours would vastly reduce their attractiveness to shippers, since it would eliminate the possibility of overnight delivery. The addition of a full day to the elapsed time between the readiness of a shipment for movement at the end of one working day and its availability to the consignee at the beginning of another reduces air transportation's advantage of speed and tips the balance against this transportation mode in favor of slower but cheaper ones. In short, the threat that curfews pose to air cargo transportation is that they would force extensive cancellations of overnight all-cargo flights.

What are the prospects that limited or complete curfews will be widely imposed? In the U.S. the FAA has the statutory authority to preempt noise regulation but has not as yet done so. Until it does, states, localities, and airports are free to take action. Apparently, there is some difference of opinion between the U.S. Department of Transportation and the Federal Aviation Administration as to what action at the federal level, if any, would be appropriate. The FAA has been working on a National Airport Noise Policy since June of 1975; until it is completed and the necessary approvals obtained, the Department of Tranportation has been reluctant to exert its authority. One reason has been that, if it did so, lawsuits involving claims for damages could be filed against the federal government.

There appears, however, to be growing pressure for federal preemption and the promulgation of a federal program to halt the spread of curfews. The Airport Operators Council International has stressed in a formal recommendation that the federal government must take the responsibility for solving the noise problem. It has recommended: that the application of the Federal Aviation Regulation Part 36 be tightened; that new regulations be adopted which would require the retrofitting with sound absorbent material of existing jet aircraft that do not meet FAR Part 36; and that aircraft operating procedures deigned to minimize noise be required, consistent with safety, in noise-sensitive areas. Most of the airlines, as well as the airport operators, favor federal preemption.

If federal preemption does occur, it will undoubtedly impose requirements on the airlines that will increase their costs but, in the long run, that is

U. S. AIRPORTS

- PASSENGER AIRCRAFT
  - 5.7% OF ARRIVALS
  - 3.2% OF DEPARTURES
- ALL CARGO AIRCRAFT
  - 36.5% OF ARRIVALS
  - 42.8% OF DEPARTURES

NON U. S. AIRPORTS

- PASSENGER AIRCRAFT
  - 2.8% OF ARRIVALS
  - 1.6% OF DEPARTURES
- ALL CARGO AIRCRAFT
  - 22.2% OF ARRIVALS
  - 24.2% OF DEPARTURES

FIGURE 1-47. NIGHTTIME FLIGHT OPERATION FROM 11:00 P.M. - 5:00 A.M. (1975)

probably a better solution than to permit the spread of curfews. It appears that the worst effects of curfews can be avoided and that a major new threat to nighttime cargo operations from this practice will not materialize in the U.S.

The outlook in Europe and Japan is much different. There, curfews are being initiated or explicitly approved by national governments. There is little likelihood, therefore, that a noise reduction program will be regarded as an acceptable alternative to local action. For this reason and because nighttime restrictions have already spread so widely, it appears that they will not be abandoned; in fact, the number will probably increase. Shipment by air has more of an advantage in time on long international hauls than it does domestically in the U.S., and overnight delivery on trans-Atlantic and trans-Pacific hauls is relatively less important, since Customs procedures inevitably involve delays in airports and make true overnight delivery impossible. Thus, European curfews may not be too serious for the long-range international air cargo operations.

Airport Congestion

Deregulation proposals will also tend to increase aircraft congestion at airports. As noted in the preceding subsection, additional carriers can be expected to enter both freight and passenger markets. To the extent this occurs, there will be an increasing number of flights. In the airfreight area, these flights are likely to occur during the night time. The prime shipping time for airline customers, particularly forwarders, is for departures that occur after midnight and before 4 a.m. These departures are preferred in order that the traffic produced at the origin city during the day can be consolidated, tendered to the airlines at the airport, and shipped to destination for next-morning delivery. The dedicated airport which may ultimately come about due to congestion and other considerations could develop in the form of a new cargo or regional cargo airport, or could similarly develop at low-usage military fields in a joint tenancy concept.

Pricing

In the current deregulation atmosphere, the CAB has already adopted a de facto deregulation policy with regard to air freight rates. The current policy consists in allowing carriers to implement rates up to the maximum cost level recognized by the CAB, and also to implement rates which are substantially below the fully allocated cost levels developed by the Board. Since early in 1977, the CAB has routinely approved carrier tariff proposals which recover only ground handling costs and make a minimum contribution to flight capacity costs. Their latest indications are that they will also approve rates which do not fully recover even ground handling costs, provided the carrier can show good reason why the rate should be approved.

A further aspect of deregulation is that the aircraft size limitation under which smaller carriers can operate completely free of route and rate regulation will be increased substantially. For example, current proposals will raise the payload capacity of aircraft exempt from CAB regulation from 7,500 to 18,000 pounds (3409 to 8181 kg). This is approximately the payload capacity of a DC-9, or the equivalent of a 707 belly. This will have the effect of attracting marginal operators, especially of aging equipment, to the domestic freight marketplace, with an attendant increase in fuel consumption and airport congestion. This also allows Federal Express to operate the larger aircraft it has petitioned for.

Civil Reserve Air Fleet

The CRAF is worthy of discussion because of its relationship to and possible impact upon civil freight carriers. The long-range passenger aircraft needs of CRAF are well filled; in the heavy airlift oversize and outsize cargo requirement there is a substantial shortfall. CRAF may be a very significant factor in both the design and financing of new all-cargo capacity.

Since 1952, although never mobilized, the CRAF has provided a significant strategic airlife augmentation resource to meet contingency requirements worldwide. As of April 1, 1977, civil aircraft committed to the CRAF provided approximately 35 percent (225 long-range international class aircraft) of the nation's long-range strategic airlift capabilities. The CRAF cargo capability is divided into narrow-body equivalent aircraft (bulk and shaped pallet load cargo) and wide-body (oversize, i.e., C-141 size pallet and vehicle) cargo. Only the Air Force C-5 aircraft can accommodate large tanks/outsize cargo and other heavy military equipment.

The decreased warning time posed by the Soviet military capabilities facing the NATO alliance was described as a new and serious threat in a report (ref. 14) published early last year following an inspection trip to Europe by Senators Nunn and Bartlett of th Senate Armed Services Committee. Among the findings of the report, there is evidence that decreased warning time of a potential attack against NATO forces in Western Europe imposes serious restraints on the planned movement of the combatnt augmentation forces from the U.S. to Europe. If these forces are to arrive on time, they must be moved exclusively by air. There is an already recognized shortfall in current strategic airlift capabilities to meet contingency requirements. In the face of this reported decreased warning time, the demand for existing strategic airlift forces is likely to exceed the availability.

Proposed near-term solutions to this potential deficiency include modification/improvement to a portion of the MAC fleet and modification to some of the U.S. civil wide-body passenger fleet to essentially a convertible configuration incorporating a cargo capability. The proposed increased organic capability will come from stretching and added inflight refueling capability to the C-141 fleet. The proposed civil mod program would be based on a modification to long-range, wide-body, passenger aircraft to include one of the following:

- o Side doors, non-reinforced floors, manual loading
- o Side or nose doors, reinforced floors, manual loading
- o Side or nose doors, reinforced floor with powered loading system.

The case for an increased amount of common airframe requirements between civil and military can be seen in this DOD/Air Force proposal to modify existing (or future) wide-body civil passenger aircraft. The proposed formulas for air carrier compensation and/or subsidization for enrolling their aircraft in CRAF under this program are flexible and multifold. The precedence for this subsidy concept is long-founded within the maritime industry and covers operational as well as construction monies.

Whether or not there is need to consider government subsidization with respect to future large transport aircraft to ensure that, at least, minimum military cargo compatibility requirements are incorporated is yet to be determined. Certainly a case can be made for seeking a high degree of civil-military commonality in the next generation freighter aircraft. However, any military peculiar facet in the aircraft design which affects civil performance, and therefore economics, will be met with resistance by some domestic carriers, and perhaps even more strongly by foreign international carriers who are ineligible by definition to enroll their aircraft in CRAF.

Characteristics of Transportation Modes in 1990

To compare the current air freight system with the postulated future dedicated advanced air cargo system to be described later in this report, it was necessary to establish a 1990 scenario for all modes of transportation, both surface and air. This was done with the cooperation of both the Department of Transportation's Transportation System Center, Cambridge, Mass., and NASA's Langley Research Center, Langley, Virginia. It was generally agreed by all that following the short-term down trends experienced in 1974-75, all modes would resume growth trends, but generally at slower rates than have been experienced in the past. For convenience and clarity, the structures of the various modes are described in the scenario separately for domestic and international operations. The complete scenario is presented in Appendix I-D.

Summary of Findings

The current air cargo network represents a system which is maturing but still contains wide disparities in market penetration between areas and routes, as well as the types of aircraft used to provide the various services. Cargo capacity provided by passenger aircraft as virtually universal with large increments of belly capacity provided by wide-bodied aircraft on most major routes in the free world. Pure freighter capacity is not as common, although this type of service is still rather widespread in its geographical coverage. In general, air, particularly freighter operations, is the high-cost mode, although some experiments in marginal pricing using the bellies of passenger aircraft are currently being carried out.

The commodities handled by the air mode are those considered "traditional" in the air industry, largely as a result of its status as the fast, high-cost, emergency transportation mode. Their characteristics include high value, small shipment size, perishability (in either a physical or economic use), and low density. As a result, air achieves only a miniscule penetration even among the shipments of only non-bulk commodities, although the relative value of goods shipped by air does represent a substantial portion of total non-bulk transport.

In comparing air with surface modes, it becomes apparent that air is primarily competitive with LTL truck for land shipping and with container movements for trans-ocean shipping. In general, air has service superior to these two, both in transit time and in the quality of handling, reflected in lower loss and damage claims. These advantages are increased as shipment size decreases, since the surface modes are, for the most part, geared toward the movement of larger volumes of shipments. Except possibly at the minimum shipment size level, air is almost always the high-cost mode, except on certain U.S. domestic routes where LTL competitive rates have been installed for some belly cargo services.

The handling of cargo at airports is subject to wide variations in the level of sophistication. At one extreme, substantial volumes of cargo, even on all freighter services, are handled largely by manual labor with only minimal assistance from mechanical loading devices. While this might naturally be expected in lesser developed areas where capital shortages inhibit mechanization, it also occurs at numerous "developed" points, both in the U.S. and overseas. Since some airports, such as Frankfurt, Germany, have quite sophisticated -- and costly -- systems for cargo, this would seem to indicate that the volume of business at most other locations simply does not justify the investment in such facilities, at least as far as return on capital is concerned.

In fact, the current trend with regard to automation of facilities for air cargo ground handling seems to be "simpler is better," except where obviously needed for high-volume container operations. For instance, installation of an efficient mechanized sort system in a modern high-volume container operation is justified at airports such as Frankfurt, Germany. Further down the scale, however, Federal Express at Memphis operates a system catering to a high-volume, small-package operation which uses large amounts of manual labor combined with a mechanized conveyor system, clearly illustrating the idea of "just enough" automation/mechanization to get the job done.

The situation regarding the use of unit load devices (ULD's) or containers is analagous to the previous discussion: "just enough." While most carriers operating 707/DC-8 freighters and virtually all widebody freighter operators use some sort of container or countoured pallet for aircraft loading, the variety encompassed is enormous, and many are captive to the systems of particular carriers. With the exception of the incipient development of 8 x 8 x 10- or 20-foot (2.4 x 2.4 x 3- or 6-meter) containers used on Boeing 747 main deck operations, few if any air containers can be considered truly intermodal. Only the aorementioned 8 x 8-foot (2.4 x 2.4-meter) variety bear any resemblance to the containers used in surface shipping.

Finally, the infrastructure within which the current air cargo system operates is undergoing some dramatic changes. On the domestic side, within only the last few months, the scene has been set for removal of the most important regulatory controls, e.g., route and price stucture. This has cast the industry into a period of uncertainty for which it is difficult to predict the immediate outcome. At the same time, international service seems to be subject to ever-increasing governmental influence and interference, particularly concerning routes, schedules, and rates. Last, but still important, "social" regulations, such as those relating to noise, smoke, and others, seem to be taking on even more importance both here and overseas, and occasionally present distinct obstactles to the operation of the air cargo system such as curfews and forced aircraft retirement schedules.

In short, today's air cargo system is one which is reasonably mature, but hardly fully developed. In spite of the fact that portions of the industry are now effectively unfettered to develop "naturally" according to the dictates of economics, continued participation by external influences will continue to play an important part in shaping the industry's structure.

II - ADVANCED AIR CARGO SYSTEM CASE STUDIES

Introduction

In contrast with the preceding discussion of the current air cargo system, the remainder of this report addresses the characteristics and potential demand for an Advanced Air Cargo System (AACS) of the future. One of the most important aspects of the CLASS program was to assemble a body of information relating to the needs for and the use of an AACS. This was accomplished at a micro-level through a number of company case studies, consolidated results of which are reported in this section. Portions of the data were extracted for use as an essential ingredient in the demand forecast and system analyses covered in later sections.

Approach

The industry case studies were used to address several issues of major importance to the definition and development of an Advanced Air Cargo System. Case study companies were carefully selected to represent a broad spectrum of shipper, consignee, and carrier experience with surface freight and air freight systems. Considerable care was taken to assure the applicability and usefulness of input data. These, and related topics, are discussed briefly in this section on the case study methodology.

Case Study Team - The case study task was begun by enlisting the support of leading manufacturers, consignees, and carriers who represent a wide range of industries and markets. Sixty-two U.S. domestic case study companies are identified and discussed in the following section on U.S. Domestic Case Studies. Eighteen overseas case study companies are presented in a subsequent section on International Case Studies. In most cases, the companies are prominent in their industries and have extensive experience in the selection among competing freight transportation modes.

The Equipment Interchange Association managed the domestic case study coordination. Many of the case study carriers and some of the shippers are also members of EIA.

Case study question-and-answer booklets were designed by D. L. Paden & Associates, leading transportation consultants. Dr. Paden personally conducted many of the domestic case study interviews. His organization consolidated and tabulated results in a form most usable for further analysis.

In addition to managing the overall case study task, Lockheed performed various analyses on domestic case study data. All international case study tasks were carried out by Lockheed personnel.

Case Study Issues - The basic issues addressed by the industry case studies are listed in Figure II-1. They deal with characteristics of the company and its distribution and transportation operations, its current use of air freight, and factors that influence air freight selection decisions. Then, in light of a company's present and future freight transportation requirements, inputs were obtained relating to desired attributes of an Advanced Air Cargo System and the extent to which the company would expect to use it.

System Concept - To derive the greatest benefit from case study responses, it was essential that a common framework of understanding be established. This was done by documenting and distributing to each case study company a 1990 Transportation Scenario & Advanced Intermodal Air Cargo System Concept.

The concept for an AACS is summarized in the following paragraphs. The complete 1990 Scenario and AACS Concept document is included in this report as Appendix I-D.

- The AACS will be available in the 1990's.
- The AACS will use an advanced-technology air freighter optimized for cargo carriage.
- The advanced air freighter will serve major domestic and international trade routes, primarily at distances of 800 miles or greater.
- Regional cargo airports may be separated from congested passenger airports and may, in some cases, use military airfields under joint-tendancy arrangements.
- The AACS will provide coordinated surface-to-air-to-surface operation in which the motor carrier industry will perform connecting services between the air mode and shippers/consignees as well as connecting services with rail and water modes.
- A family of all-mode cargo load devices (containers and/or trailers) will have been developed which are suitable for both air and surface use. These load devices will be interchangeable among all modes and not captive to any single mode.
- Surface carriers have the option of offering the air service to their customers as a segment in a door-to-door through movement, both domestically and internationally.

- o CURRENT DISTRIBUTION AND TRANSPORTATION OPERATIONS
  - FREIGHT CHARACTERISTICS
  - GEOGRAPHICAL DISTRIBUTION NETWORK AND FLOWS
  - TRANSPORTATION MODAL SPLIT
- o DECISION CRITERIA AND PROCESS FOR SELECTING AIR MODE IN LIEU OF SURFACE MODES
- o SENSITIVITY OF AIR MODE SELECTION TO
  - FREIGHT RATES
  - TOTAL DISTRIBUTION COST
  - SERVICE FACTORS
- o DESIRED ATTRIBUTES OF 1990 ADVANCED AIR CARGO SYSTEM
- o ESTIMATED FUTURE USE OF ADVANCED AIR CARGO SYSTEM

FIGURE II-1. CASE STUDY ISSUES

- The AACS will allow shipments to be packed in truckload or container-load lots by shippers, forwarders, and surface carriers without need for additional consolidation or break-bulk processing at the airport.

- Tarifs for intermodal service, including the air segment, will be established on a door-to-door basis covering the total freight movement. A single bill of lading and master waybill will be used for the entire movement.

- No significant regulatory constraints will act to retard system development or use. Further regulatory reforms may permit formation of multimodal transportation consortiums if necessary to achieve full efficiency of an integrated intermodal system.

- The cumulative effect of direct cost savings related to application of advanced design concepts, indirect cost savings for intermodal containerized operations, and shared costs through the Civil Reserve Air Fleet program has the potential for significant reductions from current air freight rates.

Question/Answer Booklets - All booklets, including the just-discussed 1990 Scenario and AACS Concept, are shown in Figure II-2. The booklets numbered 1, 2, and 3 were for shippers and consignees. The remaining booklet was prepared for use by carriers.

The shipper/consignee booklets contained over 80 questions on 37 pages. Many questions request detailed tabulations of product or market subjects. Other questions call for a discussion of company viewpoints or evaluation of specific topics or issues of special importance.

Briefings and Interviews - In many cases, preparatory briefings were held with companies to focus on the purposes of the CLASS program and the importance of their participation, and to acquaint them with the 1990 Scenario and AACS Concept.

After companies had completed their written response, a 2- to 4-hour interview was held to clarify and discuss any areas of difficulty. The interviews also served to illuminate many interesting, pertinent issues which might not have surfaced otherwise.

U.S. Domestic Case Studies

Case studies of 62 U.S. companies generated a great amount of data about the companies themselves and about their judgments concerning the Advanced Air Cargo System. This report of the U.S. case studies begins with a profile of the comapnies which illustrate their individual and collective size, strength, and diversity. Company inputs concerning the AACS are then presented under these headings:

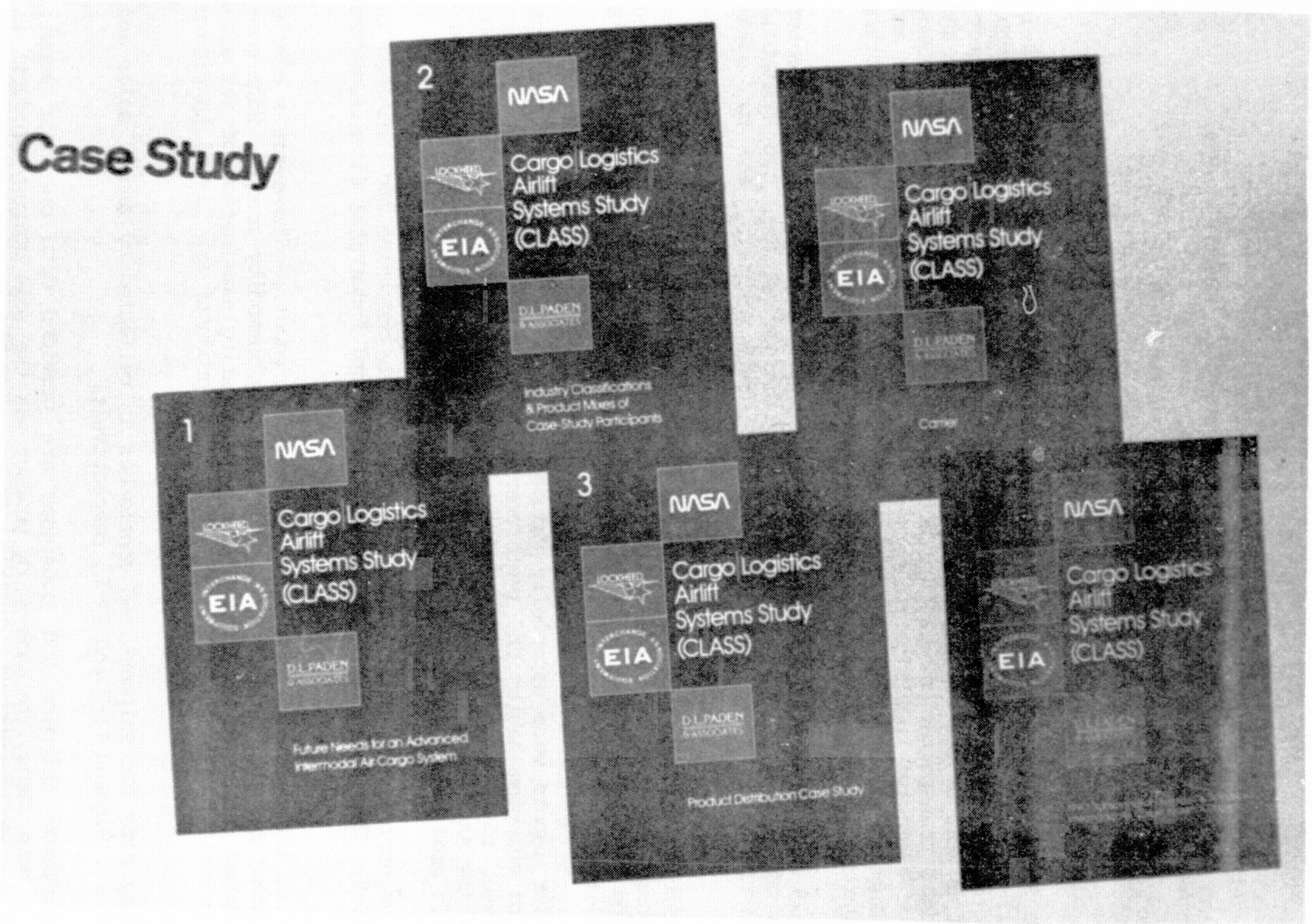


FIGURE II-2. CASE STUDY BOOKLETS

- Airfreight Eligibility and Decision Criteria
- AACS Characteristics and Requirements
- AACS Impact on Company Operations
- Potential Demand for AACS

Case Study Companies - The 38 U.S. shippers and consignees are listed in Figure II-3. Most are manufacturers, some are consignees, and many of both. Most of these companies are prominent within their industry. Many have international as well as domestic operations. They are large users of surface and air freight transportation systems, both common carriage and private. They also have extensive knowledge of current air cargo system capabilities and shortcomings with respect to their own needs. All of these factors contributed to the usefulness and credibility of their responses.

The 24 case study carriers are listed in Figure II-4. There are 16 motor carriers of general freight, a special commodities carrier, two household goods carriers, an airfreight forwarder, two rail carriers, and two ocean carriers.

Particular emphasis was placed on motor carrier case studies because the AACS concept depends upon the motor carrier to provide the interface and connecting link between the air cargo terminal and the air cargo system user's own facility.

Carrier inputs were especially valuable because of their broad knowledge concerning shipping habits and requirements of a great many client groups. Furthermore, both motor carriers and ocean carriers identified a significant role for the AACS as a substitute linehaul service - much as rail piggyback service is used today.

The major business activities of the case study companies are indicated in Figure II-5. They are grouped by two-digit Standard Industrial Classification codes.

Many of the companies have a broad line of products. Those for a single company sometimes fall into several major industry/commodity groups. Each company selected one specific product for a penetrating examination of its airfreight potential with the AACS. The case study products are listed in Figure II-6.

Company size for shippers and consignees is reflected by annual sales and market share, Figures II-7 and II-8, respectively.

Thirty-three shippers and consignes are provided data on their annual sales. In some cases, the case study product was the sole company product; in other cases, an identifiable division of the overall company produced it and furnished the sales value for that case study division. Figure II-7 shows the

ALLIS CHALMERS CORPORATION
ALUMINUM COMPANY OF AMERICA
AMF, INCORPORATED
BAXTER TRAVENOL LABORATORIES
BECHTEL CORPORATION
BLACK & DECKER MFG. CO.
BUD ANTLE, INC.
J. I. CASE COMPANY
CATERPILLAR TRACTOR CO.
CELANESE CORPORATION
CLARK EQUIPMENT CO.
D. A. B. INDUSTRIES, INC.
E. I. DUPONT DE NEMOURS & CO.
EASTMAN KODAK CO.
EATON CORPORATION
EX-CELL-O CORPORATION
THE R. T. FRENCH COMPANY
FOOD FAIR STORES, INC.
FORD MOTOR COMPANY
GENERAL MOTORS CORPORATION
GOLD KIST, INC.
THE GOODYEAR TIRE & RUBBER CO.
GROWER-SHIPPER VEGETABLE ASSOCIATION
HARNISCHFEGER CORPORATION
HERCULES, INC.
INTERNATIONAL BUSINESS MACHINES
JANTZEN, INC.
MAINE RUBBER INTERNATIONAL
MC CORMICK & CO. INC.
MONFORT OF COLORADO
J. C. PENNEY CO., INC.
RCA CORPORATION
SAFEWAY STORES, INC.
SAMSONITE
SCOTT PAPER COMPANY
TEXAS INSTRUMENTS, INC.
WESTINGHOUSE ELECTRIC CORP.
WHIRLPOOL CORPORATION

FIGURE II-3. CASE STUDY SHIPPERS AND CONSIGNEES

MOTOR CARRIERS - GENERAL FREIGHT

- ARKANSAS - BEST FREIGHT
- BN TRANSPORT, INC.
- CHIPPEWA MOTOR FREIGHT, INC.
- CONSOLIDATED FREIGHTWAYS CORP.
- COURIER-NEWSOM EXPRESS, INC.
- THE DAVIDSON TRANSFER & STORAGE CO.
- GATEWAY TRANSPORTATION CO., INC.
- IML FREIGHT, INC.
- NEUENDORF TRANSPORTATION CO.
- OVERNITE TRANSPORTATION CO.
- PACIFIC INTERMOUNTAIN EXPRESS CO.
- RIO GRANDE MOTOR WAY, INC.
- SHAY'S SERVICE, INC.
- UNITED PARCEL SERVICE
- WILSON TRUCKING CORPORATION
- YELLOW FREIGHT SYSTEM

MOTOR CARRIERS - SPECIAL COMMODITIES

- A. J. METLER HAULING & RIGGING, INC.

MOTOR CARRIERS - HOUSEHOLD GOODS

- ALLIED VAN LINES
- NORTH AMERICAN VAN LINES

AIRFREIGHT FORWARDERS

- EMERY AIR FREIGHT CORP.

RAILROADS

- BURLINGTON NORTHERN, INC.
- SOUTHERN RAILWAY SYSTEM

OCEAN CARRIERS

- SEA-LAND SERVICE, INC.
- UNITED STATES LINES, INC.

FIGURE II-4. CASE STUDY CARRIERS

SHIPPERS/CONSIGNEES

01	AGRICULTURAL CROPS	2
16	HEAVY CONSTRUCTION	1
20	FOOD PRODUCTS	4
22	TEXTILE PRODUCTS	1
23	APPAREL PRODUCTS	1
26	PAPER PRODUCTS	1
28	CHEMICAL PRODUCTS	4
30	RUBBER PRODUCTS	2
31	LEATHER PRODUCTS	1
33	PRIMARY METALS	1
35	MACHINERY	9
36	ELECTRICAL MACHINERY	4

SHIPPERS/CONSIGNEES (CONT'D.)

37	TRANSPORTATION EQUIPMENT	3
39	MISC. MANUFACTURED PRODUCTS	1
53	RETAIL GENERAL MERCHANDISE	1
54	RETAIL FOOD	2
		38

CARRIERS

40	RAILROAD	2
42	MOTOR CARRIER - GENERAL FREIGHT	16
	MOTOR CARRIER - HOUSEHOLD GOODS	2
	MOTOR CARRIER - SPECIAL COMMODITIES	1
	AIRFREIGHT FORWARDER	1
44	OCEAN CARRIER	2
	TOTAL CARRIERS	24

FIGURE II-5. INDUSTRY RESPONSES BY SIC CODE

FRESH PRODUCE

LETTUCE

FRESH POULTRY

FRESH MEAT

PERISHABLE FOODSTUFFS

SPICES

SYNTHETIC TEXTILE FIBER

WEARING APPAREL

PHOTOGRAPHIC PRODUCTS

PIGMENTS

INTRAVENOUS SOLUTIONS

LUGGAGE

COILED ALUMINUM SHEET

FOOD PRODUCTS MACHINERY

CONSTRUCTION EQUIPMENT

POWER TOOLS

OFFICE MACHINES

ELECTRICAL MOTORS

ELECTRONIC COMPONENTS

HOME LAUNDRY EQUIPMENT

MOTOR VEHICLES

AUTO/TRUCK PARTS

ENGINE BEARINGS

TIRES

MOTORCYCLES

FIGURE II-6. CASE STUDY PRODUCTS

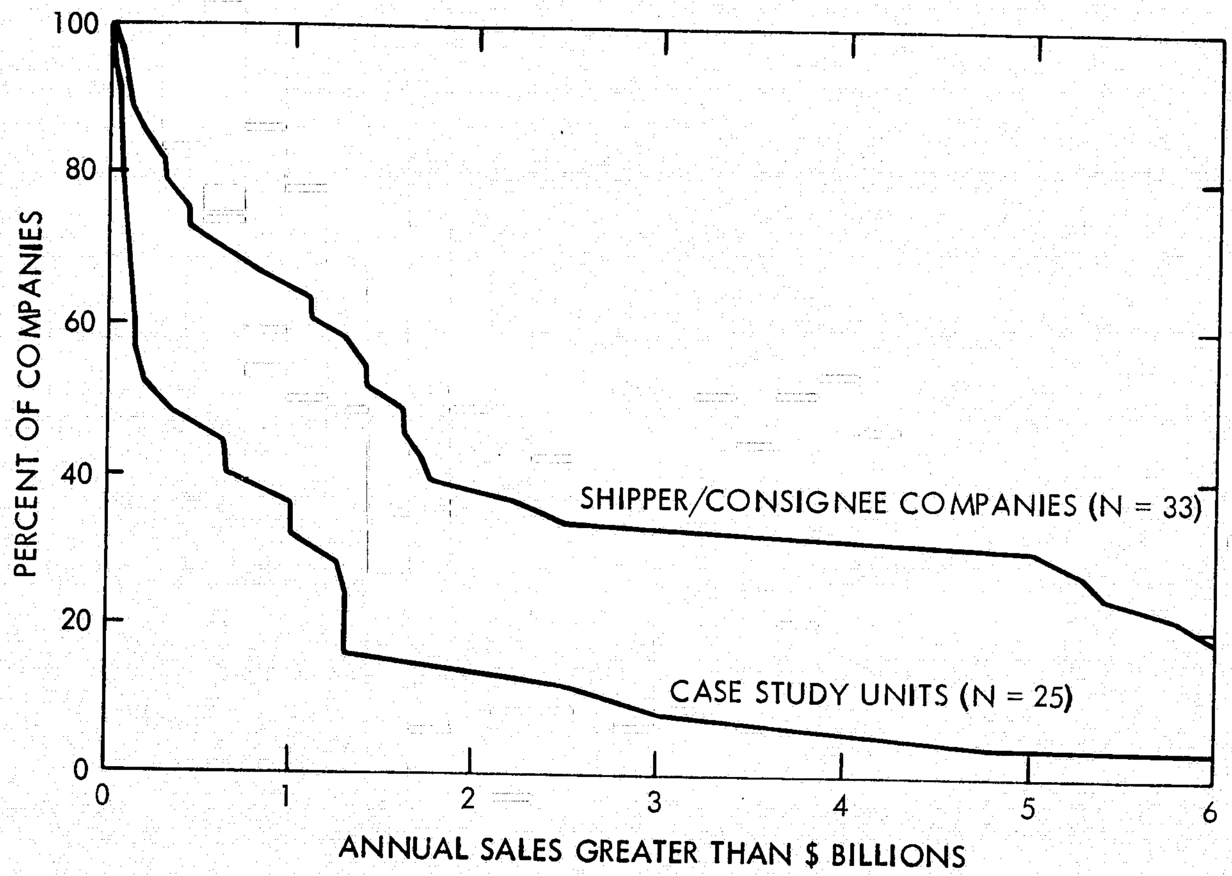


FIGURE II-7. ANNUAL SALES OF SHIPPERS AND CONSIGNEES

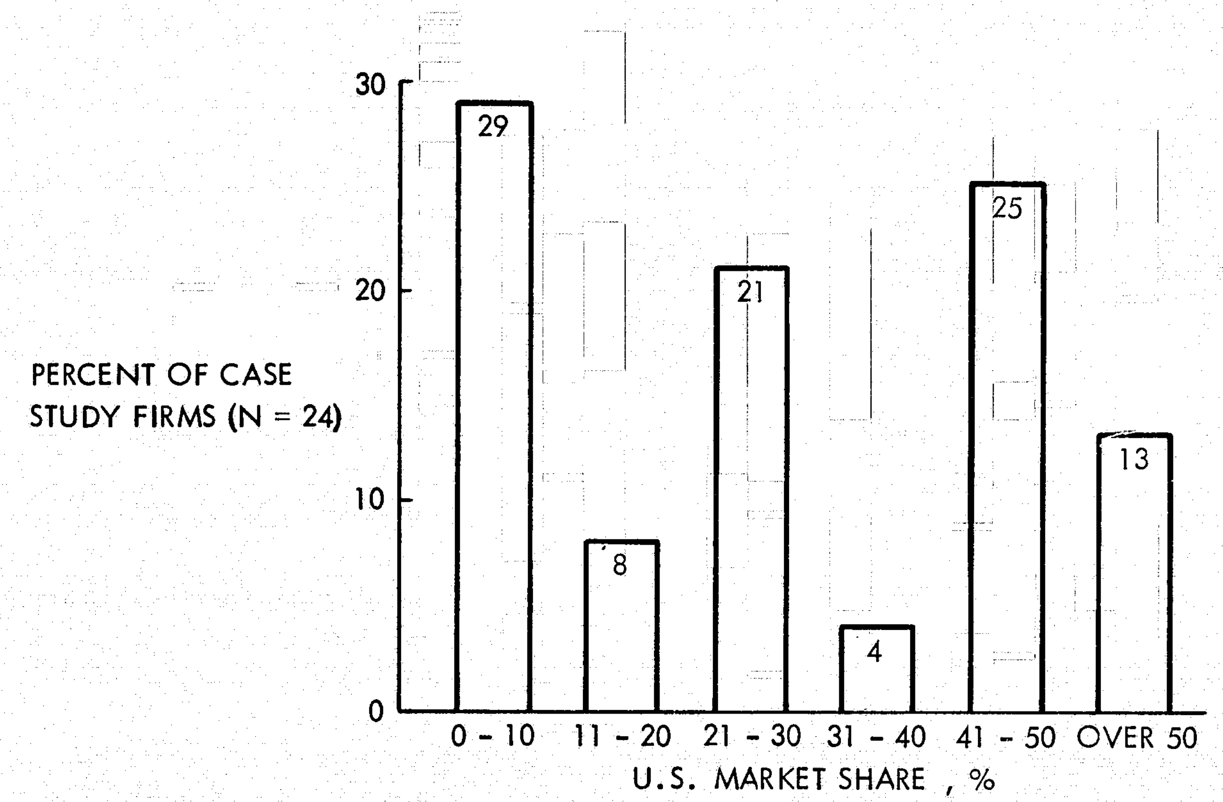


FIGURE II-8. MARKET SHARE OF SHIPPERS AND CONSIGNEES percentage of companies and case study units with annual sales equal to or greater than the amount shown along the horizontal scale. As a basis for comparison, about one-half of the Fortune 500 Industrial Companies have annual sales greater than $1 billion. The same $1 billion is exceeded by 65 percent of case study shippers/consignees and by 35 percent of their case study units.

Twenty-four shippers and consignees provided information on their competitive ranking and market share, Figure II-8. Of these, 29 percent of them have market shares of 10 percent or less. Many have a more commanding position in their industry as shown by the two bars on the right, with 38 percent of the companies having over 40 percent of their total markets.

Of 27 case study carriers, 23 reported data on annual revenues and tonnage. About 50 percent of the carriers have revenues exceeding $100 million and over 25 percent exceed $200 million, Figure II-9. About 50 percent of the carriers have annual traffic of one million tons or greater and over 20 percent move over 10 million tons annually, Figure II-10.

Airfreight Eligibility and Decision Criteria - A number of questions were asked to examine why shippers and consignees would use the AACS.

Airfreight Decision Criteria: A question about air freight decision criteria asked participants what factors are important now (1978) when using air freight rather than surface transportation modes. The question then asked them to indicate changes in their decision criteria that would affect the ranking of the factors in 1990. Each company ranked six decision criteria in order of importance from one to six. Figure II-11 shows the ranking for 1990. The rankings received by each factor are indicated by the relative heights of the six bars. First-place rankings were assigned a value of 100, second place 80, and so forth down to zero for sixth place. The composite ranking is shown for each factor in the numerals. Transit time and cost considerations were the two most important. Inventory reduction and value of the product rated high also. In addition to these six factors, transit time, rate competitiveness, inventory reduction, product value, reduced loss/damage and intermodal feasibility, the participants cited several other factors that form their air freight decision criteria. Reliability of service was noted by some participants as being an important factor in the use of air transportation.

Shelf life of the product and reduced packaging costs were considerations that caused some participants to choose air transportation instead of surface modes.

Many shippers do not relate to the concept of intermodal feasibility. They are fundamentally interested in door-to-door service, and modal interchange is not one of their concerns. To them, modal interchange is a problem for the transportation service. In this context, intermodal feasibility is more significant than the composite rating (26) indicates. Other shippers do relate to the concept of intermodal feasibility because they are more involved in the detailed planning and coordination of the shipments. These shippers note the importance of intermodal feasibilty now (1978), but more significant-

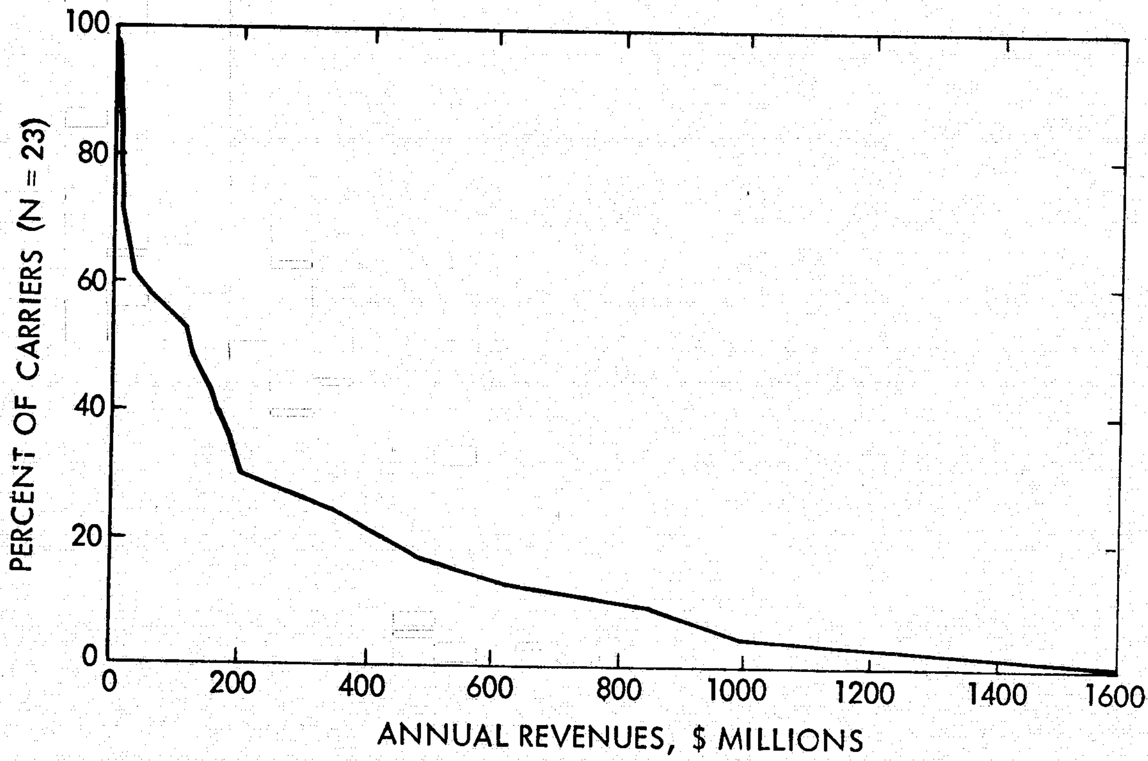


FIGURE II-9. CASE STUDY CARRIER REVENUES

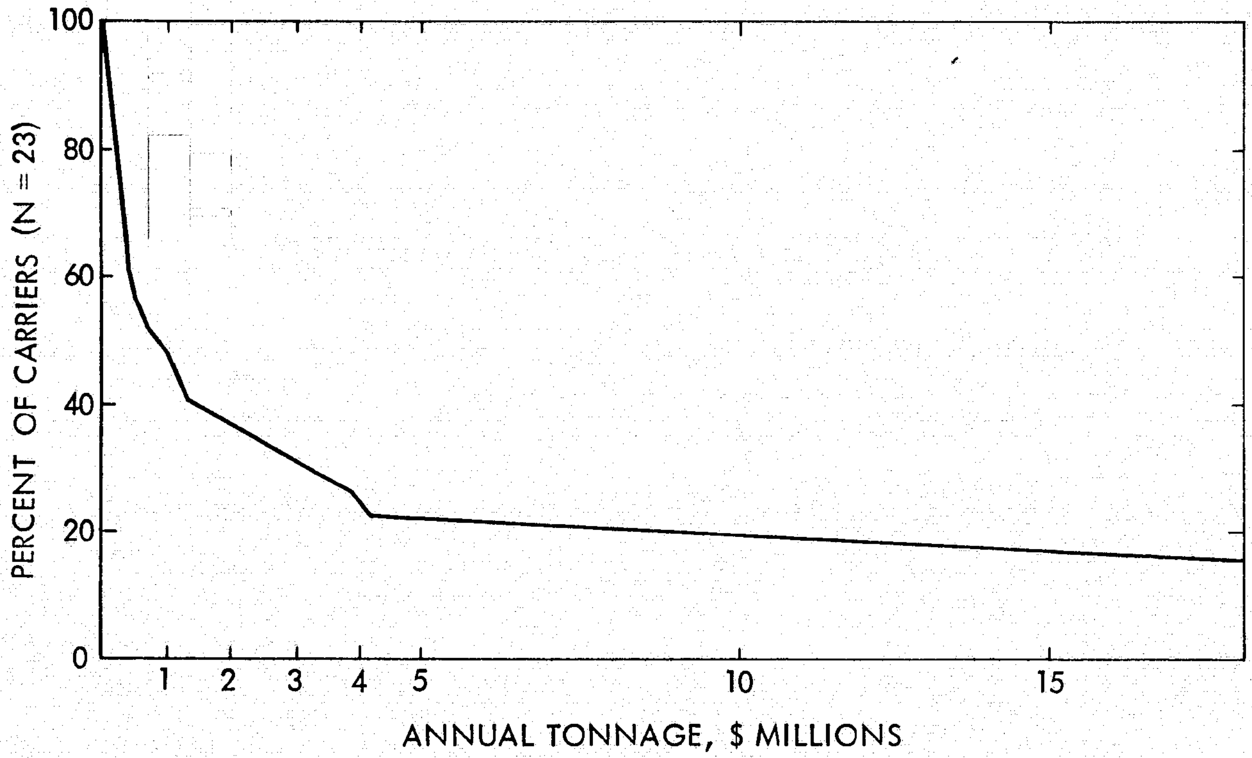


FIGURE II-10. CASE STUDY CARRIER TONNAGE

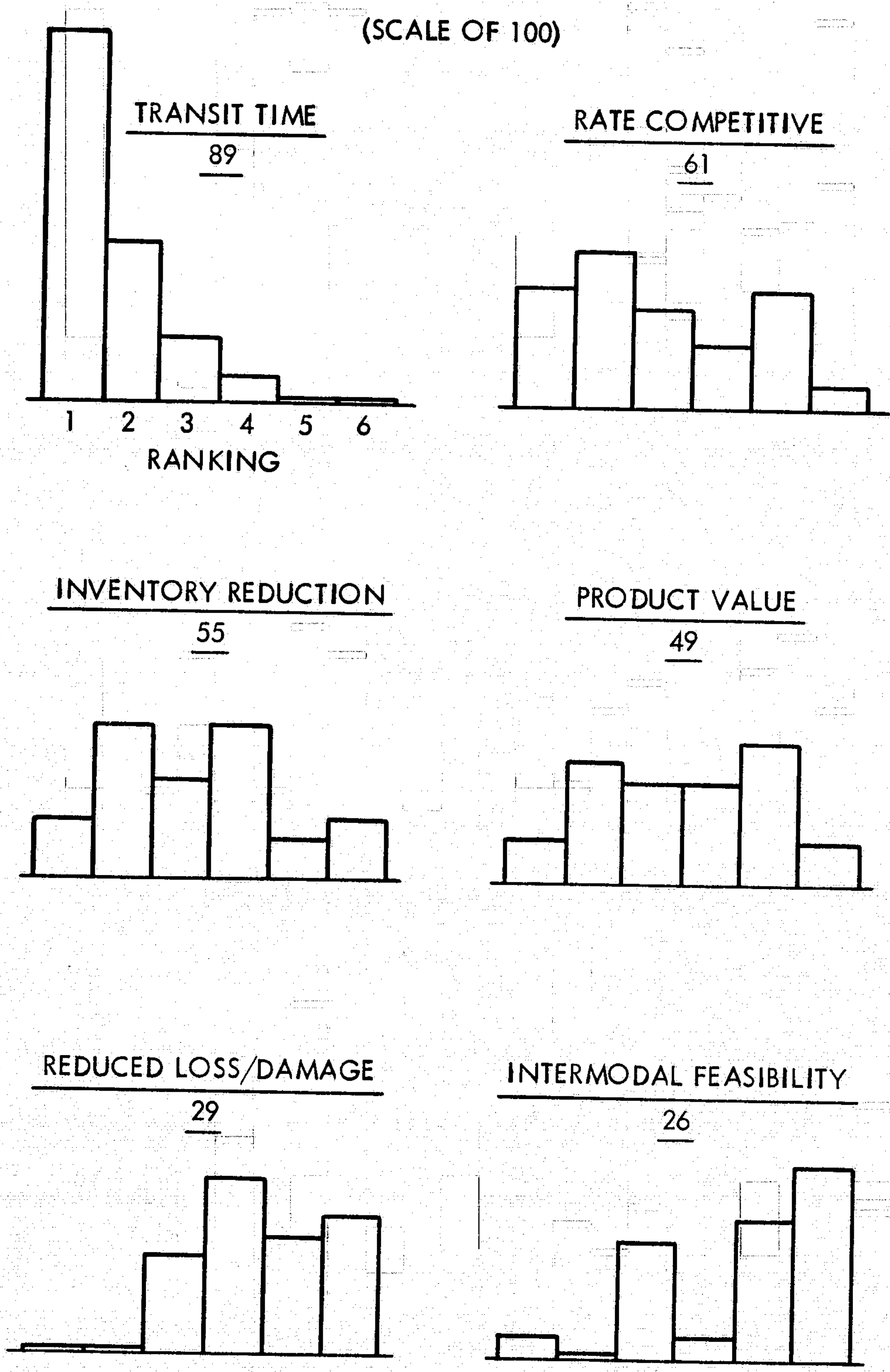


FIGURE II-11. AIR FREIGHT DECISION CRITERIA ly, the participants indicate that intermodal feasibility will be more important to them in 1990 than it is now.

Freight Rate vs. Service: Participants were asked to rate the relative importance of air freight rates and service for particular commodities or product lines and for particular commodities or product lines and for particular origin-destination markets. The importance of freight rate vs service considerations was examined for 81 different commodities. A separate importance ranking from 0 to 100 was given to freight rate and to service for each commodity. The values were then compared, and the results are shown in Figure II-12. Twenty-two percent of the commodities were ranked with equal importance values as indicated by the vertical shaded bar in the middle. The percentages of commodities for which rate was increasingly more important than service are shown to the left. As shown on the right, service was more important than rate.

Another method of displaying the raw data for Figure II-12 is shown in Figure II-13. Each dot is a paried importance rating of freight rate and service for each commodity. The average ratings are 75 for service and 69 for freight rate.

Case study companies identified commodities more sensitive to freight rate or service in Figure II-14. Commodities more sensitive to service factors are shown in the center column. They are either time-sensitive, delicate, perishable, or emergency replacement shipments. Although some commodities are generally more sensitive to either rates or service, the future AACS must assure a balanced consideration of both.

Overall, the participants' responses did not identify any specific geographical markets that have either rate or service sensitivity. The longer distances were designated rate-sensitive more often than service-sensitive.

Airfreight Decision Process: It was somewhat surprising to find that only 40 percent of the companies had ever conducted a formal Total Cost of Distribution analysis, ~nd only a third of the companies have any routinely-used standard guidelines which provide criteria for use when considering air shipment. This is not meant to imply that judgments are not informed or not rational; in fact, many such decisions are based on extensive experience and consideration of many relevant factors, but they are largely made on an ad hoc basis.

In those cases where companies do use a specific procedure, or guideline, or rule of thumb to aid in evaluating the use of airfreight for particular situations, the kinds of decision aids applied are listed in Figure II-15. The questions go like this: "Is the additional cost of air freight worth avoiding the unhappy consequence of not satisfying a customer, ... or of not replenishing a production inventory, ... or of delaying delivery of a replacement part?" Although only 19 percent of the comments specifically cited "Emergency" as a decision factor, most of the listed factors have emergency

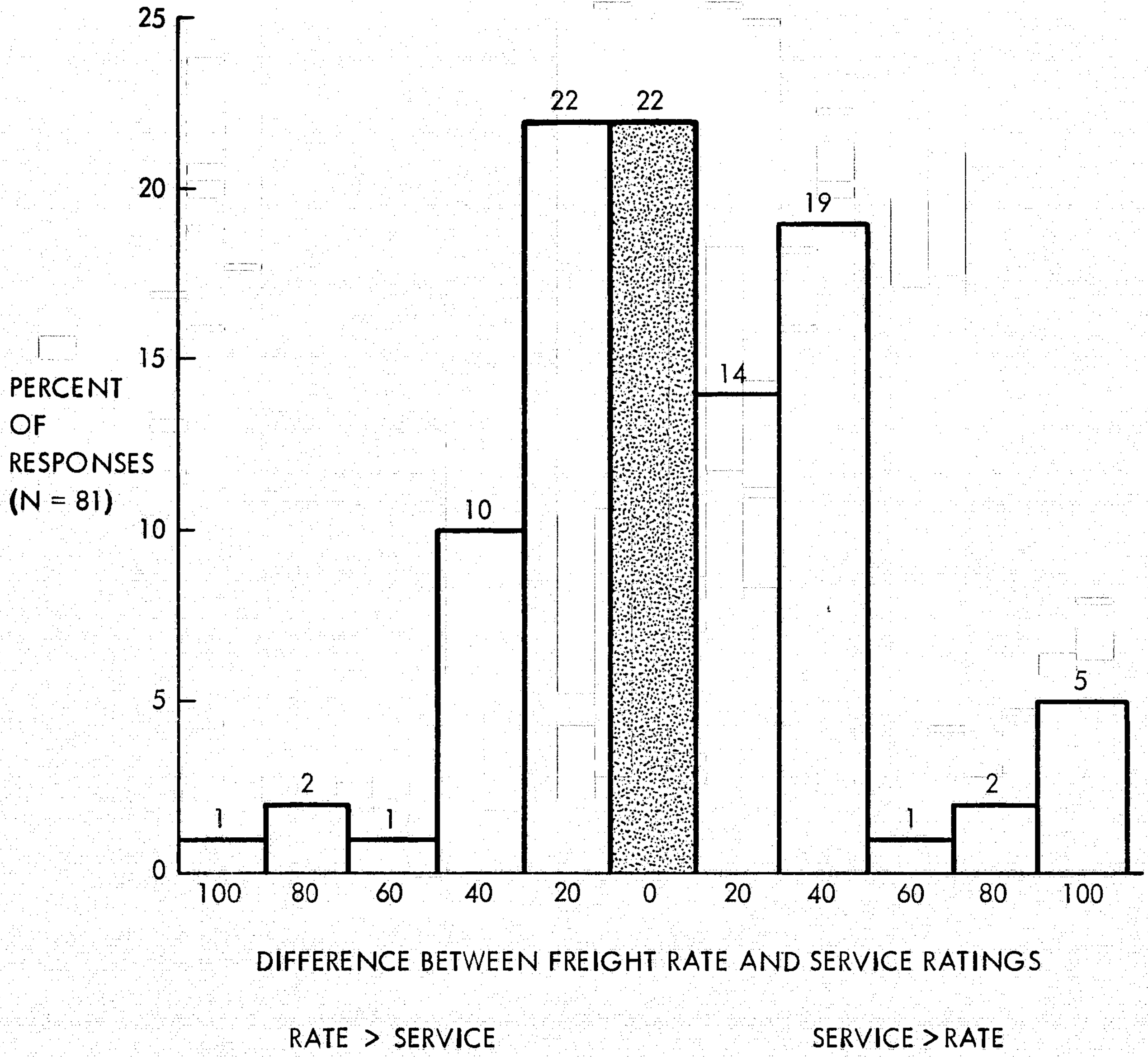
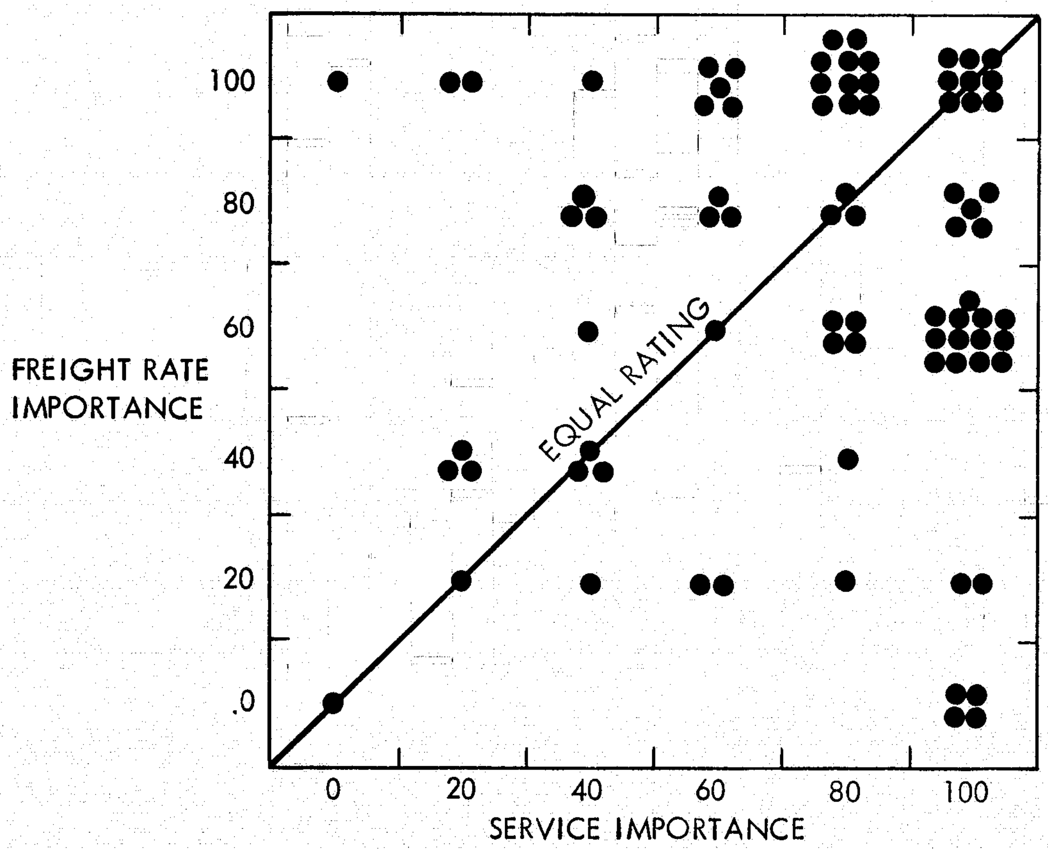


FIGURE II-12. IMPORTANCE OF FREIGHT RATE VS SERVICE
(ALL COMPANIES, ALL COMMODITIES)



AVERAGE RATINGS

SERVICE = 75

RATE = 69

FIGURE II-13. IMPORTANCE OF FREIGHT RATE VS SERVICE (PAIRED RATING FOR 81 COMMODITIES)

RATES	SERVICE	EQUAL
APPAREL	CATALOGS	APPLIANCES
ELECTRICAL EQUIPMENT	ELECTRONIC EQUIPMENT	POULTRY
FILM	FOODSTUFFS	POWER TOOLS
LUGGAGE	MACHINERY	PRODUCE
PHARMACEUTICALS	REPAIR PARTS	
RUBBER PRODUCTS		
TV SETS		

FIGURE II-14. COMMODITY SENSITIVITY TO FREIGHT RATE AND SERVICE

DECISION AID	% OF COMMENTS
CUSTOMER SATISFACTION VS COST	23
EMERGENCY	19
LOST PRODUCTION OR SALES VS COST	13
BUSINESS NECESSITY	10
TRANSIT TIME	10
TRADE-OFF BETWEEN TIME AND COST	10
PRODUCT VALUE VS COST	8
INVENTORY EXPENSE VS COST	6

FIGURE II-15. AIRFREIGHT DECISION TYPES AND FREQUENCY OF USE overtones. Keep in mind that these are aids used for today's air cargo decision-making.

In contrast, factors likely to account for an increased use of air shipment when te AACS becomes a reality are listed in Figure II-16. Seventy-two separate comments were received. Companies ranked factors in order of importance; a ranking of 10 was applied to the most important, 9 to the next, and so on to arrive at a weighted ranking. With many companies envisioning a routine use of air freight because of its potential for reduced air freight costs and reduced distribution costs, these factors assume importance comparable with the continuing need for fast emergency delivery.

The present barriers to increased airfreight use are found to be lack of service rather than rate incompatibility with the surface mode competition. Inadequate pick-up and delivery service and poor ground handling were cited as deficiencies in present air cargo operations. Restricted geographic coverage by all-cargo service inhibits many shippers. The issue of cost sensitivity vs. service sensitivity can be illustrated as shown in Figure II-17. The survey results confirm the basic service sensitivity of the 1978 market demand as shown on the top block of the Figure Demand is relatively inelastic to modest changes in airfreight rates. As the service and capacity demands are fulfilled by a growing air cargo industry, rate decreases will begin to generate additional demand. The market will attract an increasing proportion of routine, cost-sensitive shipments which by 1990 will represent a major share of total demand. The emergency, specialized traffic will grow only in response to increased demand for overall freight transportation as generated for example, by higher GNP.

<u>AACS Characteristics</u> - All case study shippers and consignees were requested to identify aspects of a future AACS - both service and physical - which would be important to them and which should accordingly be kept in mind by developers of the system.

AACS Service Characteristics: Over 150 comments were received pertaining to desired service characteristics; they are grouped by major category in Figure II-18. The service characteristic most desired by the shippers is scheduled, reliable, door-to-door operations. A frequency of departure of one per day will be adequate for many destinations, but multiple frequencies for major destinations are indicated.

AACS Physical Characteristics: Many comments were received pertaining to the advantages and disadvantages of containerization, opinions of present air containers, importance of intermodal containers, container loading preferences, etc. All of these case study results are reported in Section IV, Importance of Containerization.

<u>AACS Impact on Company Operations</u> - Case study companies also evaluated the potential impact of the AACS on their own operations. Nearly 80 comments, listed in Figure II-19, add up to cost savings and service improvements. Most shippers participating in the case studies see the AACS as an opportunity to

CATEGORY	NUMBER OF COMMENTS	WEIGHTED IMPORTANCE
REDUCED AIRFREIGHT COSTS	19	179
REDUCED DISTRIBUTION COSTS	15	125
FASTER DOOR-TO-DOOR TRANSIT	10	93
SURFACE MODE LIMITATIONS/DETERIORATION	4	37
REDUCED LOSS AND DAMAGE	5	31
CHANGING MARKET REQUIREMENTS	4	31
CHANGING PRODUCT CHARACTERISTICS	3	29
OVERALL IMPROVED SERVICE	3	24
PLANNING AND OPERATING EFFICIENCIES	2	19
RELIABILITY	2	18
OTHER FACTORS	5	43

FIGURE II-16. REASONS FOR INCREASED AIR SHIPMENT WITH AACS

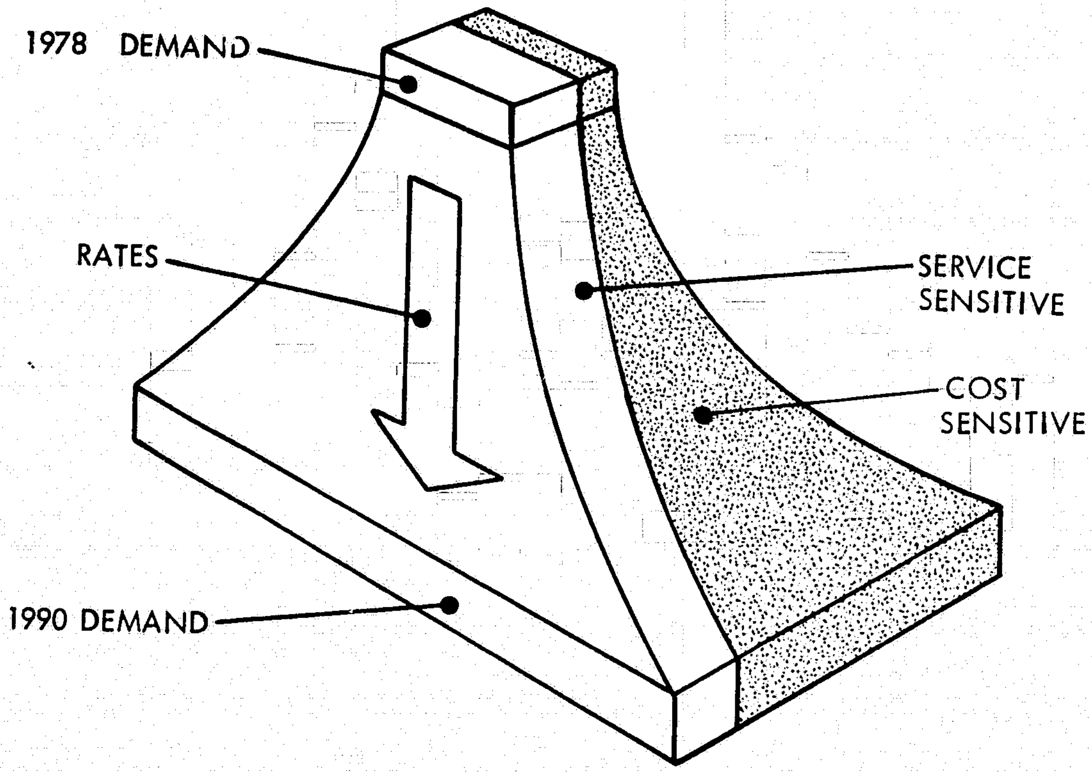


FIGURE II-17. AACS USER SENSITIVITIES TO SERVICE AND COST

CATEGORY	COMMENTS
SCHEDULES AND RELIABILITY	39
UNITIZED SERVICE	20
TRANSIT TIME	15
GEOGRAPHIC COVERAGE AND FREQUENCY	15
EQUIPMENT AND SPACE AVAILABILITY	15
LOADING/UNLOADING/TERMINAL SERVICES	15
INTERMODALITY	10
DOCUMENTATION	9
RATES	8
MISCELLANEOUS	11

FIGURE II-18. DESIRED SERVICE CHARACTERISTICS FOR ADVANCED AIR CARGO SYSTEM

CATEGORY	COMMENTS
REDUCTION IN DISTRIBUTION FUNCTIONAL COSTS	36
GREATER CENTRALIZATION OF INVENTORY	12
LITTLE OR NO CHANGE	7
INCREASED USE OR CHANGE TO AIR MODE	5
CHANGES IN MANUFACTURING	5
CHANGES IN MARKETING	5
ESTABLISHMENT OF ADDITIONAL DISTRIBUTION CENTERS	4
RELOCATION OF DISTRIBUTION ACTIVITIES	5

FIGURE II-19. AACS IMPACT ON COMPANY'S PHYSICAL DISTRIBUTION SYSTEM reduce inventory, handling, and packaging costs. In addition to changes in their distribution network, some participants indicated that, with the AACS, manufacturing schedules and locations might be changed to improve competitive positions.

Most companies had difficulty looking ahead 15 years for the purpose of identifying new market opportunities made possible by the AACS, but a few are listed in Figure II-20. In most cases, there is already some air movement of listed products for these routes - but not by the responding companies.

<u>Potential Demand for AACS</u> - In the previous subsection, we have examined reasons why companies select air freight over competing surface modes. Some of the implications of those reasons for defining system characteristics and requirements were also examined. In this section, we turn to the critical issue of "How much will the AACS be used?"

Shippers and consignees were asked to estimate their probable usage of the AACS, both for their domestic and international operations. The companies estimating No use or Emergency Use Only comprise 22 percent for North American operations and only 12 percent for operations in the rest of the world (Figure II-21). The remaining companies indicated varying degrees of Routine Use ranging from occasional to regular.

Rate Difference for 10 Percent Shipment by Air: Questions were asked of shippers/consignees and surface carriers to determine "How close to surface rates would air rates have to be for 10 percent of your freight to move by air?"

For North American traffic, Figure II-22, about 22 percent of the shippers and consignees would move 10 percent of their freight by air if rates were within 50 percent of surface modes. For carriers, about 10 percent of them would move 10 percent into the air for the same 50 percent rate difference. For traffic in the rest of the world, any given percentage of shippers/consignees or surface carriers would be willing to pay a greater rate premium for air than in North American operations. This is illustrated by Figure II-23 for shippers/consignees and Figure II-24 for surface carriers.

Rate Reduction Below Conventional Airfreight: Shippers and consignees were asked, "If rates were 45 percent less than those by conventional airfreight, what percent of your regular, routine freight would go on the AACS?" A distribution of their responses, Figure II-25, yields an average usage of 19 percent for North American operations and nearly 30 percent for the rest of the world. Similar questions were asked for zero rate reductions of 15 percent and 30 percent. When the average usage values for each rate level were plotted against the rate, curves shown in Figure II-26 resulted. For North American operations, an eight-fold increase in demand was found to exist if the AACS were available today with rates at a level 45 percent below those for conventional airfreight. For operations in the rest of the world, where air penetration of most commodities is already higher than for equivalent domestic airfreight penetration, a three-fold increase in demand

U. S. TO EUROPE, MID-EAST, ASIA

FRESH PRODUCE

FRESH MEAT

CANNED FOOD & DRINKS

U. S. TO CHINA, S. E. ASIA

PHARMACEUTICALS

WEARING APPAREL

U. S. TO FOREIGN (NOT EUROPE)

FOODSTUFFS

U. S. TO SOUTH AMERICA, EUROPE, AFRICA, MID-EAST, ASIA

APPLIANCES

ELECTRONIC COMPONENTS

LAWN & GARDEN EQUIPMENT

MOTORCYCLES & BICYCLES

RECORDS & TAPES

U. S. TO SOUTH AMERICA

MACHINERY COMPONENTS

FAR EAST TO NORTH AMERICA

CONSUMER ELECTRONICS

FIGURE II-20. NEW MARKETS FEASIBLE WITH ADVANCED AIR CARGO SYSTEM

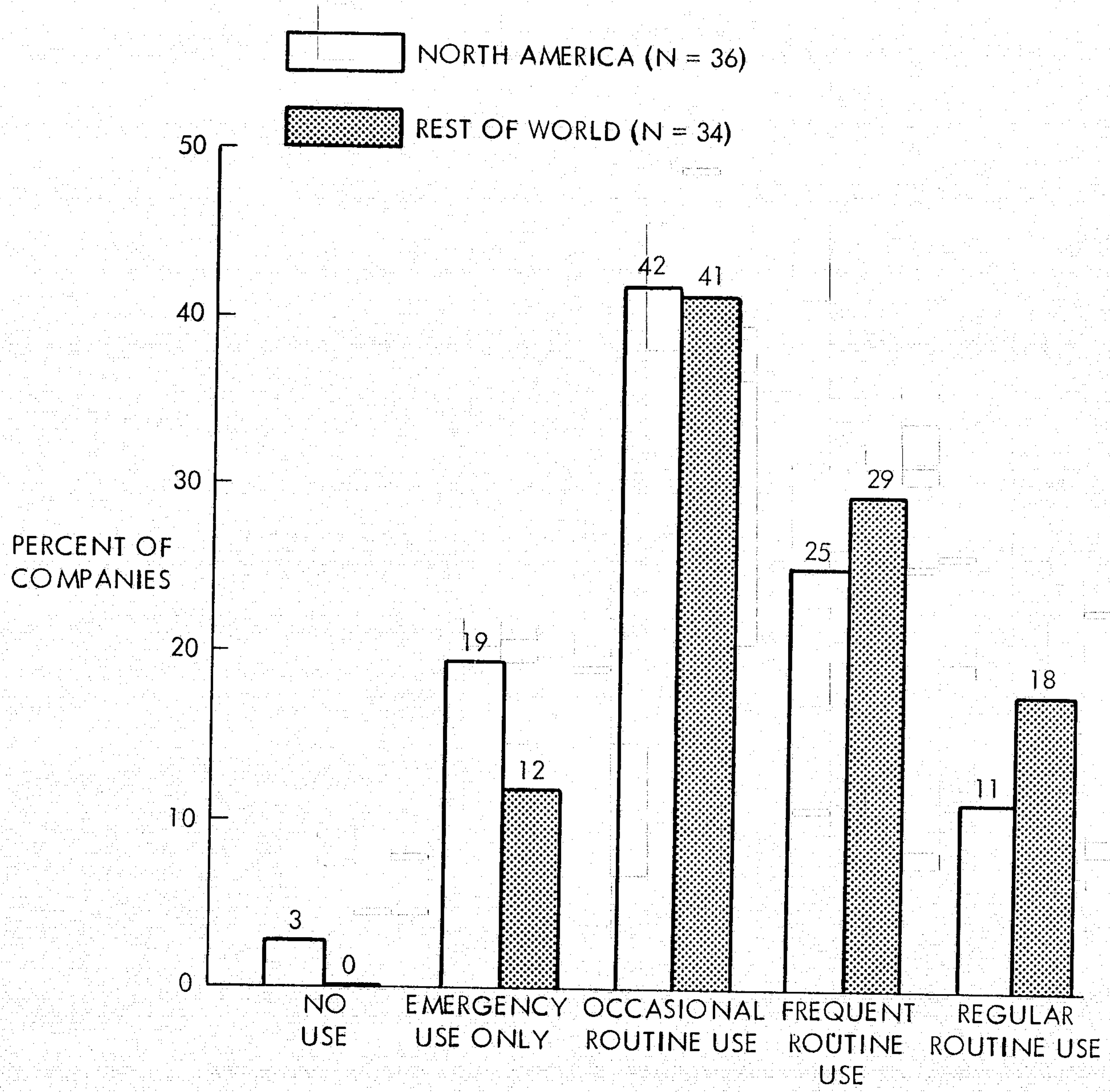


FIGURE II-21. PROBABLE USAGE OF ADVANCED AIR CARGO SYSTEM

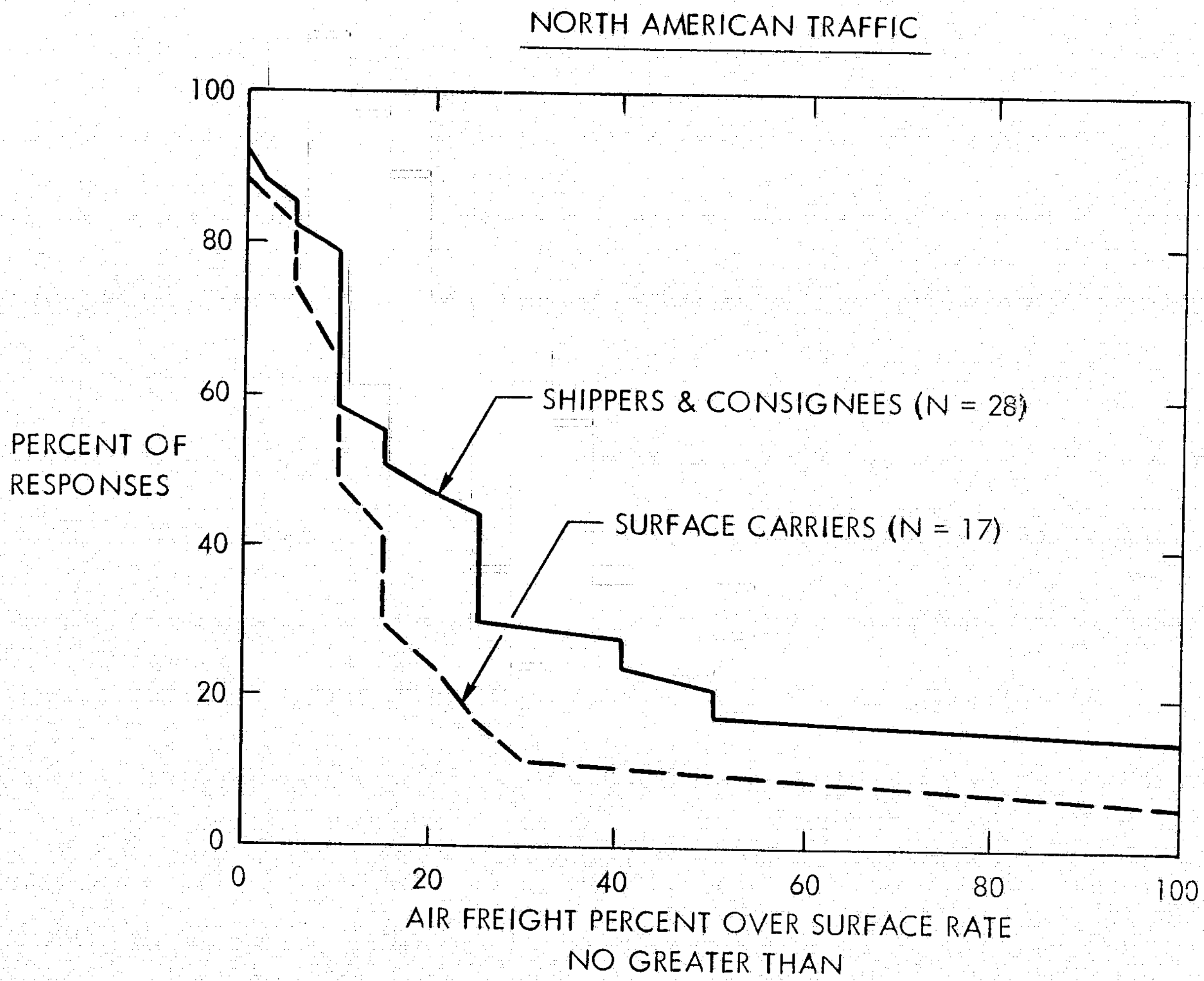


FIGURE II-22. AIR FREIGHT RATE PREMIUM BELOW WHICH 10% OF ROUTINE SURFACE FREIGHT WOULD GO BY AIR

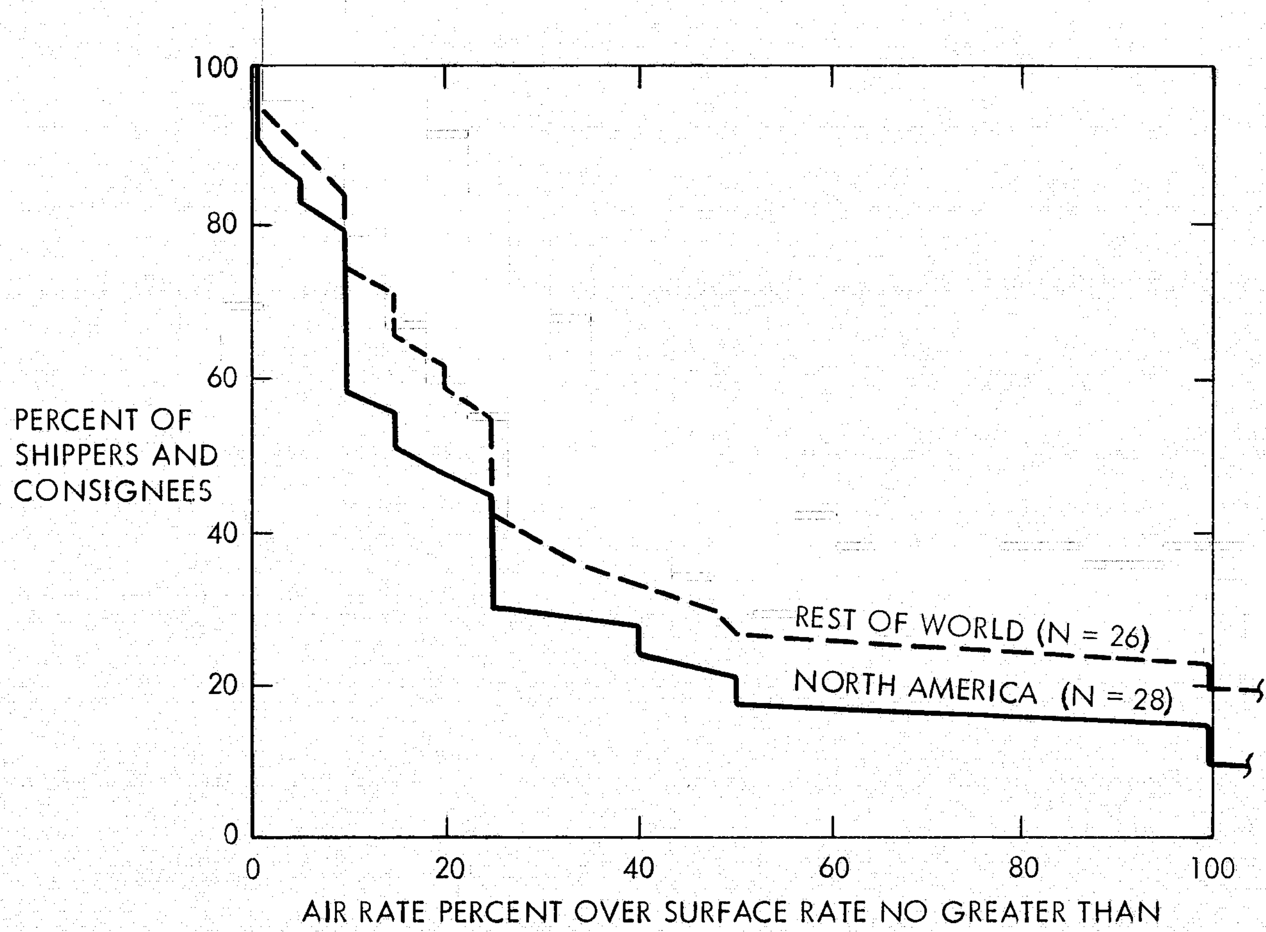


FIGURE II-23. AIR FREIGHT RATE PREMIUM BELOW WHICH 10% OF SHIPPER/ CONSIGNEE ROUTINE SURFACE FREIGHT WOULD GO BY AIR

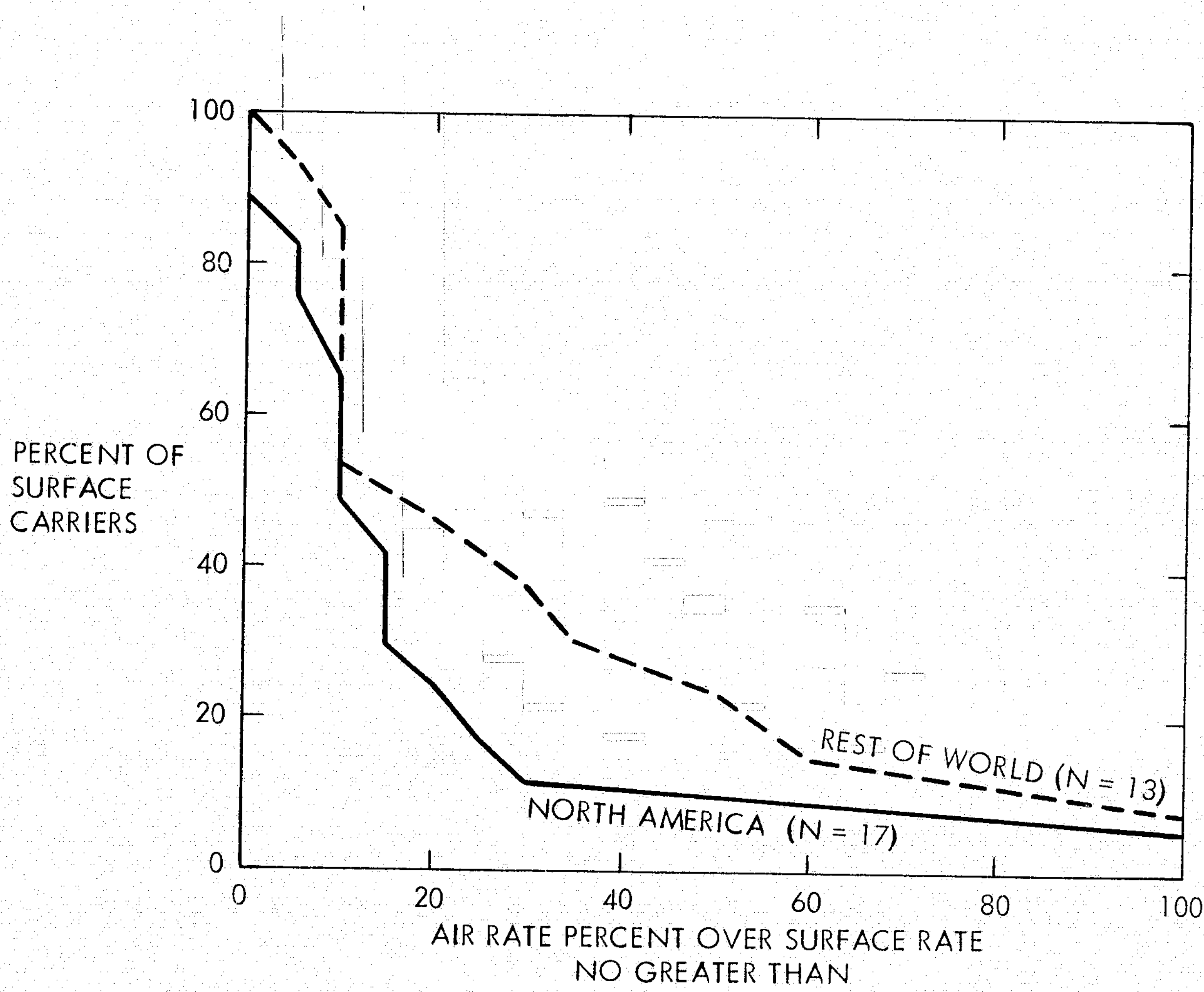


FIGURE II-24. AIR FREIGHT RATE PREMIUM BELOW WHICH 10% OF CARRIER'S ROUTINE SURFACE FREIGHT WOULD GO BY AIR

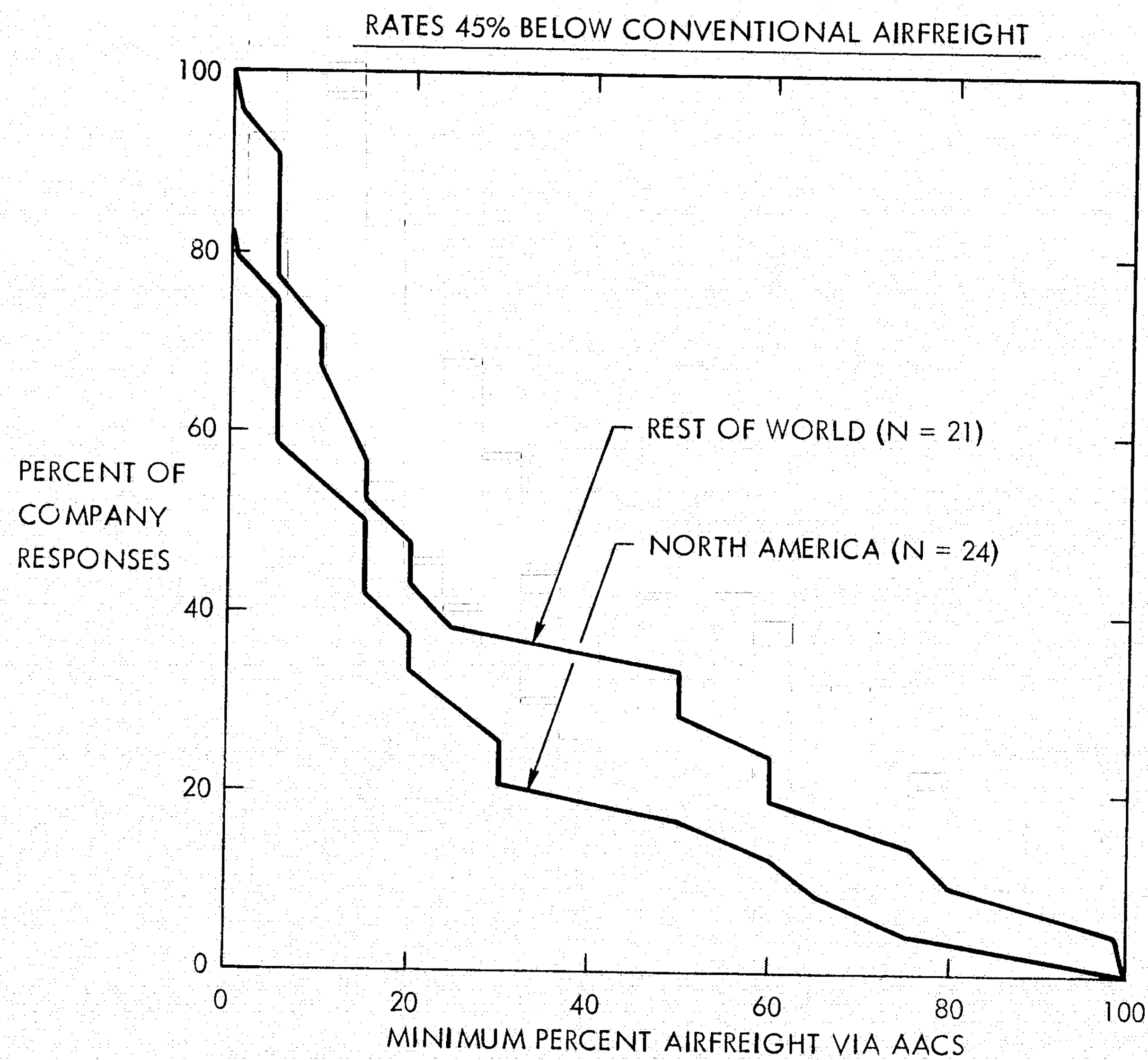


FIGURE II-25. DISTRIBUTION OF ROUTINE AACS USAGE BY COMPANY

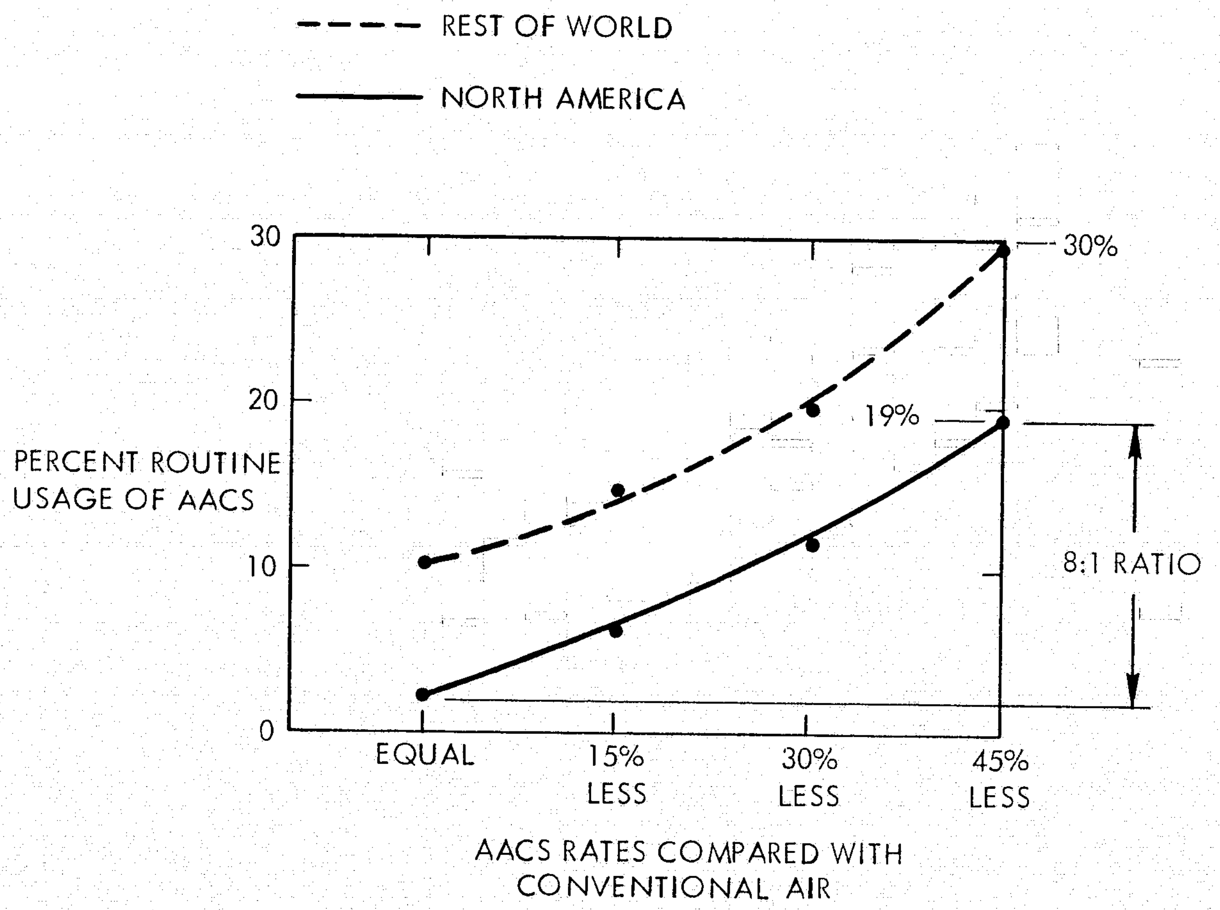


FIGURE II-26. PROBABLE ROUTINE USAGE OF ADVANCED AIR CARGO SYSTEM BY U.S. COMPANIES results from rates 45 percent below current levels. When the company responses from which Figure II-26 was constructed are weighted by the company's annual sales (Figure II-27), the demand increase for North American operations is 12 times instead of 8 as before. In subsequent application of these data on demand versus rate, the more conservative 8-fold increase is used.

AACS Demand by Manufactured Goods: Case study inputs were used to estimate the future air freight potential for the wide spectrum of manufactured products covered by the most recent 1972 Transportation Census. The approach taken for each of the nineteen 2-digit commodity groups is illustrated in Table II-1E for SIC 28, Chemicals and Allied Products. In 1972, total intercity freight movement was 172,153,000 tons (155,109,850 metric tons). Only a trace percentage (less than 0.05 percent) moved by air. Seventeen percent moved over distances greater than 800 miles (1288 kilometers). The totals for the 3-digit commodity groups show two groups, 283/Drugs and 284/Soap and other Detergents, which had measurable air penetration in 1972. Five of the case study companies manufacture products within one or more of the 3-digit commdoity groups. Their inputs and our analysis was accomplished at the 4- and 5-digit levels.

The use of three case studies relating to Code 281 indicated a potential air penetration for one percent of Transportation Commodity Code 2816, which is Inorganic Pigments. This amounts to 15,000 tons (13,515 metric tons) by air if the AACS had been available in 1972. Three case studies for Code 282 yields a potential for 15 percent air penetration of TCC 28213, Synthetic Fibers. This amounts to 304,000 tons (273,900 metric tons) or 1.2 percent of the entire Plastics Materials code. In a few cases where case study data did not cover a commodity with previously demonstrated air eligibility, the 8 fold increase ratio was applied to 1972 air penetration data. If the AACS had been available in 1972, it is estimated that it would have attracted 715,000 tons (644,215 metric tons) of Chemicals and Allied Products, a 0.4 percent penetration. A similar analysis was completed for each 2-digit commodity group, and they were summed as shown in Table II-2. In 1972, the actual air penetration amounted to only 0.06 percent. If the AACS had been operational in 1972, the air penetration would have been 0.66 percent - 11 times as high. In 1972, air tonnage for these manufactured products would have been nearly 9.7 million tons (8.7 million tons). (Further use will be made of this value in Section III, AACS Demand Forecast.) Keep in mind that this total does not include non-manufactured goods such as produce; nor does it include mail.

Motor Carrier Substitute Service Demand: Seventeen of the case study motor carriers provided data from which future demand for the AACS as a substitute service could be derived. In 1976, the 17 carriers moved over 19 million tons (17.12 million metric tons), of which 457,600 tons (411,757 metric tons) moved over distances greater than 800 miles (1288 kilometers). These carriers estimatd that 50,300 tons (45,320 metric tons) would have been diverted to the AACS if it had been operational in 1976. This is 11 percent of the long-haul freight moving more than 800 miles (1288 kilometers).

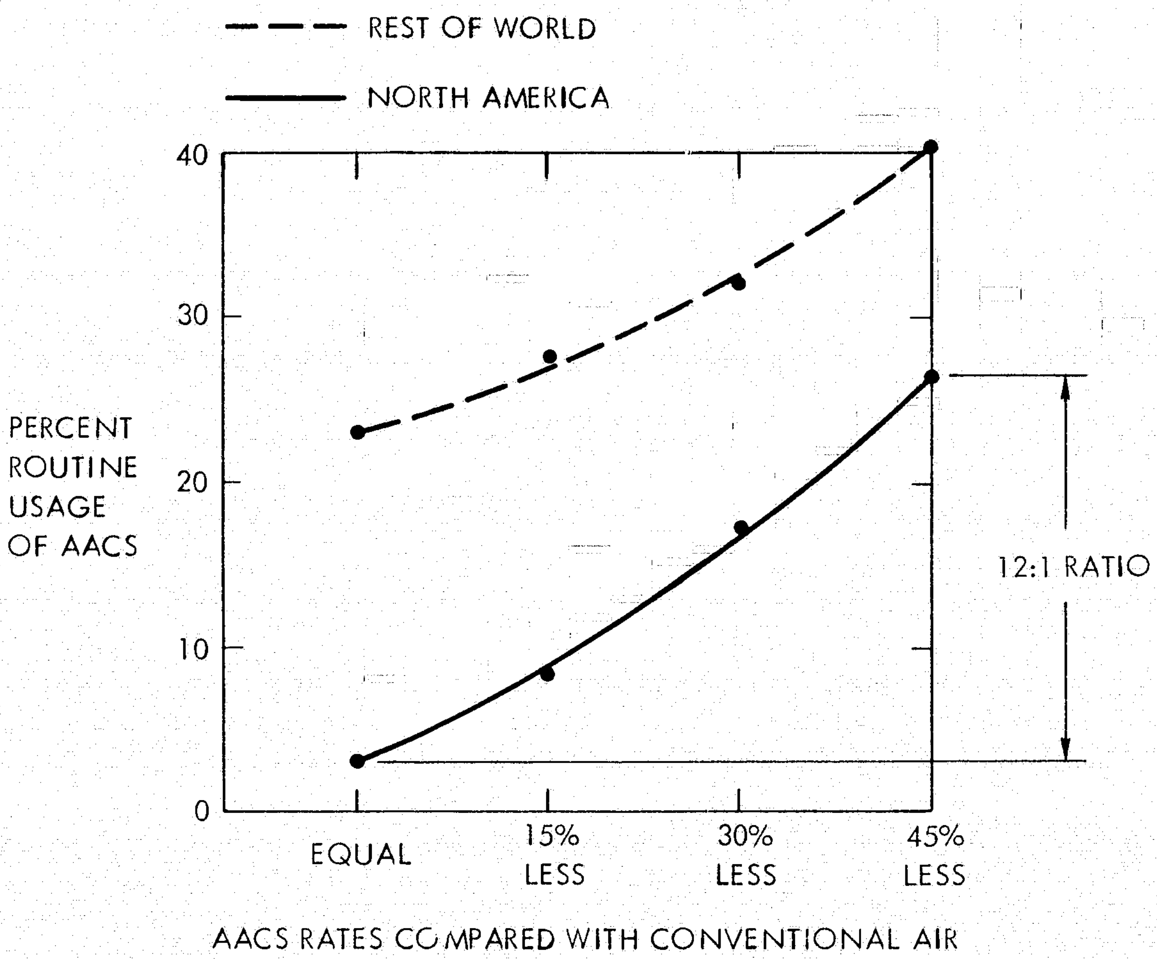


FIGURE II-27. PROBABLE ROUTINE USAGE OF ADVANCED AIR CARGO SYSTEM WITH VALUES WEIGHTED BY ANNUAL SALES

TABLE II-1E

USE OF AACS BY SIC 28, CHEMICALS & ALLIED PRODUCTS

(RATES 45% BELOW CONVENTIONAL AIRFREIGHT)

		1972 Census						AACS (1972)		
SIC/TCC Code	Commodity	Tons (000)	% Truck	% Air	% >800 Mi	Tons (000) >800 Mi	Tons (000)	% of >800 Mi	% of Total	Case Studies
28	Chemicals & Allied Products	172,153	44.8	-	17.0	29,279	715	2.4	.4	5
281	Industrial Inorganic & Organic Chemicals	79,279	37.3	-	16.1	12,764	(1) 15	.1	-	3
282	Plastics Materials	24,427	52.1	-	26.2	6,400	(2) 304	4.8	1.2	3
283	Drugs (Biological & Botanical Products)	1,491	71.7	.9	23.9	356	(3) 298	83.7	20.0	3
284	Soap and Other Detergents	11,732	77.0	.1	14.1	1,654	(4) 94	5.7	.8	1
285	Paints, Enamels, Lacquers, Shellacs, etc.	6,382	85.4	-	10.9	696	-	-	-	1
286	Gum and Wood Chemicals	896	31.0	-	20.7	185	-	-	-	-
287	Agricultural Chemicals	26,422	38.7	-	7.3	1,929	-	-	-	-
289	Misc. Chemical Products	21,524	40.6	-	24.6	5,295	(5) 4	.1	-	2

NOTES:
(1) 1% of TCC 2816
(2) 15% of TCC 28213
(3) 20% of TCC 283
(4) 8 x Conventional Air
(5) 8 x Conventional Air for TCC 2893

TABLE II-1M

USE OF AACS BY SIC 28, CHEMICALS & ALLIED PRODUCTS

(RATES 45% BELOW CONVENTIONAL AIRFREIGHT)

		1972 Census						AACS (1972)		
SIC/TCC Code	Commodity	Metric Tons (000)	% Truck	% Air	% >1288KM	Metric Tons (000) >1288KM	Metric Tons (000)	% of >1288 KM	% of Total	Case Studies
28	Chemicals & Allied Products	156,174	44.8	-	17.0	26,550	649	2.4	.4	5
281	Industrial Inorganic & Organic Chemicals	71,920	37.3	-	16.1	11,579	(1) 14	.1	-	3
282	Plastics Materials	22,160	52.1	-	26.2	5,806	(2) 276	4.8	1.2	3
283	Drugs (Biological & Botanical Products)	1,353	71.7	.9	23.9	323	(3) 270	83.7	20.0	3
284	Soap and Other Detergents	10,643	77.0	.1	14.1	1,501	(4) 85	5.7	.8	1
285	Paints, Enamels, Lacquers, Shellacs, etc.	5,790	85.4	-	10.9	631	-	-	-	1
286	Gum and Wood Chemicals	813	31.0	-	20.7	168	-	-	-	-
287	Agricultural Chemicals	23,970	38.7	-	7.3	1,750	-	-	-	-
289	Misc. Chemical Products	19,527	40.6	-	24.6	4,803	(5) 4	.1	-	2

NOTES:
(1) 1% of TCC 2816
(2) 15% of TCC 28213
(3) 20% of TCC 283
(4) 8 x Conventional Air
(5) 8 x Conventional Air for TCC 2893

TABLE II-2E

USE OF AACS BY MANUFACTURED PRODUCTS

(RATES 45% BELOW CONVENTIONAL AIRFREIGHT)

SIC/TCC Code	Commodity	1972 Census Tons (000)	% Truck	% Air	% > 800 Mi	AACS (1972) Tons (000)	% of Total	% of Tot > 800 Mi
20	Food & Kindred Products	252,165	58.9	-	12.5	2,409	.1	7.6
21	Tobacco Products	1,515	55.0	-	21.9	1	-	.3
22	Textile Mill Products	14,948	90.8	.2	14.9	258	1.7	11.5
23	Apparel & Other Finished Text. Prod.	5,485	83.7	1.9	19.9	343	6.3	31.6
24	Lumber & Wood Prod, exc. Furniture	83,289	53.7	-	22.8	0	-	-
25	Furniture and Fixtures	9,724	78.4	-	18.3	22	.2	1.2
26	Pulp, Paper, & Allied Products	87,272	45.6	-	15.7	0	-	-
28	Chemicals & Allied Products	172,153	44.8	-	17.0	715	.4	2.4
29	Petroleum & Coal Products	344,422	24.4	-	30.6	0	-	-
30	Rubber & Misc. Plastics Products	17,156	75.5	.7	19.8	370	2.2	10.9
31	Leather & Leather Products	1,234	92.9	.3	17.7	45	3.6	22.2
32	Stone, Clay, Glass, Concrete Prod.	168,384	71.3	-	4.9	6	-	.1
33	Primary Metal Products	158,455	53.5	-	8.8	230	.1	1.7
34	Fabricated Metal Prod, exc. Ordn	39,536	73.3	.2	13.5	730	1.8	13.6
35	Machinery, exc. Electrical	21,822	77.1	.7	25.1	1,122	5.1	20.6
36	Electrical Mach., Equip., Supplies	14,844	66.9	1.4	23.7	950	6.4	26.9
37	Transportation Equipment	61,595	45.3	.2	21.6	2,023	3.3	15.1
38	Instrum., Photo & Medical Goods	1,432	72.5	2.3	34.1	252	17.6	53.7
39	Misc Products of Manufacturing	4,462	71.0	.9	29.6	195	4.4	15.4
	Totals	1,459,893	49.8	.06	17.8	9,671	.66	

TABLE II-2M

USE OF AACS BY MANUFACTURED PRODUCTS

(RATES 45% BELOW CONVENTIONAL AIRFREIGHT)

		1972 Census				AACS (1972)		
SIC/TCC Code	Commodity	Metric Tons (000)	% Truck	% Air	% > 1288 KM	Metric Tons (000)	% of Total	% of Total >1288 KM
20	Food & Kindred Products	228,760	58.9	-	12.5	2,185	.1	7.6
21	Tobacco Products	1,374	55.0	-	21.9	1	-	.3
22	Textile Mill Products	13,560	90.8	.2	14.9	234	1.7	11.5
23	Apparel & Other Finished Text. Prod.	4,976	83.7	1.9	19.9	311	6.3	31.6
24	Lumber & Wood Prod, exc. Furniture	75,559	53.7	-	22.8	0	-	-
25	Furniture and Fixtures	8,822	78.4	-	18.3	20	.2	1.2
26	Pulp, Paper, & Allied Products	79,172	45.6	-	15.7	0	-	-
28	Chemicals & Allied Products	156,175	44.8	-	17.0	649	.4	2.4
29	Petroleum & Coal Products	312,454	24.4	-	30.6	0	-	-
30	Rubber & Misc. Plastics Products	15,564	75.5	.7	19.8	336	2.2	10.9
31	Leather & Leather Products	1,119	92.9	.3	17.7	41	3.6	22.2
32	Stone, Clay, Glass, Concrete Prod.	152,755	71.3	-	4.9	5	-	.1
33	Primary Metal Products	143,747	53.5	-	8.8	209	.1	1.7
34	Fabricated Metal Prod, exc. Ordn	35,866	73.3	.2	13.5	662	1.8	13.6
35	Machinery, exc. Electrical	19,797	77.1	.7	25.1	1,018	5.1	20.6
36	Electrical Mach., Equip., Supplies	13,466	66.9	1.4	23.7	862	6.4	26.9
37	Transportation Equipment	55,878	45.3	.2	21.6	1,835	3.3	15.1
38	Instrum., Photo & Medical Goods	1,299	72.5	2.3	34.1	228	7.6	53.7
39	Misc Products of Manufacturing	4,048	71.0	.9	29.6	177	4.4	15.4
	Totals	1,324,393	49.8	.06	17.8	8,773	.66	

There are about 16,000 ICC-Regulated Intercity Carrers, and they moved 780 million tons (703 million metric tons) in 1976, 32 million tons (28.8 million metric tons) of which moved farther than 800 miles (1288 kilometers). Although the 17 case study carriers represent only 0.1 percent of the total number, their long-haul tonnage is 1.4 percent of the grand total long-haul tonnage. When the 11 percent substitute service factor is applied to the 32 million tons (28.8 million metric tons), the demand potential for AACS subsitute service (in 1976) would have been 3.5 million tons (3.15 million metric tons).

For extrapolation from 1976 to 1990, a modest growth rate of 3.6 percent per year was taken from Department of Transportation forecasts. The resulting 1990 AACS potential is over 5.7 million tons (5.14 million metric tons) for air haul of motor carrier freight. It is important to note that this total does not include any analysis of the potential from private motor carriers that represent 50 percent of the total integrity ton-miles.

Ocean Carrier Substitute Service Demand: Combined tonnage of the two case study ocean carriers in 1976 was 17,400,000 (15,677,400 metric tons). They each analyzed the overall growth and air service potential for each of their major routes. Based on that analysis, which covered over 50 percent of their total traffic, they estimated a growth rate to 1990 of 4.5 percent per year which will lead to a total tonnage of over 32 million (28.8 million metric tons) in 1990. They also expect to use the AACS for 5.6 percent of that tonnage or 1,800,000 tons. When the 5.6 percent AACS penetration potential is applied to the 1990 forecast for free-world containership trade of 78 million tons, the resulting potential demand for AACS is 4,400,000 tons (3,964,400 metric tons).

Timing of Need: Previous sections indicate that potential demand for a 1990 AACS is expected to be many times greater than current levels of airfreight usage. When asked to indicate the time by which they would need the AACS in operation, companies responded as shown in Figure II-28. Over one-fifth of the companies stated an immediate need; one-half will need the AACS by 1985; and over four-fifths will need it by 1990.

International Case Studies

Until recent years, the U.S. domestic use of air cargo was far greater than the use of air cargo in overseas markets. Although U.S. market demand continues to increase, the growth rate in many international air cargo markets in much higher. To reflect the needs of foreign-based companies for an AACS, industry case studies were conducted in Europe and in Japan. The companies which participated are listed below. Their consolidated services and products are listed in Figure II-29.

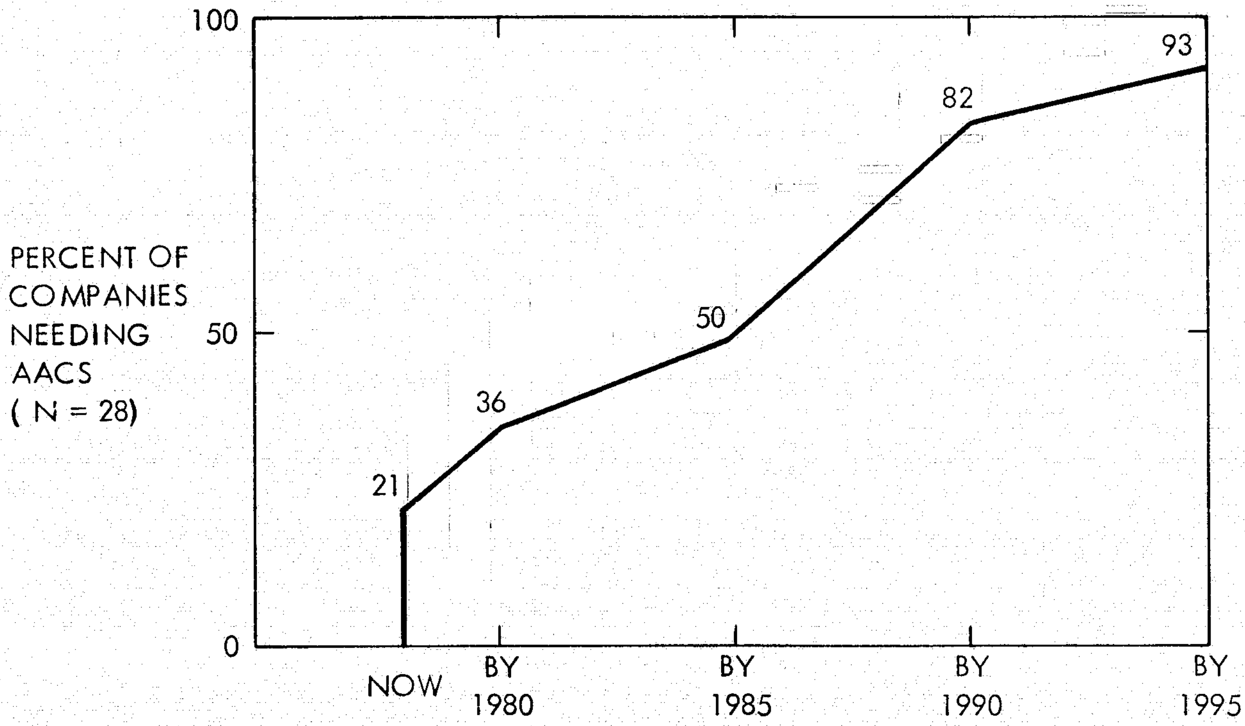


FIGURE II-28. TIMING OF NEED FOR AACS

SERVICES

AIR CARRIER

FREIGHT FORWARDER

TRADING COMPANY

PRODUCTS

AIRCRAFT ENGINES

COMPUTERS

ELECTRONIC COMPONENTS

HOUSEHOLD APPLIANCES
- KITCHEN EQUIPMENT
- LAUNDRY EQUIPMENT
- RADIO & TELEVISION
- RECORDERS

INDUSTRIAL INSTRUMENTATION

LIGHTING EQUIPMENT

MARINE FOOD PRODUCTS

MOTOR VEHICLES

MOTOR VEHICLE PARTS

OFFICE MACHINES
- CALCULATORS
- COPIERS

OPTICAL PRODUCTS

PHOTOGRAPHIC EQUIPMENT

TELECOMMUNICATIONS EQUIPMENT

FIGURE II-29. SERVICES AND PRODUCTS OF FOREIGN CASE STUDY FIRMS

Europe	Japan
British Airways	Canon, Inc.
CFM International	Fujitsu Limited
EMI Limited	C. Itoh & Co., Ltd.
Philips	Japan Air Lines
Plessey Co., Ltd.	Matsushita Electrical Ind. Co., Ltd.
Regie Renault	Nissan Motor Co., Ltd.
Thompson - CSF	Sharp Corporation
Thorne Electrical	Sony Corporation
	Tohto Suisan K.K.

The approach followed for the international case studies was similar to that described earlier for those conducted in the United States. The 1990 Transportation Scenario and AACS Concept were provided for familiarization and to serve as a baseline for common understanding of system capabilities. Written question and answer booklets were used. At least one interview of 2 to 4-hour duration was held with officials of each company. The major results from Europe and Japan were quite similar in terms of the companies' projected usage of an AACS and their reasons for needing and selecting airfreight over surface modes. Japan's airfreight needs are rising more rapidly than those of Europe, and by 1990, Japan will be the terminus for the two highest of the top 10 international trade routes.

European Case-Study Companies - Brief profiles of the European case study companies are given in the following paragraphs.

British Airways is the largest passenger and air cargo carrier in Britain. Its total share of the export and import tonnage for those carriers serving British Isles is 10 percent.

CFM International, S.A. is a jointly owned company formed by the General Electric Company and SNECMA of France for the development of the CFM56 turbofan engine. SNECMA is one of the largest producers of jet engines in Europe.

EMI Limited is one of the largest producers of electrical and electronic components in Great Britian. They produce a full line of medical equipment including the new x-ray machine which produces cross-sectional views of the human body.

Philips, Eindhoven, Holland, is the G.E. of Europe. They produce a full line of electrical appliances, radios, TV's, refrigerators, razors, and similar items. Their U.S. subsidiary is known as Norelco.

The Plessey Company Limited of Ilford Essex, England, specializes in electronics, telecommunications equipment, and navigational equipment. Their major markets are in the Middle East, Africa, South Africa and Brazil.

Regie Renault is one of France's largest automobile manufactures with assembly plants world-wide, primarily in Africa (Ivory Coast), South Africa, and South America.

Thompson-CSF is one of France's largest producers of telecommunications and air navigational equipment. Most of their equipment is outsized and is very difficult to ship by air without disassembling completely. There are some cases where the 747 can accommodate their equipment. Their major export markets are the Middle East, Africa, South America, and the Far East.

Thorne Electrical of Middlesex, England, is a major manufacturer of electronic components and electrical appliances. Their major export markets are the Middle and Far East.

The general attitude of all companies with whom Lockheed had discussions was one of great interest and need for the type of integrated surface/air system concept described in the CLASS Advanced Air Cargo System (AACS). There seems to be a much greater emphasis on the need for an AACS in Europe because of their export markets and the great distances that their export goods have to travel. There are major problems with ocean shipping at present, and most companies see those problems increasing in the future. The problems in general are as follows:

- Transit times increasing
- Lost time due to transfer of cargo at port of embarkation
- Lost time in transfer of cargo at ports of debarkation
- Lack of port facilities to handle ships
- High surcharge at ports of debarkation (airport-to-airport cheaper)
- Lack of coordination and documentation between land and sea modes
- High losses on shipments that are not containerized at shippers dock

The idea of an integrated surface-to-air-to-surface mode was of the upmost interest to the companies because all considered containerization a "must." Their usage of marine containers for shipment was approximately 100 percent, except for those items considered outsized, i.e., radar dishes and some telecommunications equipment. Most expressed a need for containers that are 9 feet (2.7 meters) or more high and 20 and 40 foot (6.1 and 12.2 meters) long. Most companies export full container loads and load at their facilities.

Airfreight Demand Stimulation With AACS - As indicated by the U.S. case studies earlier in this section, shippers and consignees are willing to pay the higher airfreight rate for international export of their products because of the long distance traveled and time to reach the market place. This is true to even a greater extent in Europe. All of the companies contacted indicated that they already move 10 to 20 percent of their exports by air at today's airfreight rates with 25 to 30 percent of these shipments being carried by charter flights.

When asked the question, "If rates were 45 percent less than those by conventional airfreight, what percentage of your regular, routine freight would go by the AACS?" A distribution of company responses yields an average usage of 70 percent for world-wide exports. This correlates with the U.S. export data shown in Figure II-26. Similar questions were asked for zero rate and reductions of 15 percent and 30 percent. When the average percent usage values for each rate level were plotted against the rate, the curve shown in Figure II-30 resulted. For European international operations, a seven-fold increase in demand was found to exist if the AACS were available with rates at a level 45 percent below those for today's conventional airfreight.

Estimated future growth through 1990 varied by company from 6 to 15 percent for their export markets. Service and rates were rated essentially equal in importance and inventory reduction, transit time, and loss and damage were also rated as equally important. The detailed company information on annual tons exported, modal split, projections of future use of the AACS in specific market areas, and the companies share of the market in these areas were considered to be proprietary. Therefore, these specific data by company are not included in this report.

Japanese Case Study Companies - Brief profiles of the Japanese case study companies are presented in the following paragraphs.

Canon, Inc. produces photographic equipment, business machines, medical and industrial optical products, micron-related products, laser-related products, and electronic components. Canon has three major plants in Tokyo area, one in Ibaragi, and one in Fukishima. There are six other manufacturing subsidiaries in Japan. Overseas factories are located in Taiwan, West Germany, Australia, and California. Total sales for 1976 were 151 billion yen or about \$685 million (@ 220 = \$1). Export sales were 60 percent of the total.

Fujitsu Limited produces a full range of computer systems and holds the largest share of the domestic computer market, the second largest computer market in the world. Fujitsu is also an important producer of telecommunications equipment and systems, semiconductor devices, and electronic components. Total company sales last year were approximately 600 billion yen or \$2.7 billion.

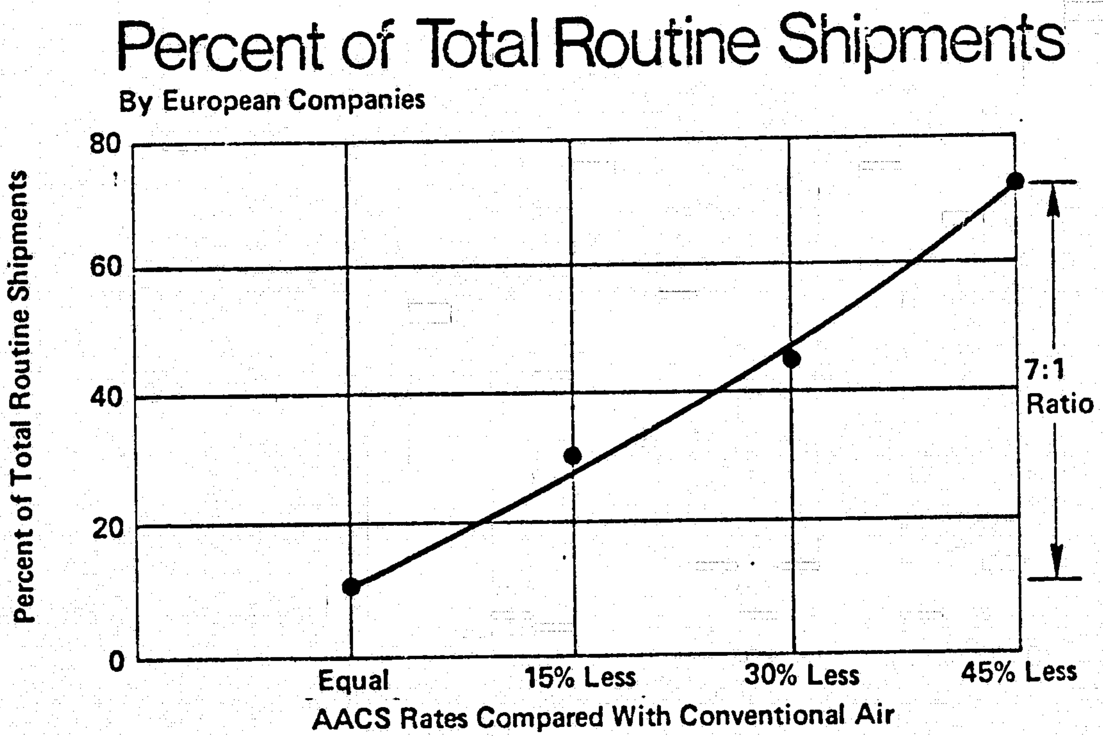


FIGURE 30. AACS RATES COMPARED WITH CONVENTIONAL AIR

C. Itoh & Co., Ltd. is the third largest general trading company in Japan. The top 10 trading companies, either through their subsidiaries or other firms which they represent, account for over 50 percent of all Japanese exports and a similar portion of total imports. Thus, they are an excellent source for trade and transportation statistics.

Japan Air Lines is the number one Japanese air carrier with both domestic and world-wide international routes. Its share of total export and import tonnage for all carriers serving Japan is approximately one-third. In the trans-Pacific market, the share is over 40 percent.

Matsushita Electric markets its products in more than 130 countries under brand names which include "National," "Pansonic," "Technics," and "Quasar." It is Japan's largest producer of electrical and electronic products for consumer use and is also prominent in production of refrigerators, air conditioners, cooking equipment and other home appliances, communications and industrial equipment lighting, batteries, and many other lines. Overseas manufacturing operations are located in 29 places in 21 different countries. Total FY 1977 sales were 1,892 billion yen or $8.6 billion. Exports from Japan, including sale of parts to overseas factories, was over 25 percent of total sales.

Nissan Motor Company produces and exports the Datsun automobile. In FY 1976, Nissan sold about 1,100,000 passenger cars and trucks in the domestic market; a similar quantity was sold abroad. Total sales were 2,025 billion yen or $9.2 billion. Assembly operations are located in 21 different countries.

Sharp Corporation manufacturers a wide range of electrical and electronic products for home, business, and industry. Separate division in Japan produce television systems, audio systems, home appliances, microwave ovens, industrial instruments, semiconductors, and electronic components. Production and assembly operations are carried out in 37 locations in 33 countries. Total sales for 1976 were 285 billion yen or $1.3 billion.

Sony Corporation is a leading manufacturer of electrical and electronic equipment with total sales in 1977 of 506 billion yen or $2.3 billion. Overseas sales accounted for over 60 percent of the total sales value. Sony was the first Japanese firm to start production of TV sets in the United States. At its plant in San Diego, California, production reached 400,000 sets in 1976.

Tohto Suisan is one of the five wholesalers of fresh and processed marine products authorized by the Minister of Agriculture and Forestry to conduct transactions at the Tokyo Metropolitan Central Wholesale Market. In FY 1976, its transactions totaled 141 billion yen or $641 million.

Japanese World Trade Factors - The following discussion is based only in part on case study responses and to a much greater extent on macro-level data collected while the case studies were in progress. It is intended only as a means of conveying some general impressions which have overtones for future Japanese trade with other nations. No attempt is made to identify and explore all pertinent issues.

The People and The Land: The Japanese population of 115 million, over half that of the United States, live within an area equal to that of Montana. The resulting average population density is over 300 per square kilometer (800 per square mile). Because of the mountainous regions inland, the density along coastal areas is much higher. The Japanese people strive for harmony in personal and business relationships but are highly disciplined and motivated to achieve difficult objectives. Japan is a long distance from all other major trade centers and, being an island nation, is accessible only by sea and air. Natural resources are very limited. To pay for required resource imports, Japan has developed an industry structure which emphasizes the export of education with a broad range of high-technology, high-value-added products. For example, Japan is the only free-world country outside the U.S. which supplies more of its own computers than does the U.S., Figure II-31.

Yen Quotation Vs. The Dollar: Figure II-32 shows the way the Japanese press reports appreciation of the yen vs the dollar. In 1976, the exchange rate was close to 300 yen per dollar all year, but it started a dramatic change in 1977 which has made the yen worth 35 percent more in dollars than it was 18 months ago. This is creating a problem for exporters who must now demand higher prices in dollars to obtain the same number of yen. Some importers, on the other hand, may recap unusually large profits. The long-term effects of this situation are not yet clear.

Japanese Export Trade: The Japanese are very sophisticated world traders, as indicated in Figure II-33 by their world-wide distribution of automobiles. Even though Japanese export growth was slowed by OPEC oil price increases and the resulting world economic shock, exports to all major world regions still doubled in the past 5-year period, Figure II-34. Rapid export growth has led to import trade barriers in the U.S. and European countries. In 1976, for example, Japan exported more color TV sets to the U.S. than its total exports during the previous year. Resulting U.S. trade pressures led Japan to agree to limit annual exports to the U.S. to 1,750,000 sets. Of course, protectionism is a two-way street. In Japan, there is strong resistance to importing beef and citrus fruit from the U.S. As an answer to protectionist pressures from U.S. and European management, labor, and government groups - overseas production capabilities are rapidly being acquired. Figure II-35 indicates U.S. locations and plans of Japanese production facilities for TV sets and motor vehicles. No longer will the world see so many products marked MADE IN JAPAN because the same products will be made right here in the U.S. and other countries.

What will this mean to the future use of air freight by Japanese exporters? Here is the answer of one case study company; it was also expressed in similar ways by several others: "Our use of air freight should increase significantly as overseas facilities are installed in order to keep them supplied with components and assemblies."

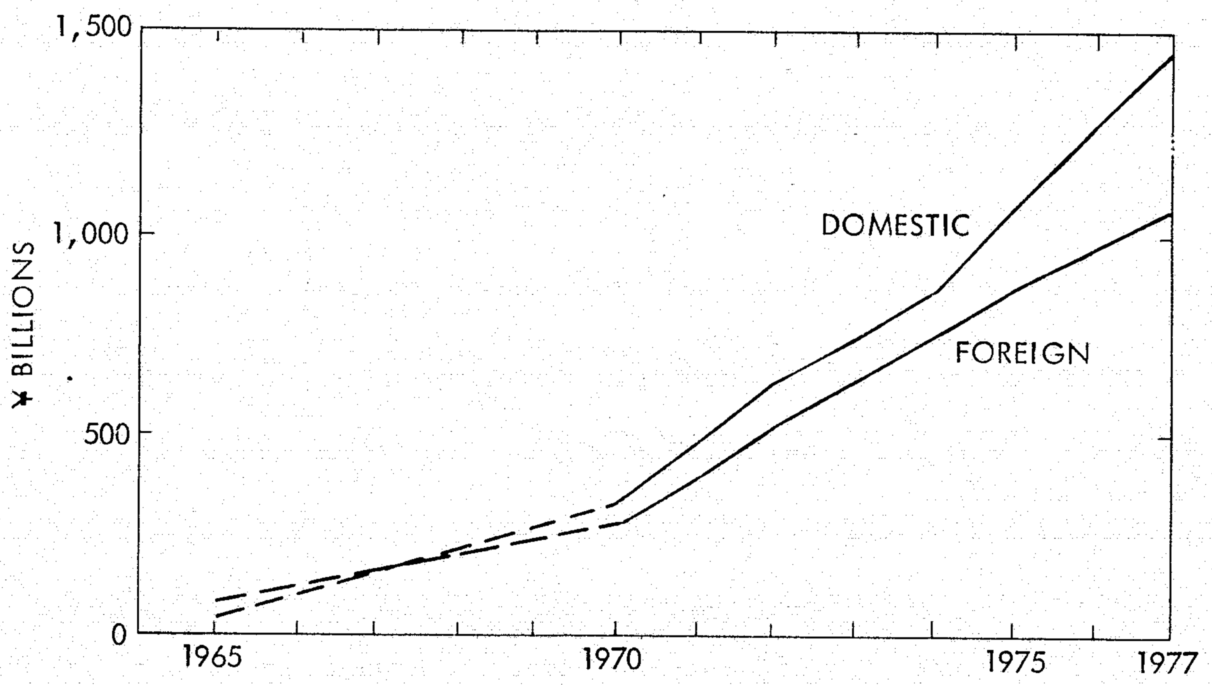


FIGURE II-31. ALL-PURPOSE COMPUTERS IN JAPAN

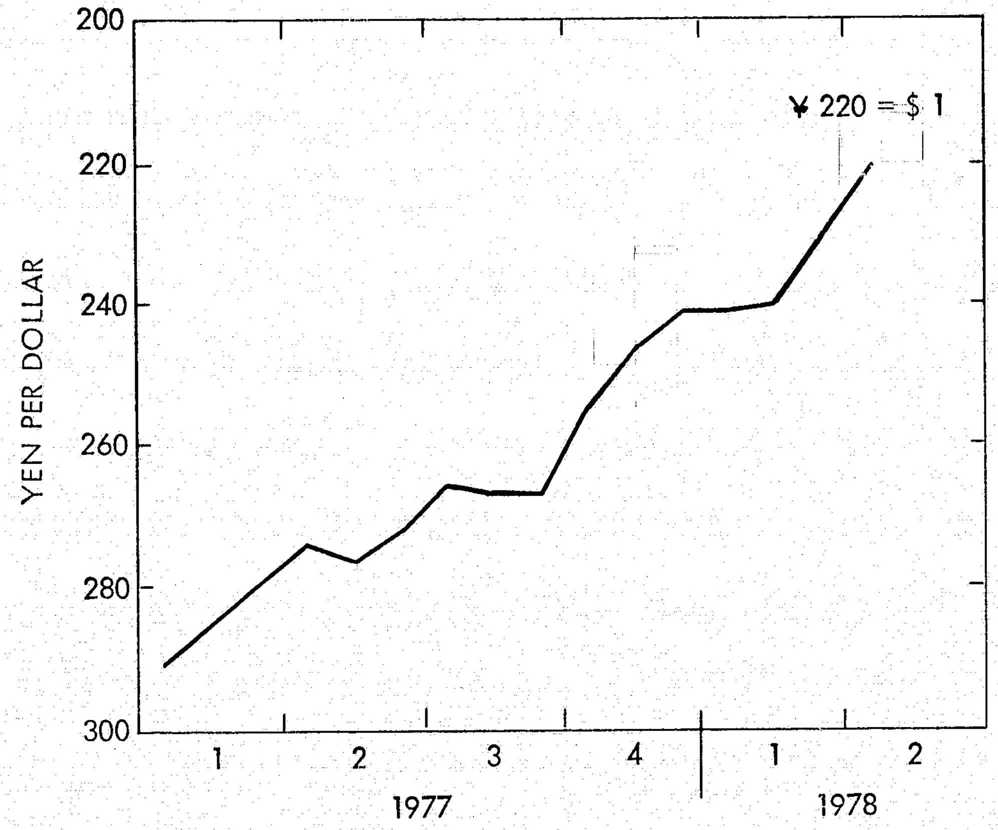


FIGURE II-32. YEN QUOTATION VS. THE DOLLAR

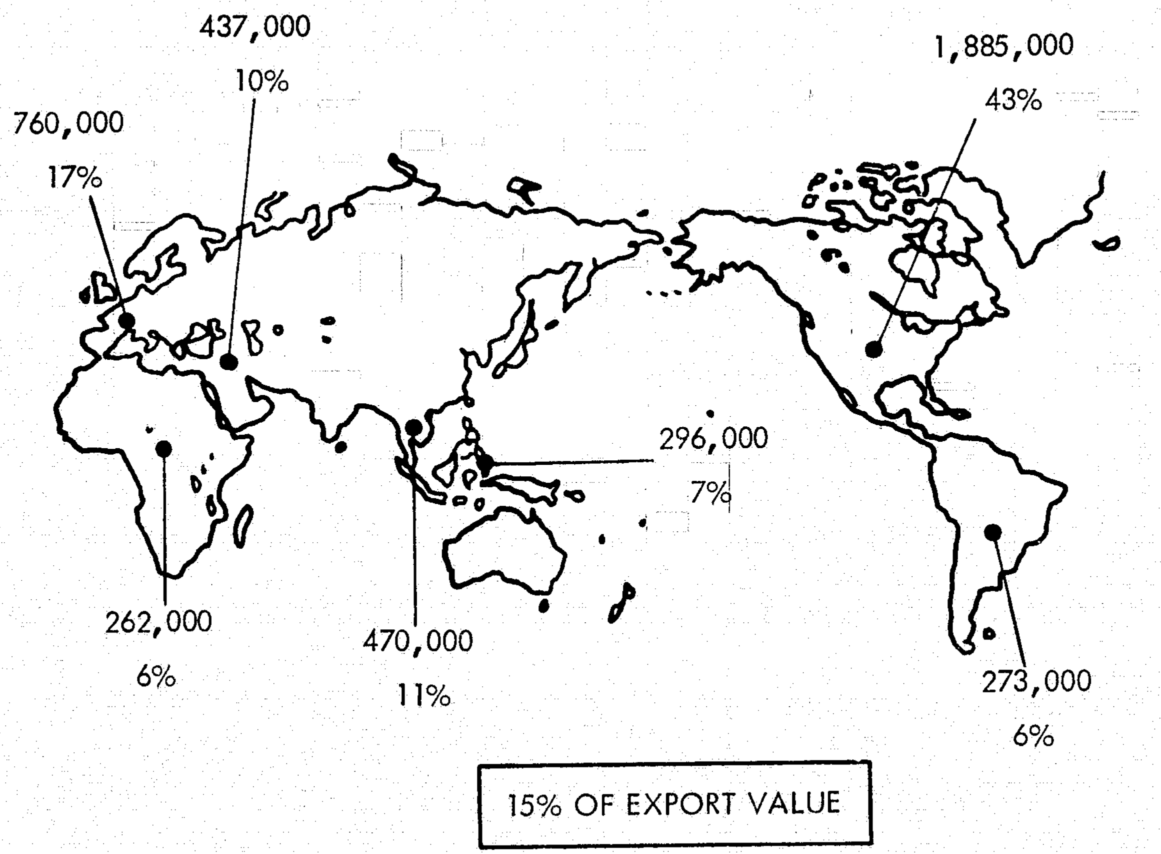


FIGURE II-33. JAPANESE AUTO EXPORTS BY REGION

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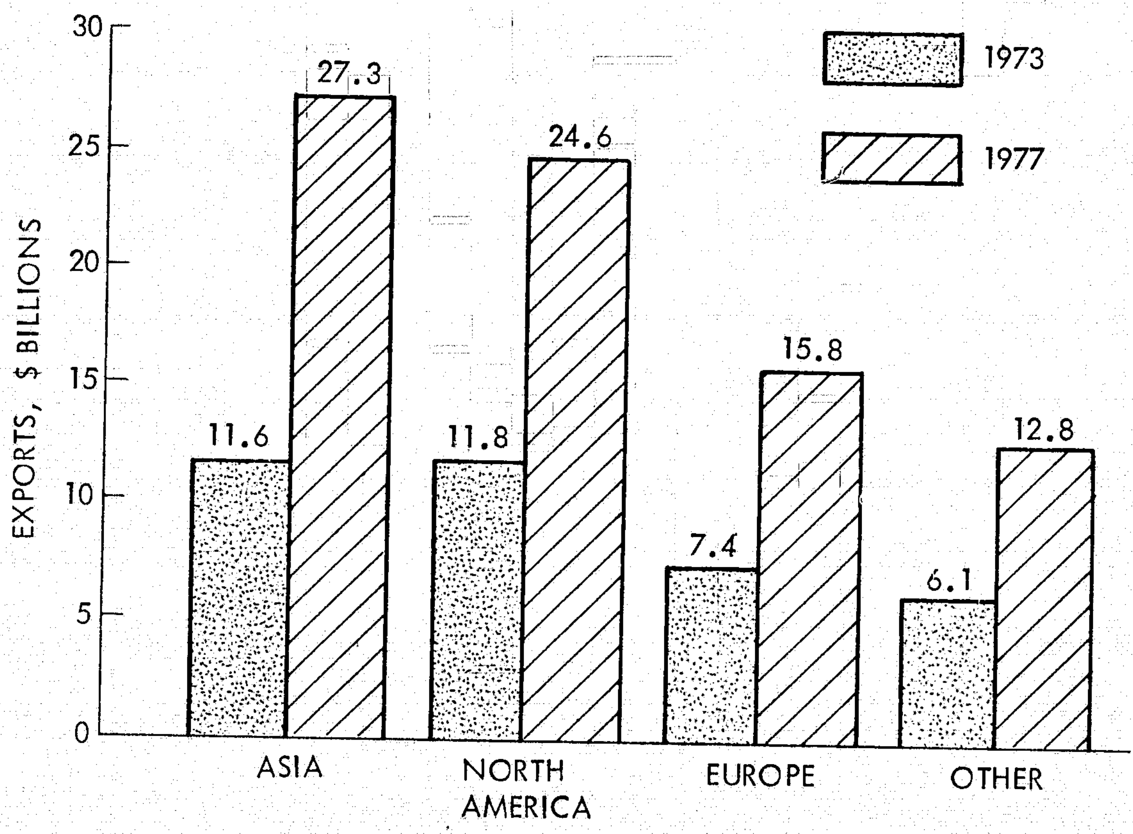


FIGURE II-34. JAPAN EXPORT GROWTH 1973 - 1977

TELEVISION SETS

SONY	SAN DIEGO (1972); 400,000 IN 1976
MATSUSHITA	MOTOROLA/ILLINOIS (1974); 500,000 IN 1976
SANYO	ARKANSAS (1976) FOR SEARS, ROEBUCK & CO.
HITACHI	PORTSMOUTH, VA. (1978) WITH G.E.; WILL PRODUCE 1 MILLION SETS PER YEAR
TOSHIBA	NASHVILLE (1978)
MITSUBISHI	CALIFORNIA (1978)

MOTOR VEHICLES

HONDA	MOTORCYCLES IN OHIO; STUDYING MOTORBUS
TOYOTA	PLANS IN WORK BUT NOT ANNOUNCED
NISSAN	

FIGURE II-35. JAPANESE PRODUCTION IN U. S. A.

Trade with China: Mitsubishi, the largest of Japan's general trading companies and sometimes referred to as Japan, Inc., has recently concluded an agreement with the Chinese government which involves long-term technological cooperation and exchange of hardware and software in technologically advanced areas such as atomic power, aircraft, and chemical facilities. It may be too early to estimate the possible impact of this landmark agreement on the future of Sino-Japanese trade. Nevertheless, it is an area which bears watching and which is being watched carefully by many Japanese companies.

Airfreight Selection Factors - A number of factors were identified by Japanese case study companies as being influential in their selection of the airfreight mode - both now and increasingly in the future. Just as in the U.S., there are trade-offs to be made between freight rate and transit time. Relative time and cost comparisons are shown here for freight shipments from Japan to Europe.

	Days	Relative Cost
Siberian Rail Landbridge	45	70
Containership	30 - 45	100
Sea and Air	15	300
Air Charter	2	500
Air with Hong Kong Transfer	3	600
IATA Carriers	2	800

The baseline for cost comparison is 100 for containership. Since there is about 8:1 ratio between IATA carrier rates and containership rates, it is easy to see why the Japanese user of air freight is attracted by the prospect of substantial rate reductions.

One of the most important features of the AACS to Japanese shippers and consignees is its door-to-door intermodal capability. At present, marine containers can travel freely between dockside and shipper/consignee facilities - but not air containers. Air containers are treated the same as the cargo they contain. If they leave the air cargo terminal, they must go through customs and are subject to import duties. Additional air container handling and cargo transfer causes unacceptable time delays for some perishables and increases the potential for damage and theft of sensitive, high-value products.

The major export markets for Japanese products are in North America and Europe. In the face of rising protectionism, efforts to develop other trade areas will be stepped up. In these developing areas, the use of air freight to minimize inventory is important because of limited warehousing and high capital costs. At present, port facilities in developing areas are congested, have excessive delay times, and prohibitive demurrage costs. In the future, product lines will be continually restructured to upgrade technological quality and value added.

Companies which have never used overseas component vendors and now being attracted by high-quality, low-cost components available in Korea, Taiwan, Hong Kong, and other locations. This will increase air freight for imports.

Another major factor in the coming year is the prospect of significant trade flow with mainland China. Just recently, this prospect has become much stronger.

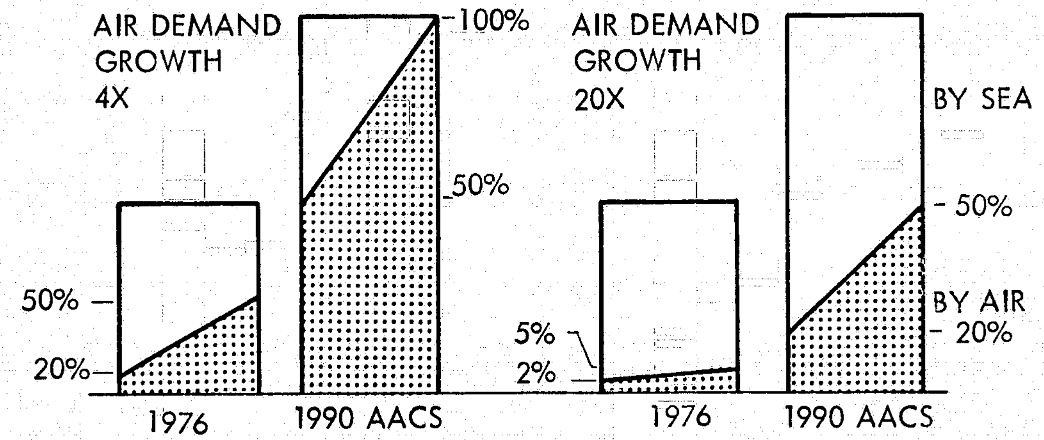
Airfreight Demand Stimulation With AACS - Results from both European and Japanese case studies show that demand for the AACS can be grossly separated into two categories as shown in Figure II-36. The high-value products, such as those listed on the left, already have a high air penetration. The lower-value but high-tonnage products, listed on the right, generally move by air today on an emergency basis only but would be attracted for routine shipments by an AACS. The vertical height of each bar represents 100 percent of the sea-plus-air shipments. Overall shipments are expected to double between now and 1990. At the same time, air penetration will increase dramatically for products such as business machines and household appliances, as shown by the darker area at the bottom of each bar. The air penetration is now 2 percent to 5 percent for these types of commodities as shown on the bar. The air penetration is predicted to increase to a range of 20 percent to 50 percent by 1990 with the AACS. The increase in penetration of 2 percent to 20 percent (or 5 percent to 50 percent) combined with overall demand growth of 2 to 1 gives a growth in air demand of 20 times.

Case study results for Japanese household appliance exports are shown in Figure II-37. They indicate an overall airfreight growth ratio with AACS of 27.5 to 1. One of the unique characteristics of the Japanese people is their preference for fresh, chilled fish over fish that have been processed. The Central Wholesale Market in Tokyo has about 50 acres devoted to a display of fresh marine products. Daily auctions are held at which retailers, restaurants, and institutions buy their daily supply. About 5 million pounds (2.27 million killograms) a day are cleared through this one market.

In 1973, Japanese imports of fish and other marine products totaled 900,000 tons (810,000 metric tons), as noted in Figure II-38. This is conservatively expected to reach 1,200,000 tons (1,080,000 metric tons) by 1990. In 1973, only 20,000 tons (18,000 metric tons) of fresh fish were imported, all by air. The only reason this figure was not considerably higher is that fresh fish must reach the market within 3 days after being packed. Current air freight service from Africa, South America, and Canada cannot meet this constraint on a regular, routine basis, partly because of the air container customs problem mentioned earlier.

If the AACS door-to-door service were available from fish exporting countries, it is estimated that as much as 550 tons (495 metric tons) per day might arrive by that mode.

The official air cargo forecast from Japan's Ministry of Transport is shown in Figure II-39. This stack chart, with imports added on top of exports, projects a growth in total exports plus imports by air from a 1976



- CAMERAS
- CALCULATORS
- COMPUTERS
- ELECTRONIC COMPONENTS

- COPIERS
- HOUSEHOLD APPLIANCES
- MARINE FOOD IMPORTS
- MOTOR VEHICLE PARTS

FIGURE II-36. AIRFREIGHT DEMAND STIMULATION

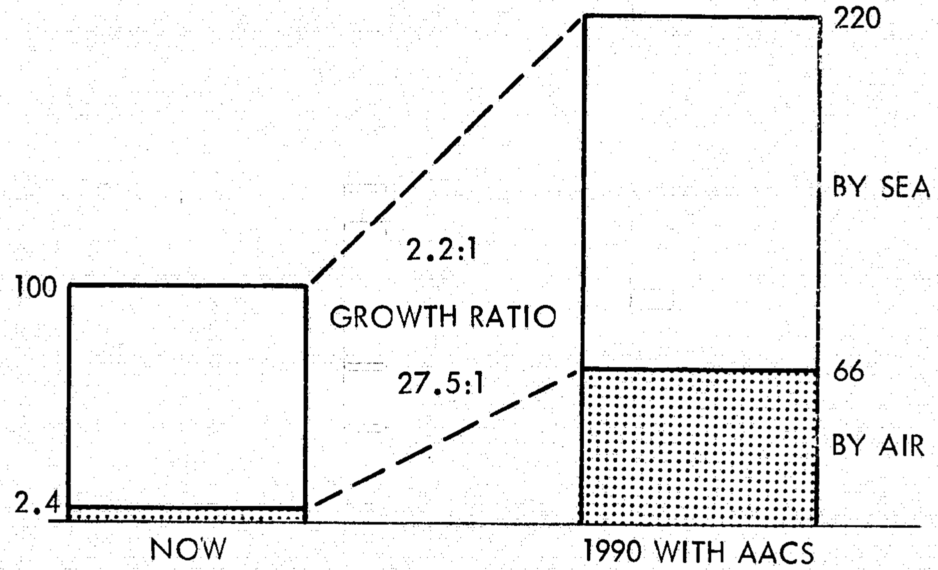


FIGURE II-37. HOUSEHOLD APPLIANCE EXPORTS BY AACS

	FRESH	PROCESSED	TOTAL
1973 TRANSACTIONS, TONS:			
DOMESTIC	606,000	114,000	720,000
IMPORT	20,000	160,000	180,000
TOTAL	626,000	274,000	900,000
1990 TRANSACTIONS, TONS:			
DOMESTIC	800,000	100,000	900,000
IMPORT	200,000	100,000	300,000
TOTAL	1,000,000	200,000	1,200,000

AACS POTENTIAL: 550 TONS/DAY

FIGURE II-38. AACS POTENTIAL FOR JAPANESE MARINE PRODUCT IMPORTS

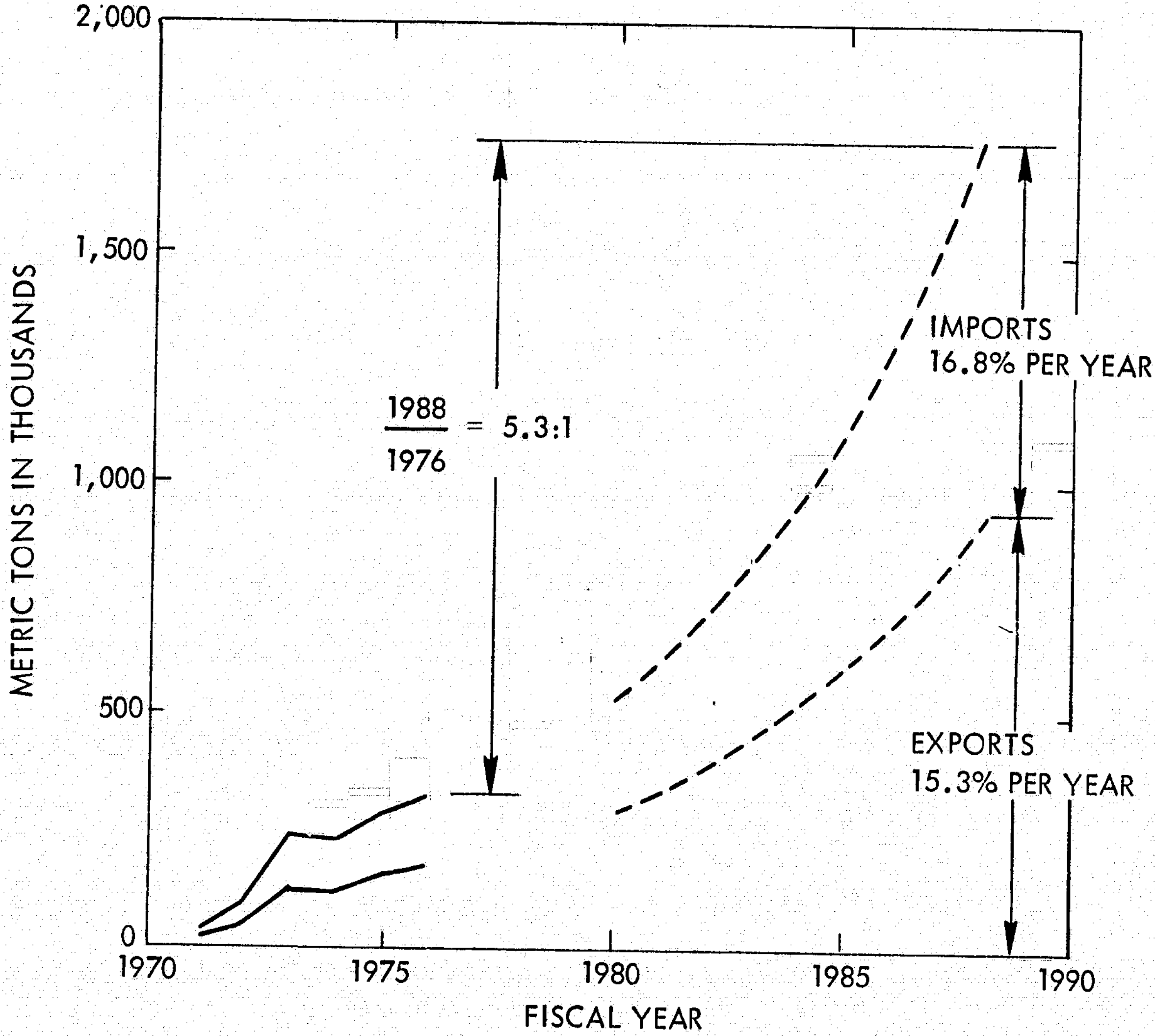


FIGURE II-39. AIR CARGO FORECAST, JAPANESE MOT level of about 333,333 tons (300,000 metric tons) to a 1988 level of about 1.89 million tons (1.7 million metric tons.) At first, the projected growth rates about 16 percent per year seemed unrealistically high. Now, however, in view of the case study responses to the door-to-door capability and freight rate reduction potential of the AACS, they seem much more reasonable.

Summary of Findings

Sixty-two U.S. shippers, consignees, and carriers were joined by 18 overseas companies to participate in the AACS case studies. Together, they represent a very broad spectrum of industries, commodities, and markets. Individually they are prominent in their industry groups. They are large users of existing surface and airfreight transportation systems. They are very conversant with current air cargo system capabilities and shortcomings and respect to their own needs. All of these factors contributed to the usefulness and credibility of their responses.

Case studies addressed characteristics of the company and its distribution and transportation operations, its current use of airfreight, and factors that influence airfreight selection decisions. In light of a company's present and future freight transportation requirements, inputs were obtained relating to desired attributes of an AACS and the extent to which the company would expect to use it.

The results of the domestic companies case studies show an 8-to-1 increase in demand if the AACS were available with rates at a level 45 percent below those for today's conventional airfreight. When the company responses were weighted by the company's annual sales, the demand increase for North America operations was 12 to 1.

Also analyzed was the future airfreight potential for the large group of manufactured products covered by the 1972 Transportation Census. In 1972 the actual air penetration amounted to only 0.06 percent by weight. From the case study input it was found that if the AACS had been operational in 1972, the air penetration would have been 0.6 percent or 11 times greater. This would have amounted to almost 9.7 million tons (8.7 million metric tons) in 1972. This trend also holds true for motor carriers participating in the study. Motor carriers estimated that the 11 percent of their freight, which moves over 800 miles (1288 km) would have used the AACS as a substitute service if it had been operational in 1976. When extrapolated to 1990, this penetration would have resulted in over 5.7 million tons (5.1 million metric tons) annually. Similar figures for ocean carriers potential use of AACS were 5.6 percent, and 4.4 million tons (3.9 million metric tons) in 1990. The major reason for this was the reduction in airfreight rates and compatibility of the AACS with the surface mode equipment, e.g., future intermodal containers.

From international case studies of European and Japanese companies most European companies interviewed were found to export 10 to 20 percent of their product by air today, with 25 to 30 percent of those shipments by charter. If today's air freight rates were reduced by 45 percent, these companies estimate they would increase their total exports to 55 to 80 percent by air. This means a regular routine use of air freight as opposed to today's occasional emergency use. Estimated future export market growth varied from 6 to 15 percent through 1990 for the companies surveyed in Europe. The European case studies indicated a potential use of the AACS by the ocean carrier at approximately 10 percent annually. The official air cargo forecast from Japan's Ministry of Transport projects a growth in total exports of over 15 percent per year from 1978 to 1988, with a 16 percent per year growth in imports.

Other important factors found in the case studies were a need for some type of door-to-door intermodal capability in the system along with through rates, and a master waybill. The need for this appeared stronger on the international market than the U.S. domestic market. If this type of system, the AACS, were available many new markets would be open. Among these are U.S. to Europe, Asia, and the Mideast shipments of fresh produce, fresh meat, canned food and drinks, U.S. to China, and Southeast Asia in pharamaceuticals and wearing apparel; U.S. to South America in machinery components; and U.S. to foreign in foodstuffs.

The case study participants expressed their dissatisfaction with present air containers. Complaints were strong concerning small size, shape, and incompatibility with existing ground transportation equipment and manufacturer/shipper facility. Concensus was expressed for large containers, larger than the M-2 container, of greater than 8-foot (2.4 meter) heights, and sizes up to "larger than today's highway limits." Compatibility with ground transportation systems and shipper facilities was exposed.

As an indication of the desire for an AACS, participants responses concerning the timing of the need for AACS shows that over one-fifth of the companies state an immediate need; one-half would like to have the AACS by 1985; and over four-fifths want it by 1990.

III - ADVANCED AIR CARGO SYSTEM DEMAND FORECAST

Introduction

Three major categories of world trade have been considered in the macro analyses: U.S. Domestic, U.S. International (U.S. imports and exports), and a representation of the Free-World international trade via data from the Organization for Economic Co-operation and Development. Since this organization is made up of 24 reporting industrial nations, the small amount of trade between less-developed countries is not accounted for.

Much has been written in the past regarding the small airfreight penetration of surface mode freight movements, currently quoted at 0.18 percent for U.S. Domestic (ref. 15) and U.S. Foreign trade (ref. 16). Over the years suggestions have been made, especially within the aircraft industry, of the possibility of increasing air penetration to as high as 2 percent. This section of the CLASS study addresses and investigates the means of creating such an increase in air penetration. The reason that total air penetration is so low is that surface modes move vast quantities of bulk commodities: energy commodities (oil and coal), raw materials (ores, gravel, fertilizers, and organic and inorganic chemical elements), and basic agricultural commodities (grains). The domestic movement of these commodities is largely long-haul and is accomplished by bulk-carrying modes such as inland waterways and pipelines. To some extent these commodities are also moved over short distance. The international movements are mainly between continents and, therefore, are mostly long-haul.

To establish the potential growth in airfreight with the Advanced Air Cargo System (AACS), the universe of commodities which have potential for air transportation must be established. From a historical viewpoint, statistical data are analyzed to establish a U.S. domestic universe based primarily on manufactured commodities which are currently moving as containerized seaborne freight. The output of the case studies described in the previous section is applied to these data, resulting in the demand for the AACS. This demand is seen to be represented by commodities that are primarily of high value, and especially internationally, those that are moving as containerized loads. Those commodities that are of very low value are mainly bulk commodities that are not generally considered to be air-eligible except in special circumstances. This study establishes that these bulk commodities comprise the vast majority of all tonnage and that the air-eligible commodities represent a small proportion of the total tonnage of all commodities over all distances.

To meet the requirements for both English and Metric units, all data are provided in both units. In the figures, two scales are provided. Tables are identified with an "E" or "M" for English or Metric units, respectively - e.g. Table III-2E or Table III-2M.

Several appendices are provided for this section. Appendices III-A and III-B contain details of the carload waybill statistics, and output from the Census of Transportation CTS #1 tapes, respectively. Appendix III-C provides metric-unit equivalents of all tables found in the main body of this section. Apendix III-E explains how containerized tonnage is obtained from the containerizable tonnage described in Appendix III-D. Appendix III-F describes the analysis of the OECD foreign trade data.

Supplements A, B, and C are bound separately from this volume, and are obtainable from NASA.

Supplement A contains output from the Maritime Administration's U.S. Seaborne Trade Long-Term Forecast for the total seaborne tonnage of all commodities at the 3-digit level. These commodities are defined as being containerizable and are grouped by the actual level of containerization achieved in 1974. Supplement B presents the actual containerized tonnages for the same groupings. Both supplements present the U.S. foreign trade flows between the U.S. and 13 major world regions.

Supplement C presents the detailed analyses of the OECD Series C foreign trade data for the Free-World and presents the derivation of the demand for the Advanced Air Cargo System.

U.S. Domestic Transportation Data Analysis

Department of Transportation Forecast - To establish the U.S. Domestic demand for the Advanced Air Cargo System (AACS) using output from the Case Studies, analysis of macro data for all modes was considered to be the starting point. The Department of Transportation developed forecasts (ref. 17) for each mode. Since these modal forecasts did not consider radical changes in modal technology, the effect of the AACS on the surface and air mode freight is not reflected in the DOT forecasts. These forecasts, however, form an excellent macro base from which to establish the demand for the AACS. Much of the traffic to be carried in the AACS will come from other modes, while its existence will surely generate totally new markets. Only the former market is considered in detail and thus somewhat conservative forecasts are generated. Traffic carried by the other mdoes is mainly comprised of bulk commodities generally considered unlikely to travel by air due to their low value and that they do not require the speed of travel offered by the air mode. Thus, it is evident that the demand for the AACS to come primarily from manufactured goods.

The DOT forecast for all modes of transportation is presented in Table III-1E-1, -2. Both tonnage and ton-mile data are presented with the derived average distances for each mode. Table III-1E-1, -2 shows that, except for the water mode and private truck, each mode is forecast to have an increase in the average distance that freight will be hauled by 1990. However, each mode

TABLE III-1E-1. DEPARTMENT OF TRANSPORTATION FORECAST

Tonnage	1975 % Share	1975 Tons Millions	1980 % Share	1980 Tons Millions	1990 % Share	1990 Tons Millions	Annual Growth Rate - % 1980 - 1990
Rail	30	1480.1	30	1914.9	32	2561.2	2.95
Motor Carrier	15	740.0	15	957.5	16	1280.6	2.95
Private Truck	17	838.7	17.5	1117.0	18	1440.7	2.58
Sub Total	62	3058.8	62.5	3989.4	66	5282.5	2.85
Water	20	986.7	20	1276.6	19	1520.7	1.77
Pipeline	18	880.1	17	1085.1	15	1200.6	1.02
Air	.1	4.9	.1	6.4	.1	8.0	2.26
Grand Total	100	4933.7	100	6383.0	100	8003.8	2.29

Ton Miles	1975 % Share	1975 Ton-Miles Billions	1980 % Share	1980 Ton-Miles Billions	1990 % Share	1990 Ton-Miles Billions	Annual Growth Rate - % 1980-1990
Rail	33.5	761	40.2	1152	42.5	1754	4.29
Motor Carrier	8.6	196	7.2	208	9.5	394	6.60
Private Truck	10.8	245	8.6	248	6.6	273	0.97
Sub Total	52.9	1202	56.0	1608	58.6	2421	4.18
Water	24.5	557	22.7	650	20.1	829	2.46
Pipeline	22.4	510	21.1	606	21.0	868	3.66
Air	0.18	4	0.17	5	0.22	9	6.05
Grand Total	99.98	2273	99.97	2869	99.92	4127	3.70

Source: U. S. DOT National Transportation Trends & Choices To the Year 2000, Page 69 for Tonnage & Mr. Costello, DOT for Ton-Miles

TABLE III-1E-2.

Average Distance - S.M.

	1975	1980	1990
Rail	514.2	601.6	684.8
Motor Carrier	264.9	217.2	307.7
Private Truck	292.1	222.0	189.5
Sub Total	393.0	403.1	458.3
Water	564.5	509.2	545.1
Pipeline	579.5	558.5	723.0
Air	816.3	769.2	1125.0
Grand Total	460.7	449.5	515.6

has an average distance that is less than the threshold for the AACS of 800 miles (1288 kilometers). After the published ton-mile data in "Trends and Choices" were found to be incorrect, the latest data were obtained directly from the DOT. The rail freight ton-miles will increase only 130 percent rather than the much published 143 percent. Rail's share of the total freight market changes only slightly from 42 to 42.5 percent. The corrected data are reflected in Table III-1E-1, -2. Subsequent analyses of the domestic system concentrate on the tonnage data from which the demand for the AACS and the fleet mix are established.

Forecasts Using Transportation Association of America (TAA) Data - As a comparison with the DOT forecast, an additional forecast of Transportation Association of America (TAA) data for rail and truck freight movements has been made. It is based on the GNP forecast titled "Resource Allocation" from an FAA Study (ref. 18). Table III-2 presents total GNP (ref. 19) data in 1972 dollars, and the ratio of GNP (Manufacturing) to total GNP. It is evident from Table III-2 and Figure III-1 that the historical variation of the ratio is slight with a trend regression that is constant at 0.245; i.e., the GNP (Manufacturing) is 24.5 percent of the total GNP. With this trend, the GNP (Manufacturing) is forecast based on the FAA forecast of Total GNP.

The historical rail and truck tonnage is presented in tabular form in Table III-3E and M and graphically in Figure III-1. A consistent decline in the pounds of rail and truck movement per dollar of GNP (Manufacturing) is seen. This trend is forecast to continue through the year 2000. GNP (Manufacturing) appears to be a good correlator for freight transportation. Thus, the forecast for rail and truck tonnage is derived from the trends of pounds of freight per dollar of GNP (Manufacturing) and the ratio of GNP (Manufacturing) to Total GNP. The resulting forecast for the year 2000 of rail and truck tonnage of 5,400 million tons (4,860 million metric tons) is only 77 percent of the extrapolated DOT forecast of 7,000 million tons (6,300 million metric tons). The DOT forecast, however, will be used as the future trend in the subsequent analyses, since the GNP correlation was a simplistic approach and the DOT forecast represents a more detailed multi-mode analysis than attempted here. The FAA study results are presented as a further reference point.

Small Shipment Data - A part of the total freight movements is that defined as small shipments, those under 10,000 pounds (4545 kilograms) per shipment. The major modes for small shipments over the historical period 1950 through 1974 have been truck and rail, with rail having lost almost totally to truck (Table III-4E and Figure III-2). The growth in the total small shipment demand for truck and rail has averaged only 0.6 percent per year, with the truck growth averaging 2.0 percent per year. The total for truck and rail has been forecasted based on the decline of pounds of small shipments per dollar of GNP (Manufacturing), resulting in average growth rate of 0.9 percent per year to 111 million tons (50.45 million metric tons) in the year 2000.

Freight Movements Reported in Tons - The TAA modal data for 1975 compare very closely with the 1975 data published in the DOT forecast, and thus the

TABLE III-2. GNP HISTORY AND FORECAST

Year	GNP 1972 $'s Billions	GNP (Manufacturing) 1972 $'s Billions	GNP (Mfg) / GNP (Total)
1947	468.3	114.9	.245
1948	487.7	121.5	.250
1949	490.7	115.0	.234
1950	533.5	131.3	.246
1951	576.5	146.0	.253
1952	598.5	150.7	.252
1953	621.8	161.2	.259
1954	613.7	149.6	.244
1955	654.8	165.8	.253
1956	668.8	166.9	.250
1957	680.9	167.8	.246
1958	679.5	153.3	.226
1959	720.4	170.7	.237
1960	736.8	172.0	.233
1961	755.3	171.2	.227
1962	799.1	186.2	.233
1963	830.7	201.0	.242
1964	874.4	215.7	.247
1965	925.9	235.1	.254
1966	981.0	254.0	.259
1967	1007.7	254.1	.252
1968	1051.8	268.4	.255
1969	1078.8	276.2	.256
1970	1075.3	260.6	.242
1971	1107.5	264.1	.238
1972	1171.1	288.8	.247
1973	1235.0	313.0	.253
1974	1214.0	296.8	.244
1975	1191.7	270.0	.227
1976	1265.0	-	-
1980	1470.0	360.2	.245
1985	1700.0	416.5	.245
1990	2000.0	490.0	.245
1995	2340.0	573.3	.245
2000	2740.0[1]	671.3	.245

(1) Based on FAA Resource Allocation Forecast from Aviation Futures to the Year 2000.

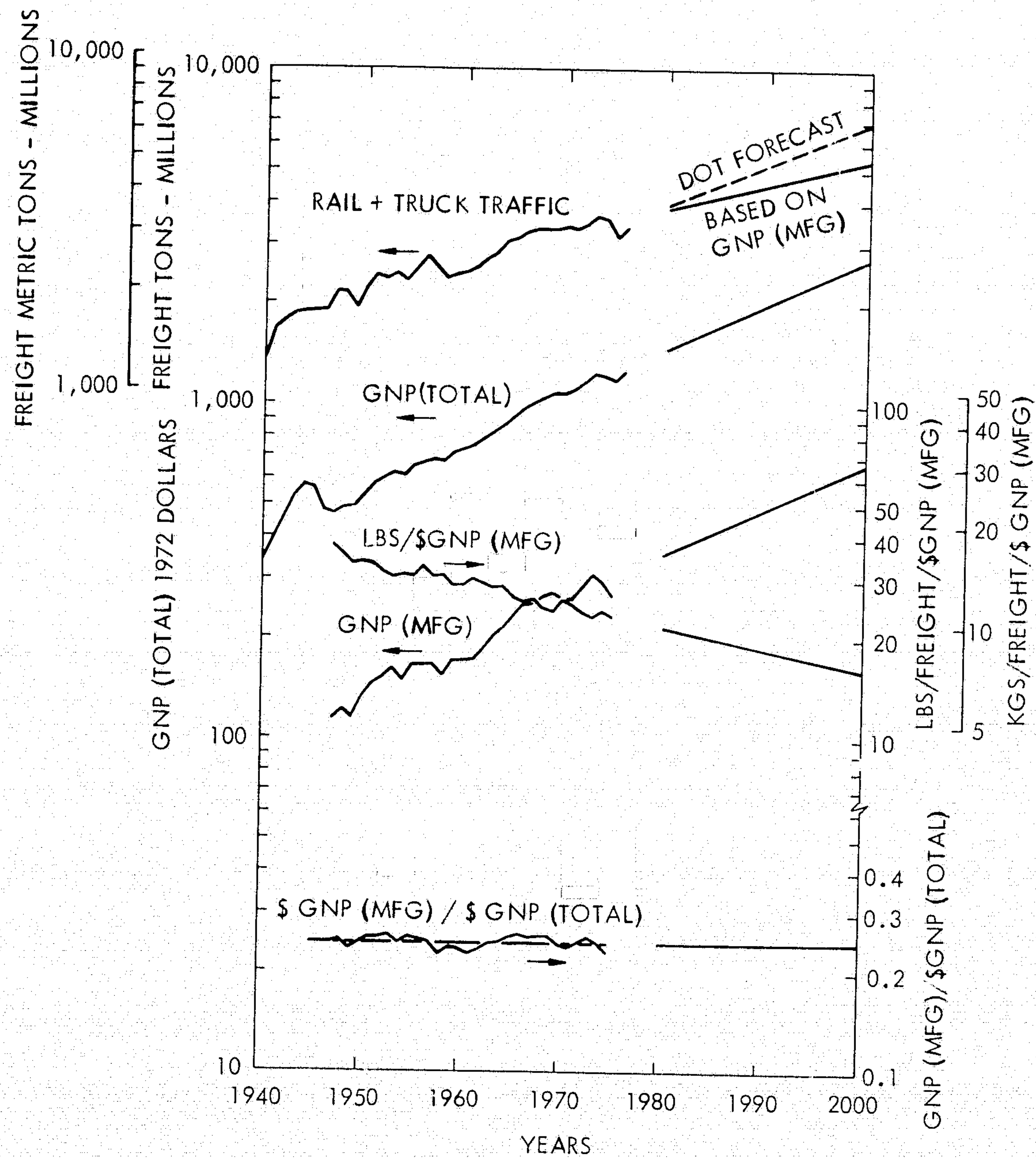


FIGURE III - 1. RAIL, TRUCK AND GNP TRENDS

TABLE III-3E. RAIL AND TRUCK FORECAST (MILLION TONS)

Year	Rail Class I & II	Truck ICC-Regulate	Truck Non-ICC Regulated	Total Truck	Total Rail & Truck	GNP Mfg. 1972 $'s Billions	Lb/$ GNP (Mfg)
1940	1069	61	211	272	1368		
1941	1296	77	312	389	1685		
1942	1498	83	204	287	1785		
1943	1557	96	196	292	1849		
1944	1565	105	218	323	1888		
1945	1493	108	286	394	1887		
1946	1432	112	354	466	1898		
1947	1613	135	421	556	2169	114.9	37.8
1948	1580	166	406	572	2152	121.5	35.4
1949	1284	176	454	630	1914	115.0	33.3
1950	1421	213	581	794	2215	131.3	33.7
1951	1547	237	634	871	2418	146.0	33.1
1952	1447	243	670	913	2360	150.7	31.3
1953	1448	270	737	1007	2445	161.2	30.3
1954	1279	271	762	1033	2312	149.6	30.9
1955	1459	314	749	1063	2522	165.8	30.4
1956	1521	330	893	1223	2744	166.9	32.9
1957	1449	330	783	1113	2562	167.8	30.5
1958	1247	329	793	1122	2369	153.3	30.9
1959	1293	375	781	1156	2449	170.7	28.7
1960	1301	387	794	1181	2482	172.0	28.9
1961	1253	401	922	1323	2576	171.2	30.1
1962	1294	440	981	1421	2715	186.2	29.2
1963	1347	458	1049	1507	2854	201.0	28.4
1964	1420	497	1173	1670	3090	215.7	28.7
1965	1479	557	1084	1641	3120	235.1	26.5
1966	1543	606	1138	1744	3287	254.0	25.9
1967	1498	600	1245	1845	3343	254.1	26.3
1968	1515	642	1169	1811	3326	268.4	24.8
1969	1558	639	1129	1768	3326	276.2	24.1
1970	1572	661	1167	1828	3400	260.6	26.1
1971	1472	707	1155	1862	3334	264.1	25.2
1972	1531	771	1163	1934	3465	288.8	24.0
1973	1616	830	1198	2028	3644	313.0	23.3
1974	1619	800	1155	1955	3574	296.8	24.1
1975	1471	688	993	1681	3152	270.0	23.3
1976	1477	784	1131	1915	3392		
1980					3890	360.2	21.6
1985					4186	416.5	20.1
1990					4582	490.0	18.7
1995					4988	573.3	17.4
2000					5404	671.3	16.1

TABLE III-4E. SMALL SHIPMENT HISTORY AND FORECAST

Year	Motor LTL Class I & II	Rail LCL Class I & II	Rail & Truck	GNP Manufacturing 1972 $'s Billions	Lb/$ GNP (Mfg).
	Net Tons - In Thousands				
1950	53,405	22 164	75,569	131.3	1.15
1951	48,941	21,282	70,223	146.0	0.96
1952	49,615	18,991	68,606	150.7	0.91
1953	51,801	16,811	68,612	161.2	0.85
1954	50,279	14,260	64,539	149.6	0.86
1955	54,132	14,045	68,177	165.8	0.82
1956	56,963	13,124	70,087	166.9	0.84
1957	57,934	11,223	69,157	167.8	0.82
1958	56,272	8,771	65,043	153.3	0.85
1959	62,721	7,730	70,451	170.7	0.83
1960	62,144	6,447	68,591	172.0	0.80
1961	63,527	5,354	68,881	171.2	0.80
1962	68,541	4,473	73,014	186.2	0.78
1963	70,794	3,345	74,139	201.0	0.74
1964	73,048	2,446	75,494	215.7	0.70
1965	76,896	2,125	79,021	235.1	0.67
1966	82,048	1,650	83,698	254.0	0.66
1967	80,190	1,512	81,702	254.1	0.64
1968	83,223	1,297	84,520	268.4	0.63
1969	84,505	1,279	85,784	276.2	0.62
1970	78,099	1,177	79,276	260.6	0.61
1971	78,500	1,100	79,600	264.1	0.60
1972	82,800	969	83,769	288.8	0.58
1973	83,789	746	84,536	313.0	0.54
1974	86,000	661	86,661	296.8	0.58
1980			91,851	360.2	0.51
1985			95,795	416.5	0.46
1990			100,450	490.0	0.41
1995			106,061	573.3	0.37
2000			110,765	671.3	0.33

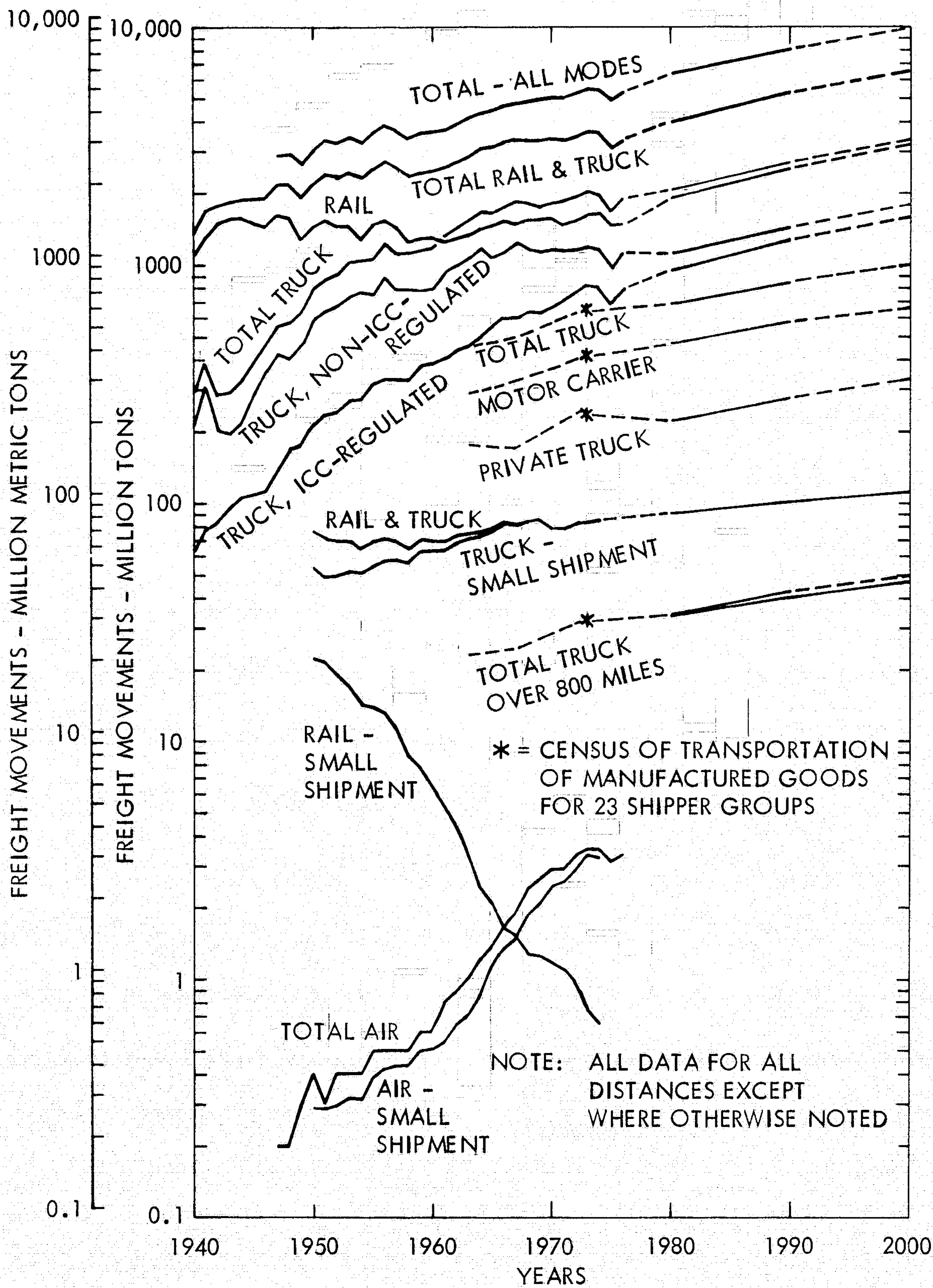


FIGURE III-2. FREIGHT MOVEMENTS IN TONS VERSUS YEARS

TAA data are used for the historical period 1940 through 1975. These data are illustrated in Figure III-2. Starting at the top of the chart, the freight movements for all modes are broken down into rail and truck, since the demand for the AACS will come from these modes rather than waterborne or pipeline. These macro data include all commodities carried over all distances. The commodities include coal, petroleum, ores, grains, and manufactured goods. It is expected that the manufactured goods will form the market demand for the AACS.

The major source for movements of manufactured goods is the Census of Transportation. Table III-5E presents the total of all commodities movements and manufactured goods movements for the three census years - 1963, 1967, and 1972 - and forecasts through the year 2000. These data show the effect of eliminating the bulk of non-manufactured goods, and are without regard for distance. The manufactured goods presented here exclude petroleum and coal products and show that manufactured goods moved by rail and truck represent approximately 30 percent of total goods moved by rail and truck.

Also, the main source of freight for the AACS is considered to be freight currently moving more than 800 miles (1288 kilometers) and presently carried by truck. Manufactured commodities presently moving by rail are doing so primarily due to the low rail rates or lack of time sensitivity. Figure III-2 shows that if the air mode continues to grow at the long-term historical rate, it will equal the total truck for over 800 miles (1288 kilometers) by 1995.

Figure III-2 presents a great deal of data for all commodities and manufactured goods. To simplify the data to represent only manufactured goods eligible for the AACS, some additional reduction factors must be considerd. In doing so, one sees that air freight has a considerably larger share of the eligible universe that is indicated by the often quoted "two-tenths of one percent." Analyses of the 1972 Census of Transportation tape CTS #1 have been made, resulting in the data presented in Figures III-3, III-4, and III-5. The data represent all manufactured goods except STCC 29 (Petroleum and Coal products), and are shown as the quantity of freight moving more than the indicated distance. Figure III-3 illustrates freight tonnage for air, truck, rail, and all modes. As an example, 122 million tons out of the 660 million tons (594 million metric tons) total movements are moved by all modes over distances greater than 800 miles (1288 kilometers).

From these data, the percentage distribution by distance is derived, Figure III-4. This clearly shows the long-haul nature of the current air system, and especially that 22 percent of rail tonnage and 5 percent of truck tonnage move more than 800 miles (1288 kilometers). These results were incorporated in Figure III-8 in arriving at the universe for the AACS.

Figure III-5 presents air penetration based on all modes; on air, truck and rail; and on air and truck. Air penetration of air and truck already stands at 2.7 percent for distances greater than 800 miles (1288 kilometers), compared with 0.1 percent for all manufactured goods for all distances. The gradient of the air and truck line is substantial such that the air penetra-

TABLE III-5E. SHIPMENTS BY MANUFACTURING ESTABLISHMENTS - TONS

Year	1963	1967	1972	1980	1990	2000
All Commodities - Bulk and Manufactured - Rail and Truck Only						
Total Freight Movements - Tons (Millions)						
Rail	1347	1498	1531	1915	2561	3200
Motor Carrier	458	600	771	958	1281	1600
Private Truck	1049	1245	1163	1117	1441	1800
Total Truck	1507	1845	1934	2075	2722	3400
Rail & Truck	2854	3343	3465	3990	5283	6600
Total All-Modes Manufactured Goods(1) - Tons (Millions)						
	882.526	966.957	1119.629			
Percent Distribution - Rail and Truck Only						
Rail	43.9	44.6	38.7			
Motor Carrier	32.9	33.5	35.8			
Private Truck	19.9	17.6	21.3			
Manufactured Goods(1) by Rail & Truck - Tons (Millions)						
Rail	387.429	431.263	433.296	527	681	826
Motor Carrier	290.351	323.931	400.827	469	580	672
Private Truck	175.623	170.184	238.481	223	278	335
Total Truck	465.974	494.115	639.308	692	858	1007
Rail & Truck	853.403	925.378	1072.604	1219	1539	1833
Manufactured Goods Movements - Percent Share of Total Freight Movements						
Rail	28.8	28.8	28.3	27.5	26.6	25.8
Motor Carrier	63.4	54.0	52.0	49.0	45.3	42.0
Private Truck	16.7	13.7	20.5	20.0	19.3	18.6
Total Truck	30.9	26.8	33.1	33.3	31.5	29.6
Rail & Truck	29.9	27.7	31.0	30.6	29.1	27.8

(1) Manufactured goods for 23 Shipper Groups excluding Petroleum & Coal Products.

Sources:
Historical Data - TAA Facts & Trends
Forecast Data - Based on DOT Trends & Choices

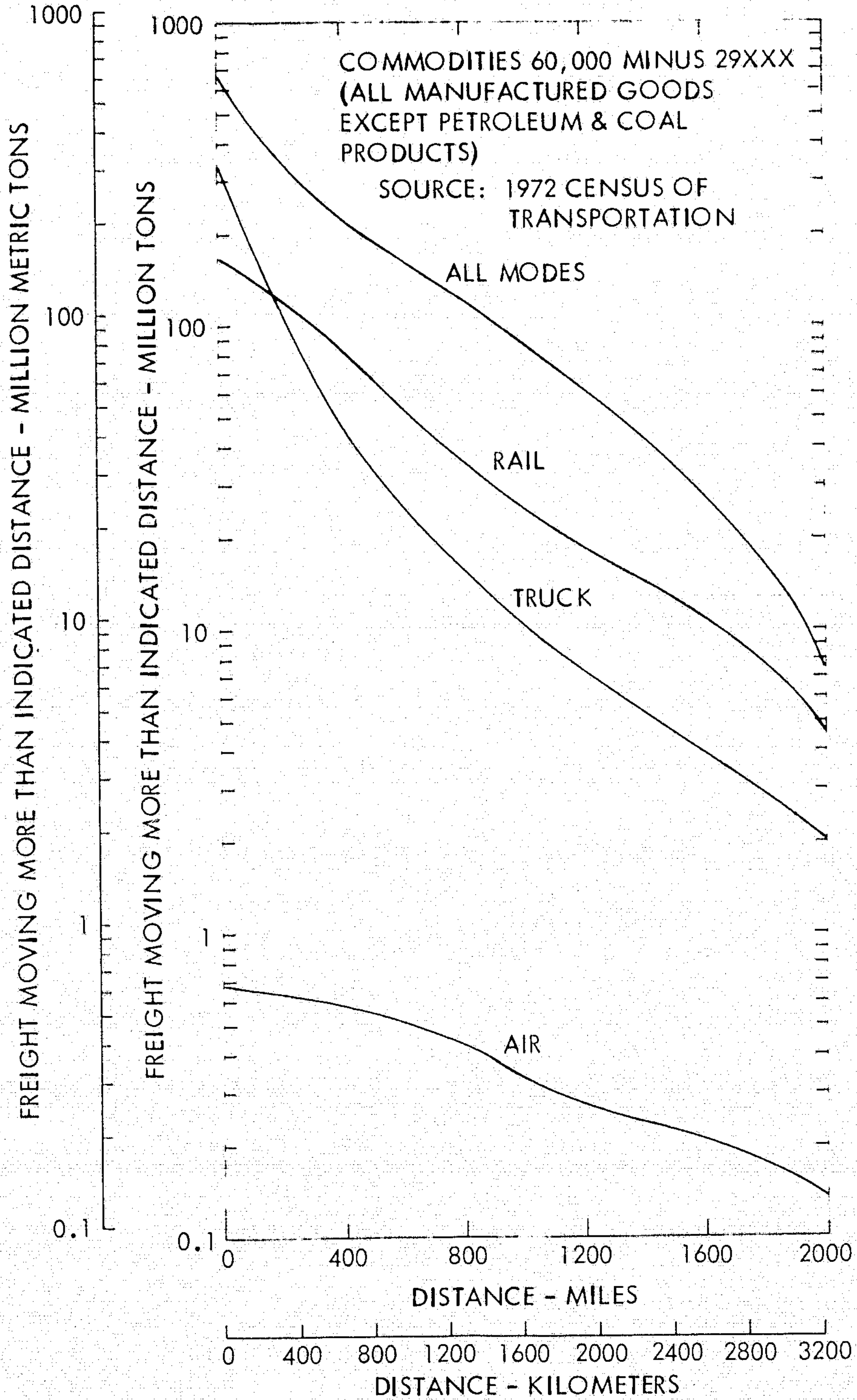


FIGURE III-3 . FREIGHT MOVEMENTS IN TONS VERSUS DISTANCE HAULED

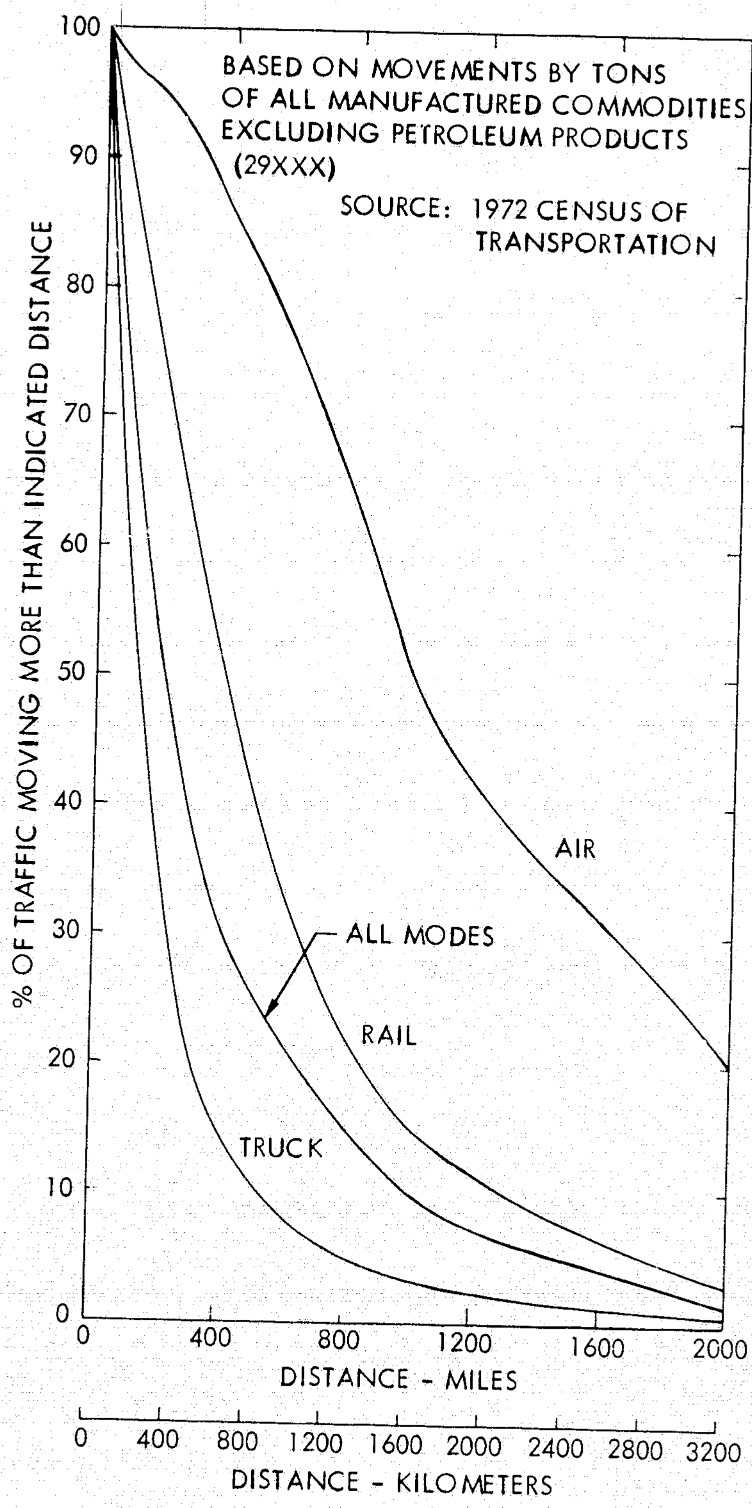


FIGURE III-4. DISTRIBUTION OF FREIGHT BASED ON MOVEMENTS BY TONS

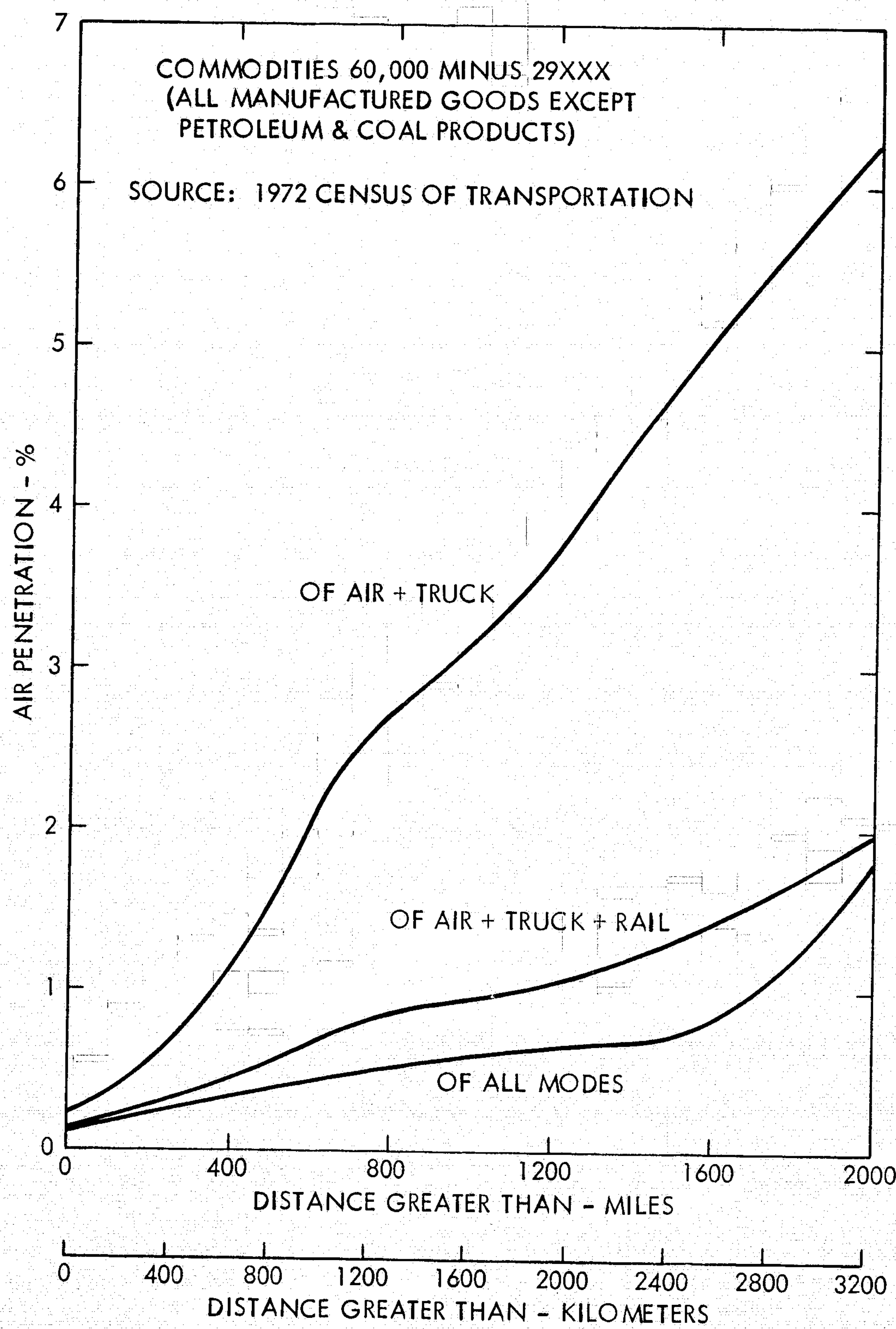


FIGURE III-5. AIR PENETRATION OF FREIGHT TONS tion reaches almost 6.3 percent for distances greater than 2000 miles (3200 kilometers).

Figures III-6 and III-7 for Carload Waybill statistics present the results of analyses detailed in Appendix III-A. These statistics are provided for commodities defined at the 3-digit level and have been ranked based on the revenue per ton-mile. Figures III-6 and III-7 show that 11.5 percent of all commodity tonnage and 20 percent of manufactured goods tonnage generate revenues greater than 3 cents per ton-mile (2.08 cents per metric ton-kilometer). The latter fraction is used to establish the universe from which the AACS will draw its freight, since many manufactured goods, being primary manufactured goods rather than finished manufactured goods, move by rail because of the low rates, or are time-insensitive.

The predominance of low-value, bulk commodities moving by rail is further illustrated in Table III-6E. This table presents a summary of the shipper group from the 1972 Census and shows the top 10 commodities by total tons moved, along with the tonnage moved by rail, and the percentage by rail. The shipper group represents approximately the combination between the first- and second-digit levels and, therefore, represents a gross level.

Figure III-8 summarizes the effects of these factors by presenting only manufactured goods for rail, truck, and air. The universe for the AACS is now seen to be 54 million tons (48.6 million metric tons) in 1976, growing to 86 million tons (77.4 million metric tons) in the year 2000, rather than the all modes tonnage from Figure III-2 of 5300 million (4770 million metric) in 1976 and 10,000 million (9000 million metric) in 2000. Also in Figure III-8 historical data and the ATA forecast for total air cargo are presented. A large portion of the ATA cargo forecast is made up of lower-hold or belly cargo, thus leaving a small demand for all-cargo services. This small all-cargo demand results from a very conservative total cargo forecast and a forecasted substantial growth in belly load factor. This small all-cargo demand is assumed to be absorbed by the AACS.

The demand for the AACS derived in Section II was established by using the commodity distribution statistics from the 1972 Census. Actual 1972 air penetration was increased based on the Case Study results reflecting additional diversion to air from the proposed 45 percent rate reduction. This process was performed at the 4-digit level of commodity classification but where such detail was not available, approximation's were made at aggregated levels of 3 and 2 digits.

The degree of penetration for the AACS established from the Case Studies as if it were in service in 1972 is assumed to remain constant through the year 2000. The resulting domestic air cargo demand forecasts are tabulated in Table III-7E along with the rail and truck universe data. The air cargo tonnage with the AACS in service is calculated by multiplying the projection for rail and truck, specific commodities, over 800 miles (1288 kilometers) by the "percent of universe", and is illustrated in Figure III-8.

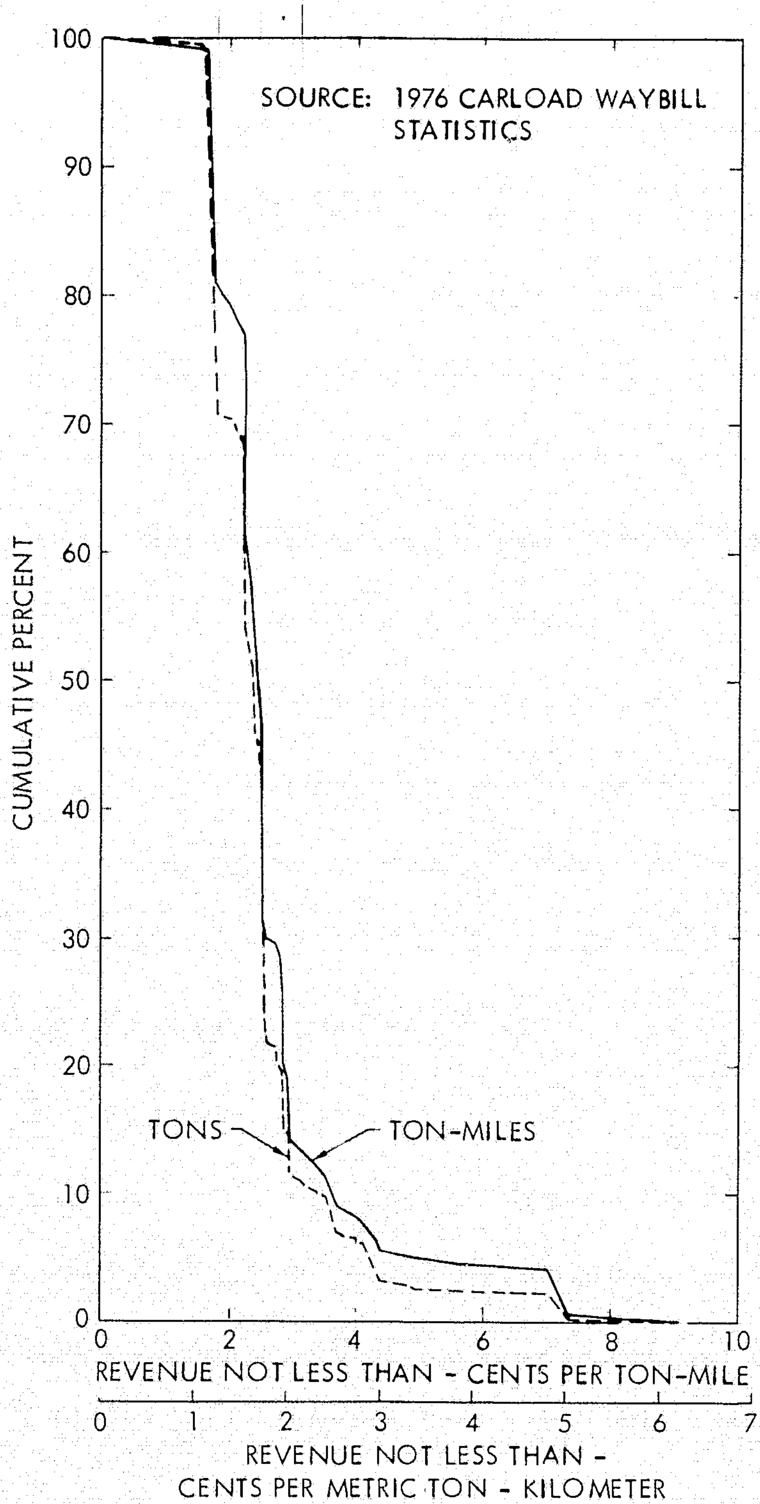


FIGURE III-6. **DISTRIBUTION OF RAIL FREIGHT BY REVENUE - ALL COMMODITIES**

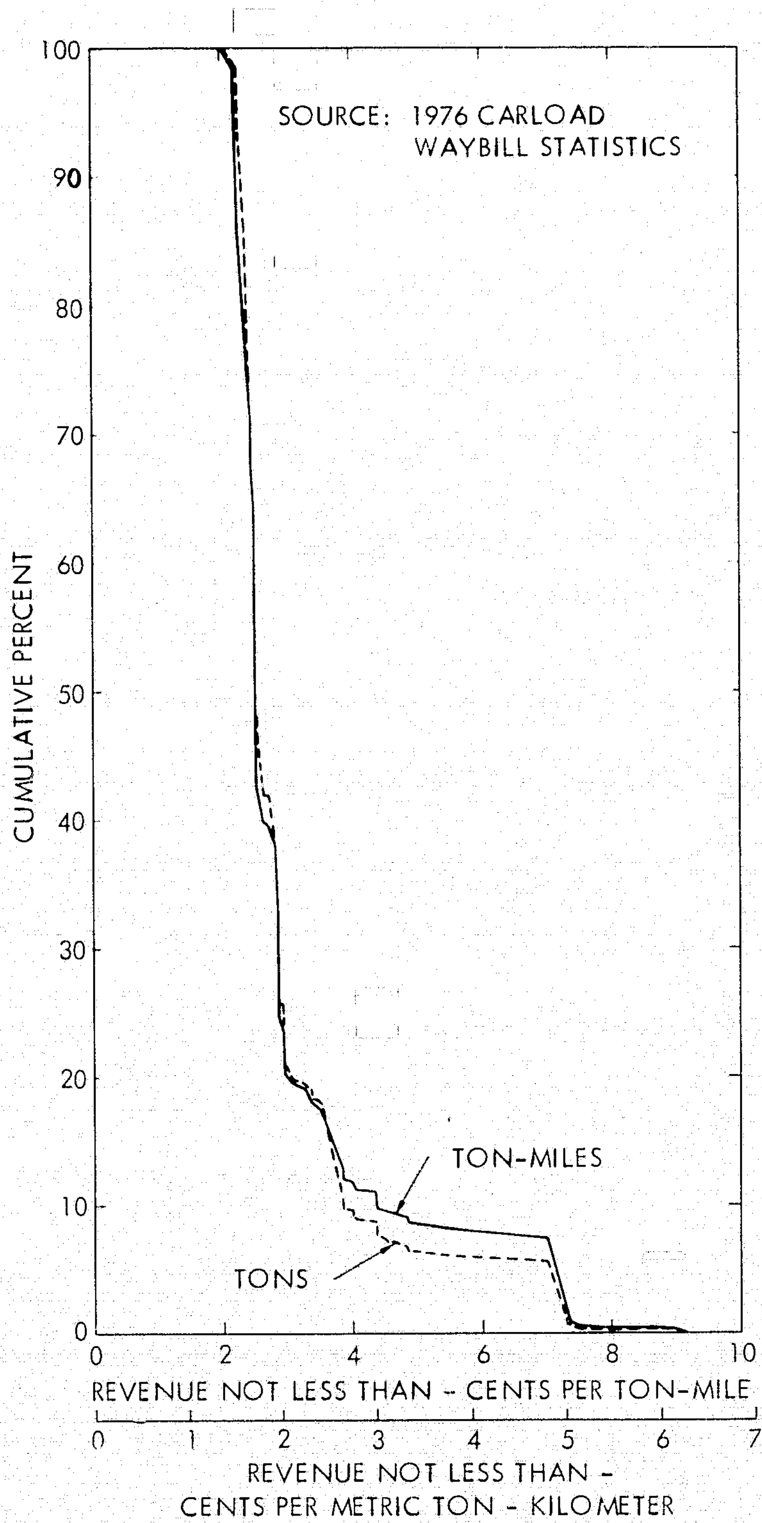


FIGURE III-7. DISTRIBUTION OF RAIL FREIGHT BY REVENUE - MANUFACTURED GOODS ONLY

TABLE III-6E. 1972 CENSUS RESULTS

Top Commodities by Tons

Rank		Total Tons (Millions)	Rail Tons (Millions)	Percent Rail of Total
	All 23 Shipper Groups(1)	1,119,629	433,296	38.7
1	Stone, Clay & Glass Products	178,122	39,009	21.9
2	Canned, Frozen & Other Food Products	154,015	78,086	50.7
3	Primary Iron & Steel Products	139,461	60,944	43.7
4	Chemicals, Plastics, etc.	111,853	54,361	48.6
5	Paper & Allied Products	89,410	46,314	51.8
6	Lumber & Wood Products Except Furniture	79,991	36,716	45.9
7	Drugs, Paints & Other Chem. Prod.	58,902	22,265	37.8
8	Candy, Beverages & Tobacco Prod.	57,996	8,931	15.4
9	Meat & Dairy Products	42,616	8,012	18.8
	Top 9 Shipper Groups	912,366	354,638	38.9
	Top 9 as Percent of Total	81.5	81.8	
10	Motor Vehicles & Equipment	39,990	23,714	59.3
	Top 10 as Percent of Total	85.1	87.3	

(1) The total for the 23 Shipper Groups excludes Petroleum and Coal Products

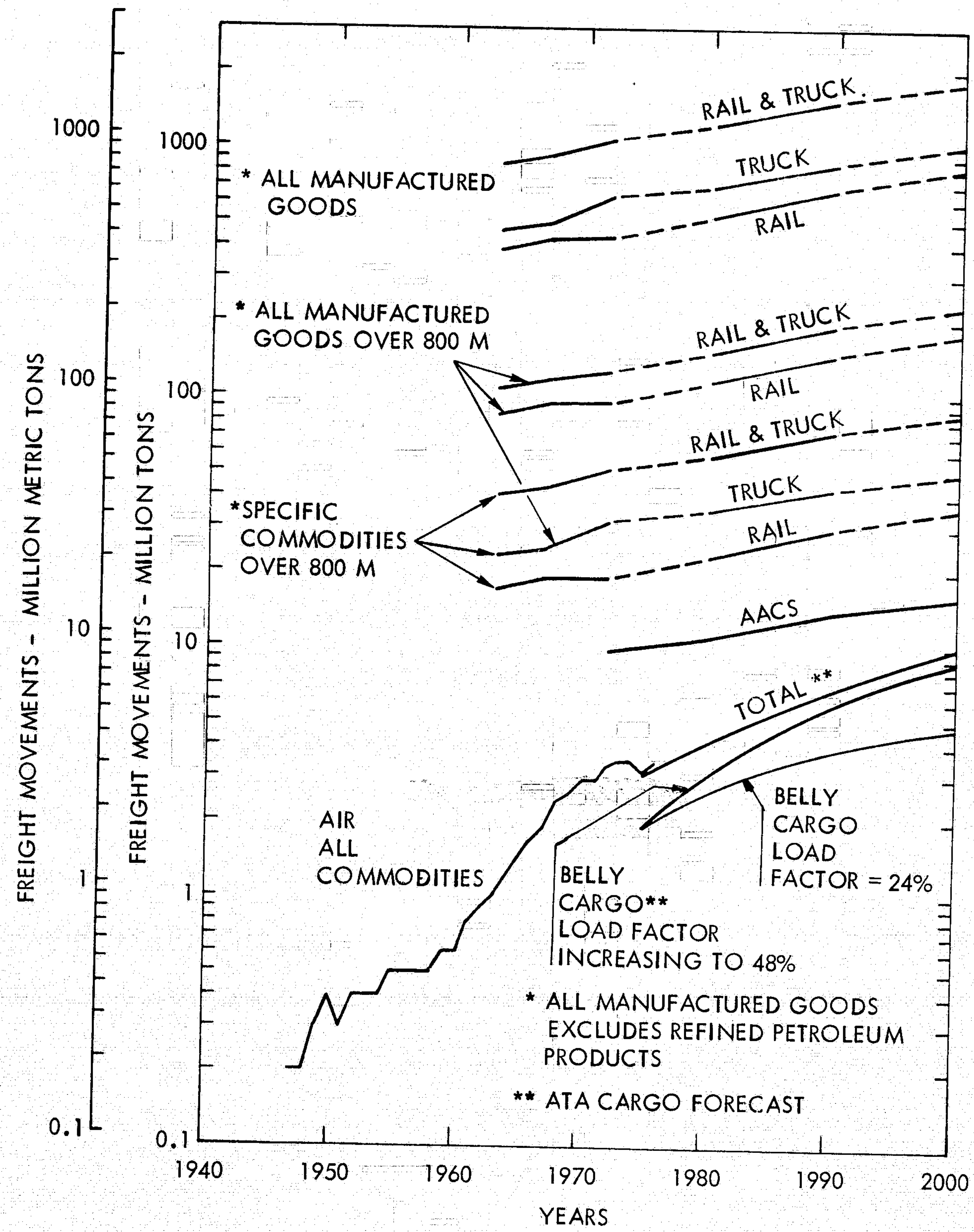


FIGURE III-8. MANUFACTURED GOODS MOVEMENTS IN TONS VERSUS YEARS

TABLE III-7E. MARKET UNIVERSE FOR AACS AND CASE STUDY CORRELATION MANUFACTURED GOODS ONLY

Year	1963	1967	1972	1980	1990	2000
			Million Tons			
Rail - Total	387.429	431.263	433.296	527	681	826
Rail over 800 mi[1]	84.460	94.015	94.459	115	148	180
Rail - Specific Commodities[2]	16.892	18.803	18.892	23	30	36
Truck - Total	465.974	494.115	639.308	692	858	1007
Truck over 800 mi[3]	23.299	24.706	31.965	35	43	50
Truck - Specific Commodities[4]	23.299	24.706	31.965	35	43	50
Rail & Truck						
Total	853.403	925.378	1072.604	1219	1539	1833
Over 800 mi	107.759	118.721	126.424	150	191	230
Specific Commodities	40.191	43.509	50.857	58	73	86
Case Study Results for 45% Rate Reductions						
Percent of Universe			19.0	19.0	19.0	19.0
Air Tonnage with AACS			9.671	11	14	16
ATA Belly Cargo Forecast[5]				3	6	9
Remaining Demand for AACS				8	8	7

(1) 21.8 percent of rail tons move over 800 mi.
(2) 20 percent of rail tons move at yields of 3¢/tsm or more
(3) 5 percent of truck tons move over 800 mi.
(4) All manufactured goods by truck considered eligible for AACS
(5) Specific Commodities (Rail & Truck) times Percent of Universe/100
(6) Air Transport Association of America Cargo Forecast 1975-2000, January 1978

The two forecasts, the AACS demand and the ATA forecast, are independent except for the possibility that the AACS demand based on the Case Studies may contain some small shipment demand. Answers provided by some Case Study participants could be interpreted to imply that the participants' projected AACS demand included small shipments already being sent by air. It is not feasible to quantify this, but it would adjust the AACS demand downward. The belly cargo forecast is a substantial part of the total ATA cargo forecast. If all the belly cargo forecast by the ATA is considered to be included in the AACS demand derived from the Case Studies, the entire belly forecast should be subtracted from the Case Study demand to arrive at the dedicated demand available to the AACS. Thus, in 1990, the Case Study demand of 14 million tons (12.6 million metric tons) is reduced to 8 million (7.2 million) by subtracting the ATA belly forecast of 6 million tons (5.4 million metric tons), Figure III-8 and Table III-7E. The AACS demand in Table III-7E is equivalent to 8 million tons (7.2 million metric tons) in 1980 and 1990 and reducing to 7 million (6.3 million) in the year 2000, based upon the assumption that the belly forecast of the ATA will, in fact, still come about with the introduction of the AACS. That in itself is a debatable issue in that, with the lower rates available with the AACS, the belly cargo may not grow as the ATA has forecast.

Some of the data are subject to different interpretations that may lead to different demand estimates. A good way to accommodate this situation is to establish lower and upper boundaries on the forecast. An upper boundary for the AACS demand can be developed by combining the AACS demand and the conventional forecast. As noted above, the belly forecast incorporates a doubling of the weight load factors by 2000. Shippers appear to be reluctant to commit their routine shipments to passenger aircraft belly holds, even at rates almost as low as motor carrier rates. Apparently, low rates are not sufficient incentive to induce shippers to change their transportation demand to an air system that could easily be filled to capacity if only a few major shippers shifted to air and whose future growth and traffic patterns are completely dependent on the passenger market. Thus, the belly load factor may not double from 24 percent in 1975 to 48 percent in the year 2000, even if the AACS does not come into existence. With the existence of AACS, the belly load factors are expected to remain as they are at present at best, and the remainder of the conventional ATA forecast would be available to the AACS. Under this concept, the upper boundary of the AACS forecast for 1990 is 10 million tons (9 million metric tons).

Values for the lower and upper boundaries in millions of tons (millions of metric tons) for different periods are:

	1980		1990		2000	
	Million Tons	Million Metric Tons	Million Tons	Million Metric Tons	Million Tons	Million Metric Tons
Lower Boundary	8	7.2	8	7.2	7	6.3
Upper Boundary	8.2	7.4	10	9	11.2	10

There are still elements of conservatism in the AACS forecast. As noted above, the AACS demand does not include non manufactured goods or mail. Also, it does not include adjustments for air used as substitute service by the motor carriers. While the motor carriers do not generate traffic themselves, they can generate air traffic if they select air as a substitute for surface line-haul.

The motor carriers' projected use of the AACS as a substitute service was identified by the Case Studies. The demand forecast was 5.7 million tons (5.2 million metric tons) in 1990. There was some difficulty determining from the Case Study data where there might be an overlap in the shipper/consignee responses and the resulting cargo demand forecast and the motor carriers substitute service demand forecast, because the motor carrier serves most of those shipper/consignees who do not have their own private carriage. Therefore, while the motor carriers' demand for substitute service has not been quantified to the extent that it can be included in the AACS forecast, it will add to the AACS demand.

Figures III-9 and III-10 show the background for the air penetration versus transportaton revenue or yield correlation. Figure III-9 shows yield in constant 1976 dollars versus years from 1947 for the three major modes: rail, truck, and air. It shows a dramatic decrease in the yield by air with only a slight decrease for truck and a gradual increase for rail. This clearly shows that air has become a more economical mode of transportation since 1947, while truck has become only slightly more economical, and rail has become relatively more expensive.

Studies by Boeing (ref. 20) assume a continuation of constant yield in current dollars in a 5 percent inflationary economy resulting in a continuation of the downward trend of air yields in constant 1976 dollars. The 1976 yield for all-cargo services is 27 cents/tsm (30 cents/metric tsm) ; then the constant dollar value for year n = $\frac{27}{(1.05)^n}$, where n is number of years after 1976.

Year	n	Constant $ Yield	% Reduction in Yield from 1976
1980	4	22.2	17.8
1985	9	17.4	35.6
1990	14	13.6	49.6

For the total air cargo industry, the yield in 1976 is 31.8 cents/tsm. If this is held constant in current dollars during a 5% inflationary period through the year 2000, then the constant 1976 dollar values will be:

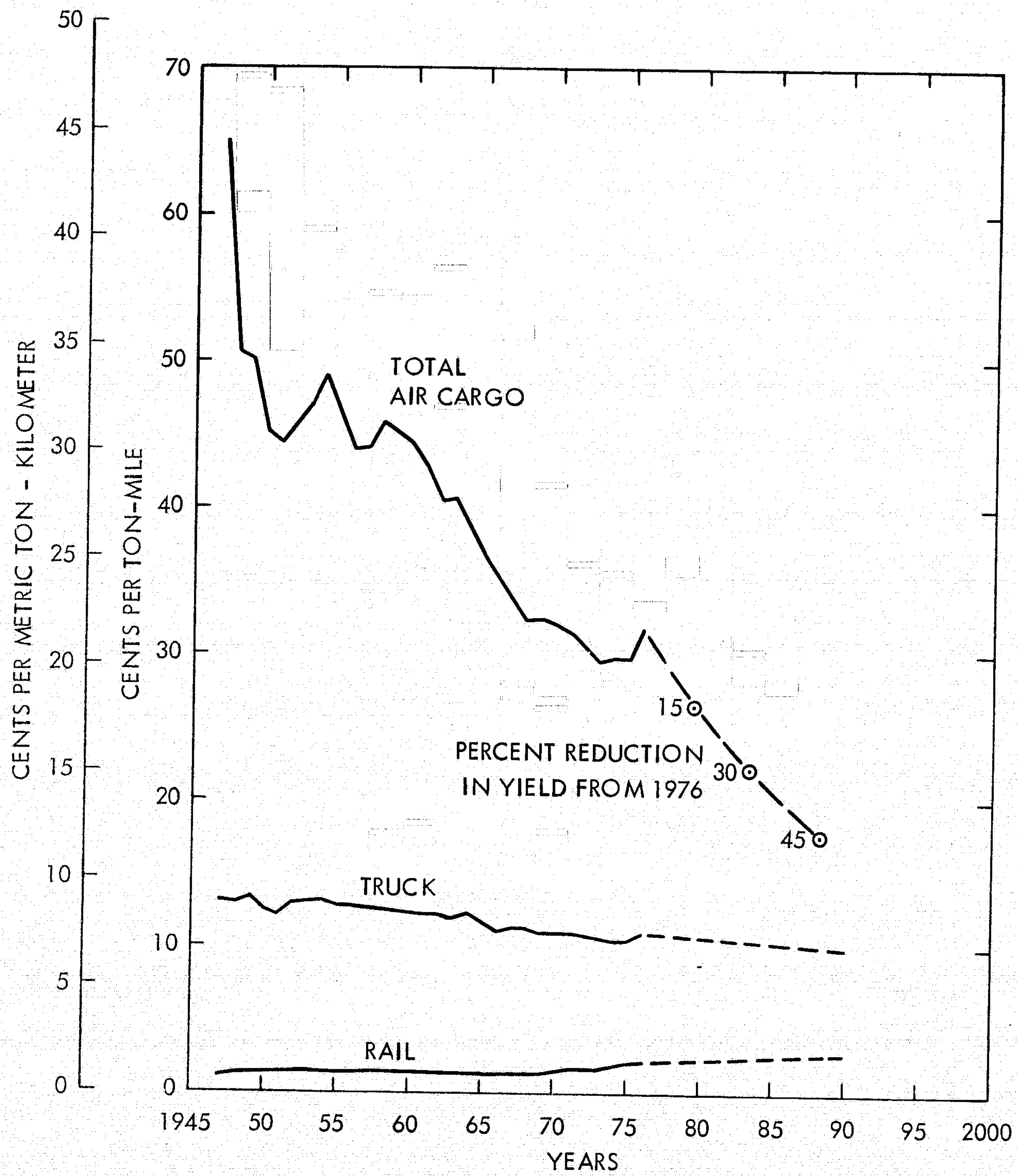


FIGURE III-9. TRANSPORTATION REVENUES IN 1976 DOLLARS

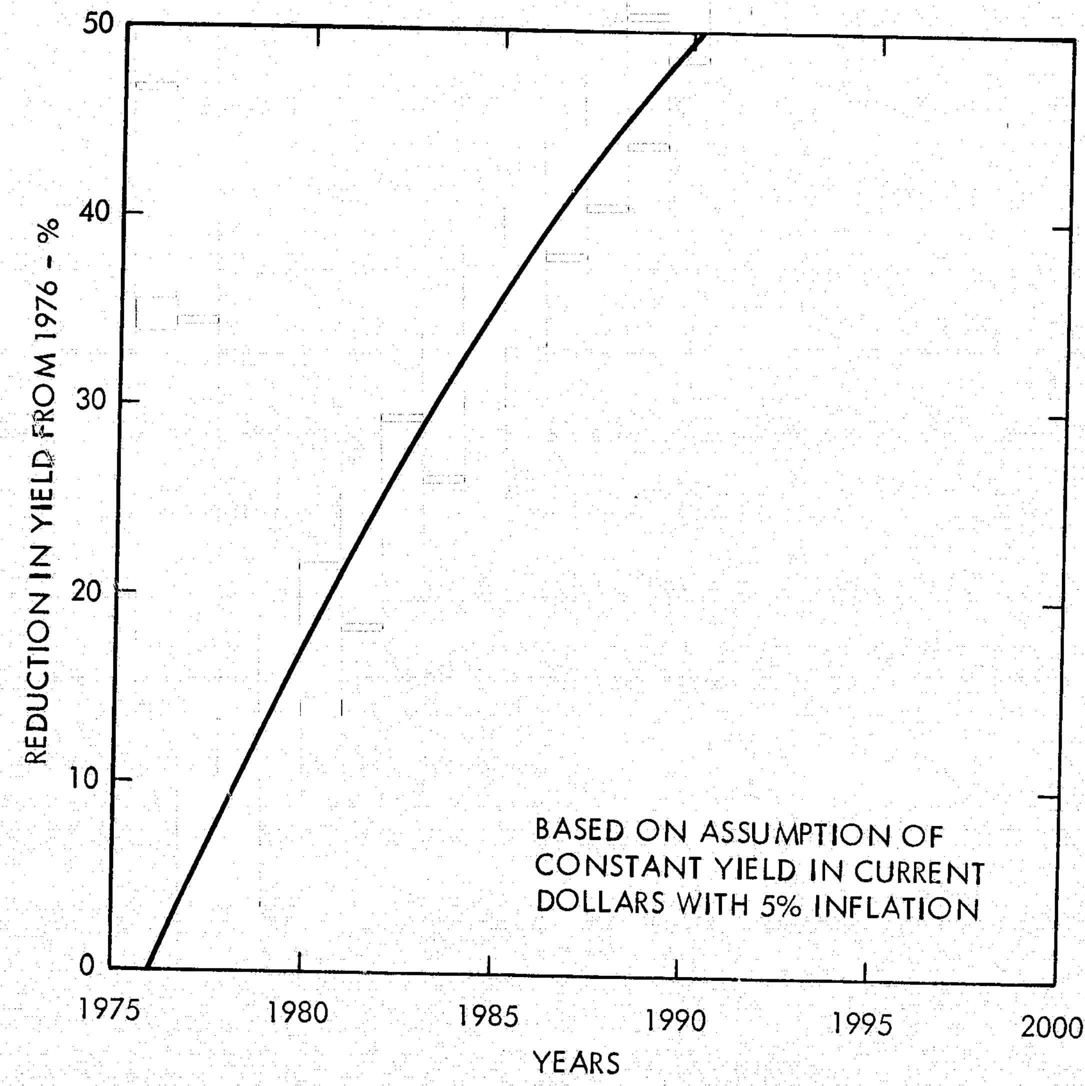


FIGURE III-10. REDUCTION IN YIELD FROM 1976

Year	Current Dollars	Constant 1976 Dollars	% Reduction in Yield from 1976
1976	31.8	31.8	----
1980	31.8	26.2	17.6
1985	31.8	20.5	35.5
1990	31.8	16.1	49.4

The 15-, 30-, and 45-percent reductions from 1976 levels are shown in Figure III-9. Figure III-10 shows the progressive reduction in yield from the 1976 levels versus time and shows that the 45 percent reduction in yields can be achieved by about 1988. Clearly, the historical reduction in air freight yield has been a major stimulus for the growth of air freight. Figure III-11 shows this increased penetration as a function of the constant 1976 dollar yield. These data are tabulated in Table III-8. The regression analysis, Table III-9, shows a continuation of this trend of growth in air penetration. this increase in air penetration is translated into tons in Figure III-12 for the various levels of yield reduction. Table III-10 presents the tabulated data for Figure III-12. From Figure III-12, several things are apparent: (1) 15-percent reduction in yield by 1991 may be required to achieve the ATA belly forecast; (2) the dotted line from the historical air data to the AACS demand presents the timing for the reductions in yield and shows the demand of 14 million tons (12.7 million metric tons) is achievable by 1988; and (3) the yield/penetration correlation for 45-percent reduction in yield is extremely close to the Case Study demand result for the 45-percent reduction in rates.

U.S. and Foreign International Transportation Data Analyses

The subject of U.S. and Foreign International Transportation, or expressed another way; Foreign Trade Transportation, is a difficult subject to address due to the lack of conformity of statistical data, and to the lack of specific modal data. Also, again due to the availability of statistical data, an approximation has been made in representing the Free-World foreign trade. The single, most-reliable source of foreign trade data is the OECD - the Organization for Economic Co-operation and Development. This organization publishes foreign trade data for the 24 OECD reporting nations in dollars and units of quantity, but not by the various modes. Since these 24 reporting nations trade between themselves and with the rest of the world, only the trade between any two less-developed nations is excluded, amounting to a loss of only a small percentage of world trade.

Since the OECD data do not include modal data, some approximations had to be made to arrive at modal data in order to ultimately arrive at the demand for the AACS. To establish these approximations, two further important data

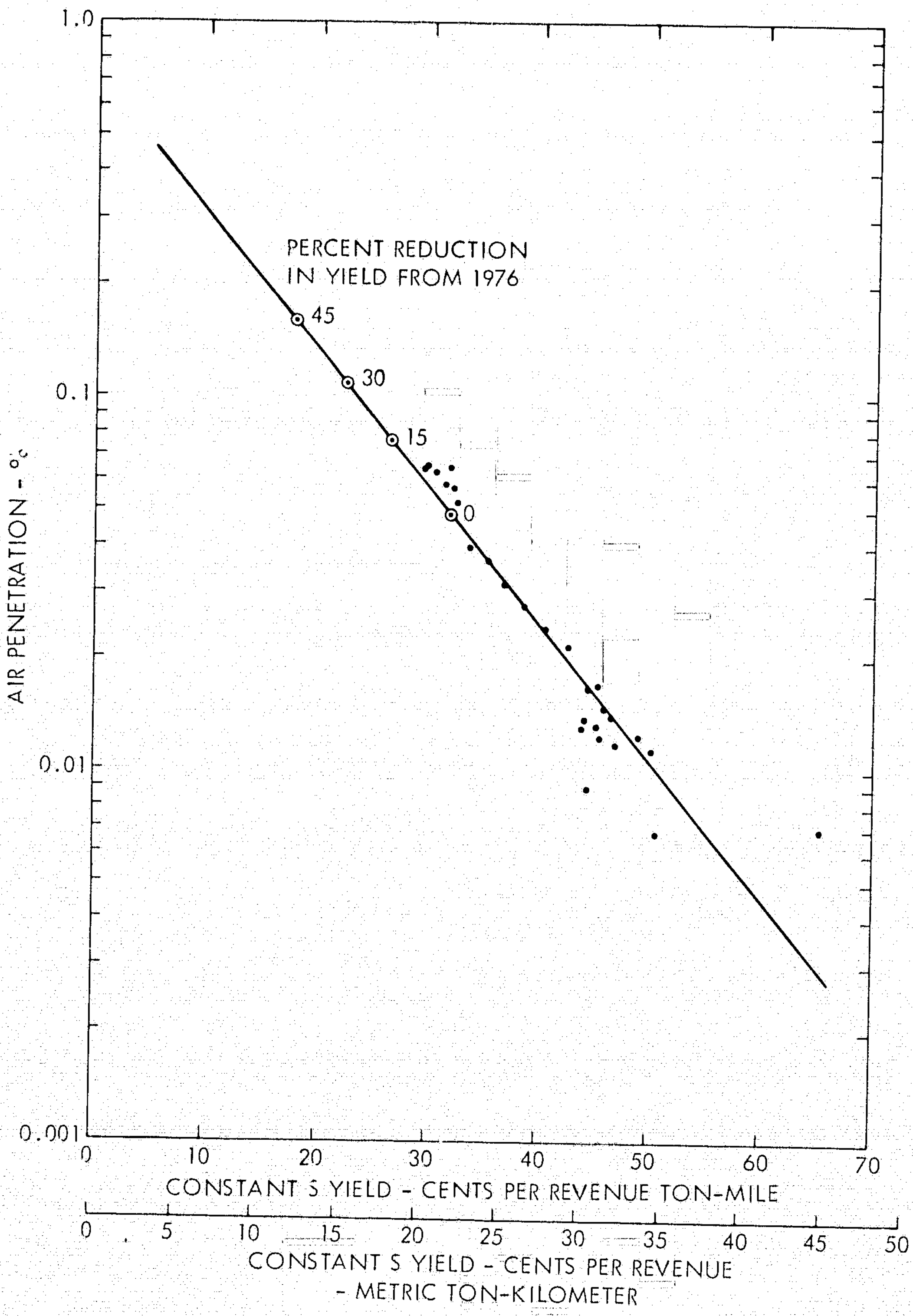


FIGURE III-11. AIR PENETRATION VS YIELD

TABLE III-8. U. S. DOMESTIC YIELD AND AIR PENETRATION

Years	Constant Dollar Yield ¢/tsm	¢/mt km	Air Penetration
1947	65.09	44.58	0.0070
1948	50.62	34.67	0.0068
1949	50.04	34.27	0.0113
1950	45.15	30.93	0.0131
1951	44.41	30.42	0.0090
1952	45.63	31.25	0.0123
1953	46.94	32.15	0.0117
1954	48.98	33.55	0.0124
1955	46.40	31.78	0.0140
1956	43.93	30.09	0.0130
1957	44.01	30.14	0.0137
1958	45.81	31.38	0.0147
1959	45.10	30.89	0.0170
1960	44.42	30.43	0.0166
1961	42.64	29.21	0.0216
1962	40.41	27.68	0.0232
1963	40.59	27.80	0.0240
1964	38.58	26.43	0.0275
1965	36.83	25.23	0.0316
1966	35.23	24.13	0.0363
1967	33.69	23.08	0.0396
1968	32.36	22.16	0.0495
1969	32.44	22.22	0.0523
1970	32.08	21.97	0.0573
1971	31.5	21.58	0.0579
1972	30.44	20.85	0.0630
1973	29.48	20.19	0.0641
1974	29.79	20.40	0.0654
1975	29.67	20.32	0.0653
1976	31.81	21.79	0.0645

TABLE III-9. U. S. DOMESTIC AIR FREIGHT YIELD VERSUS AIR PENETRATION REGRESSION ANALYSIS

Yield (x)	65.0900	40.4100
Penetration (y)	7.0000	23.2000
	50.6200	40.5900
	6.8000	24.0000
	50.0400	38.5800
	11.3000	27.5000
	45.1500	36.8300
	13.1000	31.6000
	44.4100	35.2300
	9.0000	36.3000
	45.6300	33.6900
	12.3000	39.6000
	46.9400	32.3600
	11.7000	49.5000
	48.9800	32.4400
	12.4000	52.3000
	46.4000	32.0800
	14.0000	57.3000
	43.9300	31.5000
	13.0000	57.9000
	44.0100	30.4400
	13.7000	63.0000
	45.8100	29.4800
	14.7000	64.1000
	45.1000	29.7900
	17.0000	65.4000
	44.4200	29.6700
	16.6000	65.3000
	42.6400	31.8100
	21.6000	64.5000

* Penetration is % x 1000.

Coefficient of Correlation		-0.8975
Linear: $y = a + bx$		
	(a)	123.3836693
	(b)	-2.2946042
Coefficient of Determination	(R^2)	0.8055063
Exponential: $y = ab^x$		
	(a)	709.2934568
	(b)	0.9194151
Coefficient of Determination	(R^2)	0.8886373
Geometric: $y = ax^b$		
	(a)	11,063,409.79
	(b)	-3.5469011
Coefficient of Determination	(R^2)	0.9332309

Standard Error of Estimate	
Linear	9.2248
Exponential	5.0774
Geometric	3.6227

Table III-9 (Continued)

Curve Generators

	Linear	Exponential (1)	Geometric
	123.3836693	709.2934568	11,063,409.79
	-2.2946042	0.9194151	-3.5469011
	1.	2.	3.
	5.0000	5.0000	5.0000
	5.0000	5.0000	5.0000
	65.0000	65.0000	65.0000
Yield	5.0000	5.0000	5.0000
Penetration (2)	111.9106	465.9981	36,703.8416
	10.0000	10.0000	10.0000
	100.4376	306.1556	3,140.4212
	15.0000	15.0000	15.0000
	88.9646	201.1409	745.4347
	20.0000	20.0000	20.0000
	77.4916	132.1474	268.6979
	25.0000	25.0000	25.0000
	66.0186	86.8194	121.7682
	30.0000	30.0000	30.0000
	54.5455	57.0394	63.7802
	35.0000	35.0000	35.0000
	43.0725	37.4743	36.9175
	40.0000	40.0000	40.0000
	31.5995	24.6202	22.9901
	45.0000	45.0000	45.0000
	20.1265	16.1752	15.1394
	50.0000	50.0000	50.0000
	8.6535	10.6269	10.4186
	55.0000	55.0000	55.0000
	-2.8196	6.9818	7.4301
	60.0000	60.0000	60.0000
	-14.2926	4.5869	5.4571
	65.0000	65.0000	65.0000
	-25.7656	3.0136	4.1083

(1) Exponential chosen since geometric gives impossible solution at low yields

(2) Penetration is percent times 1000

TABLE III-10. AIR FREIGHT VS YIELD

Percent Reduction in Yield	Constant-Dollar Yield	Air Penetration %	1980	Air Freight 1990 Short Tons (Millions)	2000
			6383.0[1]	8003.8[1]	10036.2[1]
0	31.80	0.0485	3.10	3.88	4.87
15	26.50	0.076	4.85	6.08	7.63
30	22.25	0.109	6.96	8.72	10.94
45	17.70	0.160	10.21	12.81	16.06
				Metric Tons (Millions)	
			5780.6[2]	7260.9[2]	9104.7[2]
0	31.80	0.0485	2.81	3.52	4.42
15	26.50	0.076	4.40	5.52	6.92
30	22.25	0.109	6.31	7.91	9.92
45	17.70	0.160	9.26	11.62	14.57

(1) Total freight, all modes (short tons).

(2) Total freight, all modes (metric tons).

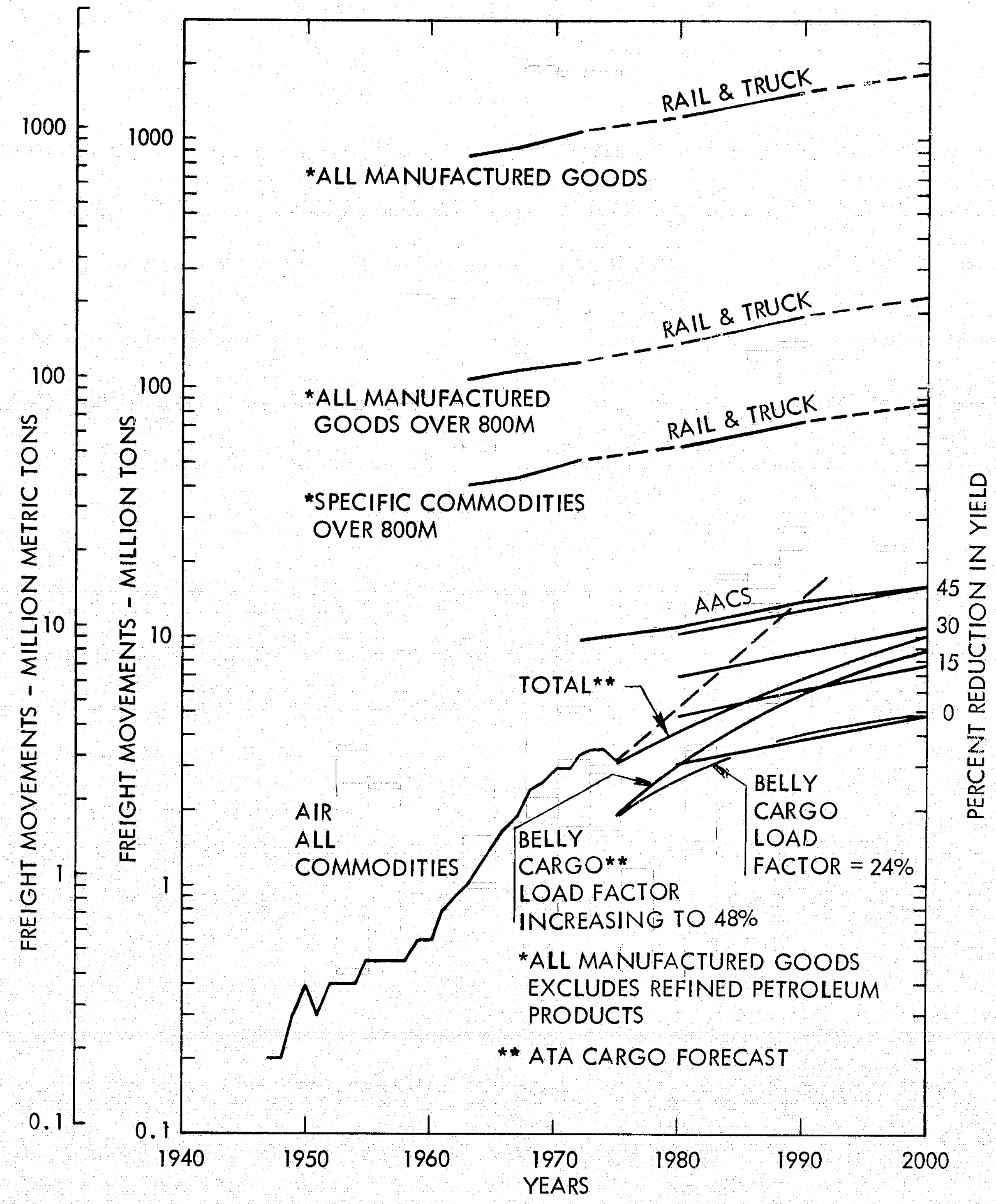


FIGURE III-12. MANUFACTURED GOODS MOVEMENT IN TONS VERSUS YEARS sources were used. The Department of Commerce (DOC) Annual Summary Data Analysis provides the modal statistical data for just U.S. foreign trade from which assumptions are made to arrive at the approximation of modal distribution in the OECD data. The Maritime Administration (MarAd) Long-Term Forecast, again for just U.S. foreign trade, provides a thorough understanding of the containerizability of commodities and provides a firm base, for comparison purposes, of a forecast to the year 2000.

In summary, the MarAd analysis identifies commodities by their historical level of seaborne containerization. With this information the DOC Annual Summary Data are analyzed to establish the modal distribution, by commodity and by levels of seaborne containerization. The relationship that is not evident is that the higher the level of seaborne containerization of a commodity, the higher the air penetration of that commodity. Results from these two sources are then applied to the OECD data to establish the "Free-World" demand for the AACS.

Maritime Administration Long-Term Forecast Data - The MarAd Long-Term Forecast provides forecasts to the year 2000 for all foreign trade commodities expressed at the 3-digit level for each of the U.S. trading partners. These trading partners have been grouped into major regions, and the commodities have been regrouped by degrees of containerization.

The degrees of containerization were developed by MarAd in analyses of 1974 U.S. Foreign Trade Data at the 4-digit level aggregated to the 3-digit level. These degrees of containerization are 0-5, 5-20, 20-40, 40-60 and 60-100 percent containerization. Each commodity was viewed as being to some degree containerizable. An important statement (ref. 21) by MarAd is "In 1974...growth rate (of containerization) abated somewhat, not because of any negative influences, but because the industry is approaching the limits of economic feasibility. By 1974 most containerizable commodities had already been adapted to containerized transport." (See Figure III-13.) This statement has added importance in the CLASS study in that it is assumed that the supply of cargo for the AACS will come from those commodities that are already containerized, and that the U.S. containerized seaborne cargo has reached a nearly mature market level. Future growth will approximate overall growth of foreign trade. In the MarAd analyses, each commodity was analyzed from the 1974 data to establish the percentage of that given commodity that was containerized. This analysis identified the level or economic limit of containerization for that commodity and identified the large quantities of bulk commodities, e.g., coal, oil, and grain, which are considered at least for the foreseeable future as not being eligible for the AACS.

For the remainder of this section, the terms "containerizable" and "containerized" are defined as follows:

- Containerizable - refers to the total tonnage, imports and exports, of those commodities of which some proportion is containerized from a low of near zero to 100 percent containerized. Of the 180 commodity descriptions at the 3-digit level only 14 for U.S. Imports and 15 for

FIGURE III-13

QUOTE FROM MARAD

"IN 1974, ... GROWTH RATE (OF CONTAINERIZATION) ABATED SOMEWHAT, NOT BECAUSE OF ANY NEGATIVE INFLUENCES, BUT BECAUSE THE INDUSTRY IS APPROACHING THE LIMITS OF ECONOMIC FEASIBILITY. BY 1974, MOST CONTAINERIZABLE COMMODITIES HAD ALREADY BEEN ADAPTED TO CONTAINERIZED TRANSPORT."

SOURCE: CONTAINERIZED CARGO STATISTICS, CALENDAR YEAR 1974
U. S. DEPARTMENT OF COMMERCE, MARITIME ADMINISTRATION

U.S. Exports are considered to be totally liquid or dry bulk and are not considered to be containerizable.

- o Containerized - refers to the actual tonnage moved in containers and is arrived at by multiplying the total tonnage of the 3-digit level description by the numerical average of the range of percent containerization. Based on the MarAd statement in Figure III-13, each commodity description is near its maximum level of economic containerization.

An introduction to the details of the actual 3-digit level commodity descriptions by their degree of containerization are presented in Appendix D. The full MarAd Long-Term Forecast at the 3-digit level for U.S. World totals and for 13 separate U.S. trading partner regions are also presented in the supplements. Supplement A presents the detailed forecast for U.S. imports and Supplement B presents the U.S. exports (may be obtained from NASA). The 3-digit commodity data, in metric tons, are summarized to the 1-digit level, and each level of containerization is also summarized. Percentage shares of the total U.S. imports or exports for each of summary levels are given. Material from these summaries are discussed here in the body of the report.

As shown in Table III-11E, for the containerizable imports and exports, 23 percent of the total tonnage that moved in U.S. Foreign Trade was actually containerizable and is forecast to grow to 33.5 percent by the year 2000. Tables III-12E and III-13E present imports and exports, respectively. This clearly illustrates how much the universe of foreign trade is reduced by extracting the 14 import and 15 export bulk commodities in order to arrive at the trade universe for the AACS. This universe is further reduced by establishing the actual containerized tonnage as described in the above definitions.

Looking at the results of these containerized tonnages in Table III-14E for imports and exports, we now see the trade universe for the AACS. The containerized tonnages for U.S. imports and exports combined amount to 2.8 percent of the total foreign trade tonnage in 1975 and are forecast to grow to 4.2 percent by the year 2000. The annual growth rate for 1975 through 2000 approximates 5 percent. Tables III-15E and III-16E present imports and exports, respectively, which show a very good balance for containerized imports and exports through the year 2000. As stated previously in Section II of the Case Studies, 5.6 percent of this containerized cargo can be considered to be air-penetrable by the AACS. Thus, the tonnage of U.S. foreign trade that could be moved by the AACS would be in the order of 991,500 metric tons or 0.157 percent of the U.S. total, had it been in service in 1975, and 3,396,000 metric tons or 0.235 percent of the U.S. total by the year 2000.

To convert the previously mentioned tonnage data into metric ton-miles the measure of productivity for aircraft, typical air distances are presented in Table III-17E. Since the U.S. is treated as an entity, an approximation has been developed to arrive at an average air distance from the U.S. to the various trading-partner regions.

TABLE III - 11E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZABLE CARGO - IMPORTS & EXPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS OF COMMODITIES 1975	1990	2000
60 - 100	5,367,226	15,910,101	29,109,956
40 - 60	8,044,586	17,493,828	28,267,450
20 - 40	15,209,775	26,993,646	38,999,384
5 - 20	35,223,335	62,056,694	92,314,788
0 - 5	96,894,320	210,410,214	344,881,788
TOTAL	160,739,242	332,864,483	533,573,366
BULK COMMODITIES	536,281,316	871,689,610	1,057,817,382
TOTAL TRADE	697,020,558	1,204,554,093	1,591,390,748
% CONTAINERIZABLE COMMODITIES	23.1	27.6	33.5

TABLE III - 12E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZABLE CARGO - IMPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS OF COMMODITIES 1975	1990	2000
60 - 100	4,569,819	12,726,918	22,179,588
40 - 60	3,124,960	7,797,409	13,340,380
20 - 40	3,684,690	5,944,508	8,266,008
5 - 20	11,323,499	21,389,073	32,714,410
0 - 5	33,623,397	67,850,675	105,606,599
TOTAL	56,326,365	115,708,583	182,106,985
BULK COMMODITIES	371,522,386	629,812,077	733,819,690
TOTAL IMPORTS	427,848,751	745,520,660	915,926,675
% OF CONTAINERIZABLE COMMODITIES	13.2	15.5	19.9

TABLE III - 13E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZABLE CARGO - EXPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS OF COMMODITIES 1975	1990	2000
60 - 100	797,407	3,183,183	6,930,368
40 - 60	4,919,626	9,696,419	14,927,070
20 - 40	11,525,085	21,049,138	30,733,376
5 - 20	23,899,836	40,667,621	59,600,378
0 - 5	63,270,923	142,559,539	239,275,189
TOTAL	104,412,877	217,155,900	351,466,381
BULK COMMODITIES	164,758,930	241,877,533	323,997,692
TOTAL EXPORTS	269,171,807	459,033,433	675,464,073
% OF CONTAINERIZABLE COMMODITIES	38.8	47.3	52.0

TABLE III-14E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS & EXPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS CONTAINERIZED 1975	1990	2000	1975-2000 ANNUAL GROWTH RATE - %
60 - 100	4,293,782	12,728,084	23,287,965	7.0
40 - 60	4,022,312	8,746,934	14,133,742	5.2
20 - 40	4,562,928	8,098,089	11,699,814	3.8
5 - 20	4,341,727	7,640,042	11,371,825	3.9
0 - 5	1,988,739	4,193,736	6,761,281	5.0
TOTAL	19,209,488	41,406,885	67,254,627	5.1
BULK COMMODITIES	677,811,070	1,163,147,208	1,524,136,121	3.3
TOTAL TRADE	697,020,558	1,204,554,093	1,591,390,748	3.4
% CONTAINERIZED COMMODITIES	2.8	3.4	4.2	

TABLE III-15E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS CONTAINERIZED 1975	1990	2000	ANNUAL GROWTH %
60 - 100	3,655,857	10,181,535	17,743,670	6.5
40 - 60	1,562,486	3,898,711	6,670,196	6.0
20 - 40	1,105,404	1,783,350	2,479,802	3.3
5 - 20	1,343,658	2,529,306	3,874,858	4.3
0 - 5	797,615	1,529,437	2,379,667	4.5
TOTAL	8,465,020	19,922,339	33,148,193	5.6
BULK COMMODITIES	419,383,731	725,598,321	882,778,482	3.0
TOTAL IMPORTS	427,848,751	745,520,660	915,926,675	3.1
% OF CONTAINERIZED COMMODITIES	2.0	2.7	3.6	

TABLE III-16E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - EXPORTS

PERCENT CONTAINERIZATION	TOTAL SHORT TONS CONTAINERIZED 1975	1990	2000	ANNUAL GROWTH %
60 - 100	637,925	2,546,549	5,544,295	9.0
40 - 60	2,459,826	4,848,223	7,463,546	4.5
20 - 40	3,457,524	6,314,739	9,220,012	4.0
5 - 20	2,998,069	5,110,736	7,496,967	3.7
0 - 5	1,191,124	2,664,299	4,381,614	5.3
TOTAL	10,744,468	21,484,546	34,106,434	4.7
BULK COMMODITIES	268,427,339	437,548,887	641,357,639	3.5
TOTAL EXPORTS	269,171,807	459,033,433	675,464,073	3.7
% CONTAINERIZED COMMODITIES	4.0	4.7	5.1	

TABLE III - 17E. MARAD SEABORNE DATA ANALYSIS

AIR DISTANCES - STATUTE MILES

TO/FROM	NEW YORK	CHICAGO	LOS ANGELES	AVERAGE(1)
1 CANADA	-	-	-	1,000
2 OECD EUROPE	4,000	4,400	5,700	4,460
3 OTHER FREE EUROPE	-	-	-	4,500
4 JAPAN	6,800	6,300	5,400	6,370
5 AUSTRALIA	10,300	9,500	7,600	9 520
6 NEW ZEALAND	9,400	8,400	6,600	8,540
7 MIDDLE EAST	6,600	7,100	8,300	7,090
8 AFRICA	6,000	7,000	8,000	6,700
9 L/D ASIA	10,100	9,300	8,400	9,520
10 L/D AMERICA	4,800	5,400	6,500	5,320
11 COMMUNIST EUROPE	4,600	5,000	6,300	5,060
12 COMMUNIST ASIA	8,300	7,800	6,900	7,870
13 ALL OTHER COUNTRIES	-	-	-	6,200

(1) Weighted average based on traffic distribution of 50% New York, 30% Chicago, and 20% Los Angeles.

The regional distribution by tonnage of containerized seaborne trade are presented in Tables III-18E through III-20E. The tables clearly show for 1975 the predominance of OECD Europe with 38 percent share of the total U.S. Imports and Exports. With Japan - 17 percent share, Less Developed America - almost 15 percent, and Less Developed Asia - almost 14 percent, these top four regions account for almost 84 percent of total U.S. containerized trade. The MarAd forecast by the year 2000 shows some small changes in the percent share and thus ranking from 1975, but the top 2 are unchanged in ranking.

Comparable data in ton-miles based on the average airborne distances are presented in Tables III-21E through III-23E. OECD Europe remains the number one U.S. regional partner with 29 percent share, but due to the greater distances from the U.S., Less Developed America with 13 percent. Again, these top four regions account for almost 83 percent of total U.S. containerized trade. No changes in the ranking of these top four regions are anticipated through the year 2000.

Total cargo, bulk and containerized, is summarized by region in Tables III-24E and III-25E for improts and exports, respectively. The percentages of containerized tonnage is also presented. The data show the effect of massive bulk (petroleum) imports from the Middle East, Africa, and L/D America on the containerized percentage.

Table III-26E correlates airborne trade with containerized seaborne for 1975 only. It is seen that for most regions the regional share of total airborne tonnage is comparable with the region share of containerized seaborne tonnage. For example, OECD Europe airborne imports comprise 38 percent of the total airborne imports, and OECD Europe seaborne containerized imports comprise 39 percent of the total seaborne imports.

Tables III-27E and III-28E present the top U.S. trade partner regions for imports and exports, respectively. The rankings are based on the containerized seaborne trade and show a high degree of concentration in the top six for both imports and exports. The top six regions account for almost 95 percent of the containerized seaborne imports and almost 92 percent for exports. Airborne tonnage is also presented based on the containerized seaborne rankings, and similarly high concentrations are seen in the accumulated percentage of total airborne tonnage. For imports, the six ranked regions account for almost 98 percent, while for exports, the six regions account for over 90 percent.

Air penetration based on the combined totals of containerized seaborne and airborne tonnages is also presented. Figures III-27E and III-28E show, for the top six regions and for all regions for imports and exports, air penetration to be approximately 6 percent, more than 30 times the air penetration number when based on all commodities, bulk and containerized.

Department of Commerce Annual Summary Data Analysis - In addition to the MarAd Seaborne Long-Term Forecast previously discussed, computerized analyses of 1968, 1970, 1972, 1974, and 1976 annual summaries for total U.S. imports

TABLE III - 18E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS + EXPORTS - TONS

REGION	DISTANCE SM	1975 TONS	1975 % OF TOTAL	1990 TONS	1990 % OF TOTAL	2000 TONS	2000 % OF TOTAL
1. CANADA	1,000	508,784	2.65	1,127,270	2.72	1,713,757	2.55
2. OECD EUROPE	4,460	7,363,294	38.33	16,367,377	39.53	26,957,766	40.08
3. OTHER FREE EUROPE	4,500	95,620	0.50	225,340	0.54	371,571	0.55
4. JAPAN	6,370	3,304,816	17.21	7,737,946	18.69	12,612,799	18.75
5. AUSTRALIA	9,520	541,051	2.82	1,401,263	3.38	2,370,098	3.52
6. NEW ZEALAND	8,540	167,650	0.87	397,248	0.96	612,173	0.91
7. MIDDLE EAST	7,090	630,939	3.28	1,197,711	2.89	1,941,197	2.89
8. AFRICA	6,700	655,033	3.41	975,554	2.36	1,441,164	2.14
9. L/D ASIA	9,520	2,593,774	13.50	5,701,430	13.77	9,432,987	14.03
10. L/D AMERICA	5,320	2,837,938	14.77	5,229,054	12.63	8,101,478	12.05
11. COMMUNIST EUROPE	5,060	356,324	1.85	696,816	1.68	1,111,208	1.65
12. COMMUNIST ASIA	7,870	131,902	0.69	313,950	0.76	543,403	0.81
13. ALL OTHER COUNTRIES	6,200	22,524	0.12	36,072	0.09	45,201	0.07
TOTAL		19,209,649		41,407,031		67,254,802	

TABLE III - 19E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS - TONS

REGION	DISTANCE SM	1975 TONS	1975 % OF TOTAL	1990 TONS	1990 % OF TOTAL	2000 TONS	2000 % OF TOTAL
1. CANADA	1,000	266,874	3.15	438,829	2.20	613,336	1.85
2. OECD EUROPE	4,460	3,341,801	39.48	8,314,733	41.74	14,127,895	42.62
3. OTHER FREE EUROPE	4,500	55,882	0.66	105,371	0.53	164,479	0.50
4. JAPAN	6,370	1,749,839	20.67	4,737,579	23.78	8,122,981	24.51
5. AUSTRALIA	9,520	301,129	3.56	758,418	3.81	1,276,310	3.85
6. NEW ZEALAND	8,540	112,505	1.33	231,492	1.16	323,099	0.97
7. MIDDLE EAST	7,090	53,600	0.63	110,835	0.56	176,617	0.53
8. AFRICA	6,700	136,885	1.62	153,018	0.77	178,346	0.54
9. L/D ASIA	9,520	1,333,604	15.75	3,187,157	16.00	5,424,532	16.36
10. L/D AMERICA	5,320	926,732	10.95	1,581,554	7.94	2,247,944	6.78
11. COMMUNIST EUROPE	5,060	149,967	1.77	230,096	1.15	352,760	1.06
12. COMMUNIST ASIA	7,870	31,991	0.38	62,457	0.31	127,323	0.38
13. ALL OTHER COUNTRIES	6,200	4,263	0.05	10,857	0.05	12,621	0.04
TOTAL		8,465,072		19,922,396		33,148,243	

TABLE III - 20E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - EXPORTS - TONS

REGION	DISTANCE SM	1975 TONS	1975 % OF TOTAL	1990 TONS	1990 % OF TOTAL	2000 TONS	2000 % OF TONS
1. CANADA	1,000	241,910	2.25	688,441	3.20	1,100,421	3.23
2. OECD EUROPE	4,460	4,021,493	37.43	8,052,644	37.48	12,829,871	31.62
3. OTHER FREE EUROPE	4,500	39,738	0.37	119,969	0.56	207,092	0.61
4. JAPAN	6,370	1,554,977	14.47	3,000,367	13.97	4,489,818	0.13
5. AUSTRALIA	9,520	239,922	2.23	642,845	2.99	1,093,788	3.21
6. NEW ZEALAND	8,540	55,145	0.51	165,756	0.77	289,074	0.85
7. MIDDLE EAST	7,090	577,339	5.37	1,086,876	5.06	1,764,580	5.17
8. AFRICA	6,700	518,148	4.82	822,536	3.83	1,262,818	3.70
9. L/D ASIA	9,520	1,260,170	11.73	2,514,273	11.70	4,008,455	11.75
10. L/D AMERICA	5,320	1,911,206	17.79	3,647,500	16.98	5,853,534	17.16
11. COMMUNIST EUROPE	5,060	206,357	1.92	466,720	2.17	758,448	2.22
12. COMMUNIST ASIA	7,870	99,911	0.93	251,493	1.17	416,080	1.22
13. ALL OTHER COUNTRIES	6,200	18,261	0.17	25,215	0.12	32,580	0.10
TOTAL		10,744,577		21,484,635		34,106,559	

TABLE III - 21E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS & EXPORTS - TON-MILES

REGION	DISTANCE SM	1975 TON-MILES (MILLIONS)	1975 % OF TOTAL	1990 TON-MILES (MILLIONS)	1990 % OF TOTAL	2000 TON-MILES (MILLIONS)	2000 % OF TOTAL
1. CANADA	1,000	508.784	0.45	1,127.27	0.46	1,713.757	0.43
2. OECD EUROPE	4,460	32,840.290	29.05	72,998.501	29.86	120,231.63	30.19
3. OTHER FREE EUROPE	4,500	430.290	0.38	1,014.031	0.41	1,672.07	0.42
4. JAPAN	6,370	21,051.677	18.62	49,290.715	20.16	80,343.528	20.17
5. AUSTRALIA	9,520	5,150.805	4.56	13,340.023	5.46	22,563.332	5.67
6. NEW ZEALAND	8,540	1,431.731	1.27	3,392.498	1.39	5,227.957	1.31
7. MIDDLE EAST	7,090	4,473.358	3.96	8,491.771	3.47	13,763.087	3.46
8. AFRICA	6,700	4,388.722	3.88	6,536.212	2.67	9,655.799	2.42
9. L/D ASIA	9,520	24,692.728	21.84	54,277.614	22.20	89,802.036	22.55
10. L/D AMERICA	5,320	15,097.829	13.36	27,818.567	11.38	43,099.862	10.82
11. COMMUNIST EUROPE	5,060	1,802.999	1.59	3,525.889	1.44	5,622.713	1.41
12. COMMUNIST ASIA	7,870	1,038.069	0.92	2,470.787	1.01	4,276.582	1.07
13. ALL OTHER COUNTRIES	6,200	139.649	0.12	223.646	0.09	280.246	0.07
TOTAL		113,046.900		244,507.470		398,252.550	

TABLE III - 22E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - IMPORTS - TON-MILES

REGION	DISTANCE SM	1975 TON-MILES (MILLIONS)	1975 PERCENT OF TOTAL	1990 TON-MILES (MILLIONS)	1990 PERCENT OF TOTAL	2000 TON-MILES (MILLIONS)	2000 PERCENT OF TOTAL
1. CANADA	1,000	266.874	0.53	438.829	0.37	613.336	0.31
2. OECD EUROPE	4,460	14,904.432	29.60	37,083.709	30.99	63,010.411	31.52
3. OTHER FREE EUROPE	4,500	251.469	0.50	474.170	0.40	740.156	0.37
4. JAPAN	6,370	11,146.474	22.13	30,178.378	25.22	51,743.388	25.88
5. AUSTRALIA	9,520	2,866.748	5.69	7,220.139	6.03	12,150.471	6.08
6. NEW ZEALAND	8,540	960.793	1.91	1,976.942	1.65	2,759.265	1.38
7. MIDDLE EAST	7,090	380.024	0.75	785.820	0.66	1,252.215	0.63
8. AFRICA	6,700	917.130	1.82	1,025.221	0.86	1,194.918	0.60
9. L/D ASIA	9,520	12,695.910	25.21	30,341.735	25.36	51,641.545	25.83
10. L/D AMERICA	5,320	4,930.214	9.79	8,413.867	7.03	11,959.062	5.98
11. COMMUNIST EUROPE	5,060	758.833	1.51	1,164.286	0.97	1,784.966	0.89
12. COMMUNIST ASIA	7,870	251.769	0.50	491.537	0.41	1,002.032	0.50
13. ALL OTHER COUNTRIES	6,200	26.431	0.05	67.313	0.06	78.250	0.04
TOTAL		50,357.100		119,661.920		199,929.980	

TABLE III - 23E. MARAD SEABORNE DATA ANALYSIS

CONTAINERIZED CARGO - EXPORTS - TON-MILES

REGION	DISTANCE SM	1975 TON-MILES (MILLIONS)	1975 PERCENT OF TOTAL	1990 TON-MILES (MILLIONS)	1990 PERCENT OF TOTAL	2000 TON-MILES (MILLIONS)	2000 PERCENT OF TOTAL
1. CANADA	1,000	241.910	0.39	688.441	0.55	1,100.421	0.55
2. OECD EUROPE	4,460	17,935.858	28.61	35,914.792	28.77	57,221.224	28.85
3. OTHER FREE EUROPE	4,500	178.821	0.29	539.861	0.43	931.914	0.47
4. JAPAN	6,370	9,905.203	15.80	19,112.337	15.31	28,600.140	14.42
5. AUSTRALIA	9,520	2,284.057	3.64	6,119.884	4.90	10,412.861	5.25
6. NEW ZEALAND	8,540	470.938	0.75	1,415.556	1.13	2,468.692	1.24
7. MIDDLE EAST	7,090	4,093.334	6.53	7,705.951	6.17	12,510.872	6.31
8. AFRICA	6,700	3,471.592	5.54	5,510.991	4.41	8,460.881	4.27
9. L/D ASIA	9,520	11,996.818	19.14	23,935.879	19.17	38,160.492	19.24
10. L/D AMERICA	5,320	10,167.615	16.22	19,404.700	15.54	31,140.800	15.70
11. COMMUNIST EUROPE	5,060	1,044.166	1.67	2,361.603	1.89	3,837.747	1.94
12. COMMUNIST ASIA	7,870	786.300	1.25	1,979.250	1.59	3,274.550	1.65
13. ALL OTHER COUNTRIES	6,200	113.218	0.18	156.333	0.13	201.996	0.10
TOTAL		62,689.830		124,845.560		198,322.560	

TABLE III - 24E. MARAD SEABORNE DATA ANALYSIS

TOTAL CARGO - IMPORTS - BY REGIONS

REGION	1975 TOTAL TONS (THOUS)	1975 PERCENT CONTAIN-ERIZED	1990 TOTAL TONS (THOUS)	1990 PERCENT CONTAIN-ERIZED	2000 TOTAL TONS (THOUS)	2000 PERCENT CONTAIN-ERIZED
1. CANADA	35,752	0.75	54.424	0.81	64,493	0.95
2. OECD EUROPE	23,967	13.94	64,231	12.95	103,251	13.68
3. OTHER FREE EUROPE	284	19.68	375	28.10	539	30.52
4. JAPAN	10,516	16.64	19,747	23.99	29,530	27.51
5. AUSTRALIA	5,596	5.38	11,043	6.87	21,647	5.90
6. NEW ZEALAND	230	48.92	468	49.46	675	47.87
7. MIDDLE EAST	66,455	0.08	127,754	0.09	145,265	0.12
8. AFRICA	87,745	0.16	150,021	0.10	169,117	0.11
9. L/D ASIA	31,340	4.26	53,123	6.00	64,118	8.46
10. L/D AMERICA	161,810	0.57	258,924	0.61	308,993	0.73
11. COMMUNIST EUROPE	3,950	3.80	4,906	4.69	7,505	4.70
12. COMMUNIST ASIA	104	30.76	177	35.29	336	37.89
13. ALL OTHER COUNTRIES	95	4.49	323	3.36	451	2.80
	427,844	1.98	745,516	2.67	915,920	3.62

TABLE III - 25E. MARAD SEABORNE DATA ANALYSIS

TOTAL CARGO - EXPORTS - BY REGIONS

REGION	1975 TOTAL TONS (THOUS)	1975 PERCENT CONTAIN-ERIZED	1990 TOTAL TONS (THOUS)	1990 PERCENT CONTAIN-ERIZED	2000 TOTAL TONS (THOUS)	2000 PERCENT CONTAIN-ERIZED
1. CANADA	33,280	0.73	47,523	1.45	62,490	1.76
2. OECD EUROPE	82,559	4.87	128,449	6.27	182,461	7.03
3. OTHER FREE EUROPE	377	10.54	1,248	9.61	1,879	11.02
4. JAPAN	68,600	2.27	129,643	2.31	199,787	2.25
5. AUSTRALIA	1,615	14.86	3,768	17.06	6,117	17.88
6. NEW ZEALAND	442	12.48	1,337	12.40	2,316	12.48
7. MIDDLE EAST	7,687	7.51	12,133	8.96	18,403	9.59
8. AFRICA	8,126	6.38	11,383	7.23	16,298	7.75
9. L/D ASIA	23,591	5.34	34,789	7.23	49,325	8.13
10. L/D AMERICA	28,644	6.67	49,813	7.32	76,571	7.64
11. COMMUNIST EUROPE	13,507	1.53	31,116	1.50	48,162	1.57
12. COMMUNIST ASIA	623	16.04	7,581	3.32	11,346	3.67
13. ALL OTHER COUNTRIES	118	15.48	235	10.73	302	10.79
	269,169	3.99	459,018	4.68	675,457	5.05

TABLE III - 26E. COMPARISON OF AIRBORNE AND CONTAINERIZED SEABORNE TRADE - 1975 DATA

	IMPORTS				EXPORTS			
	AIRBORNE		SEABORNE		AIRBORNE		SEABORNE	
REGION	TONS	PERCENT OF TOTAL	TONS	PERCENT OF TOTAL	TONS	PERCENT OF TOTAL	TONS	PERCENT OF TOTAL
1. CANADA	17,450	3.28	266,874	3.15	44,000	6.26	241,910	2.25
2. OECD EUROPE	202,600	38.13	3,341,801	39.48	289,400	41.18	4,021,493	37.43
3. OTHER FREE EUROPE	2,050	0.39	55,882	0.66	2,150	0.31	39,738	0.37
4. JAPAN	56,350	10.60	1,749,839	20.67	39,900	5.68	1,554,977	14.47
5. AUSTRALIA	3,350	0.63	301,129	4.89	17,200	2.45	239,922	2.74
6. NEW ZEALAND			112,505				55,145	
7. MIDDLE EAST	3,700	0.70	53,600	0.63	44,300	6.30	577,339	5.37
8. AFRICA	2,900	0.55	136,885	1.62	22,200	3.16	518,148	4.82
9. L/D ASIA	127,850	24.06	1,333,604	15.75	38,500	5.48	1,260,170	11.73
10. L/D AMERICA	112,100	21.10	926,732	10.95	200,350	28.51	1,911,206	17.79
11. COMMUNIST EUROPE	1,900	0.36	149,967	1.77	4,550	0.65	206,357	1.92
12. COMMUNIST ASIA	500	0.09	31,991	0.38	150	0.02	99,911	0.93
13. ALL OTHER COUNTRIES	650	0.12	4,263	0.05	-	-	18,261	0.17
	531,400	100	8,465,072	100	702,700	100	10,744,577	100

TABLE III - 27E. TOP U. S. TRADE PARTNER REGIONS IN 1975 - IMPORTS

RANKED BY SEABORNE TRADE

RANK	REGION	CONTAINERIZED SEABORNE TRADE TONS	% SHARE	CUM %	AIRBORNE TRADE TONS	% SHARE	CUM %	AIR PENETRATION PERCENT
1	OECD EUROPE	3,341,801	39.48	39.48	202,600	38.13	38.13	5.72
2	JAPAN	1,749,839	20.67	60.15	56,350	10.60	48.73	3.12
3	L/D ASIA	1,333,604	15.75	75.90	127,850	24.06	72.79	8.75
4	L/D AMERICA	926,732	10.95	86.85	112,100	21.10	93.89	10.79
5	AUSTRALIA & NEW ZEALAND	413,634	4.89	91.74	3,350	0.63	94.52	0.80
6	CANADA	266,874	3.15	94.89	17,450	3.28	97.80	6.14
	TOTAL TOP 6	8,032,484	94.89		519,700	97.80		6.08
	ALL REGIONS	8,465,072	100.00		531,400	100.00		5.91

TABLE III - 28E. TOP U. S. TRADE PARTNER REGIONS - EXPORTS

RANKED BY SEABORNE TRADE

RANK	REGION	CONTAINERIZED SEABORNE TRADE TONS	% SHARE	CUM %	AIRBORNE TRADE TONS	% SHARE	CUM %	AIR PENETRATION PERCENT
1	OECD EUROPE	4,021,493	37.43	37.43	289,400	41.18	41.18	6.71
2	L/D AMERICA	1,911,206	17.79	55.22	200,350	28.51	69.69	9.49
3	JAPAN	1,554,977	14.47	69.69	39,900	5.68	75.37	2.50
4	L/D ASIA	1,260,170	11.73	81.42	38,500	5.48	80.85	2.96
5	MIDDLE EAST	577,339	5.37	86.79	44,300	6.30	87.15	7.13
6	AFRICA	518,148	4.82	91.61	22,200	3.16	90.31	4.11
	TOTAL TOP 6	9,843,333	91.61		634,650	90.31		6.06
	ALL REGIONS	10,744,577	100.00		702,700	100.00		6.14

and exports at the 3-digit level have been made with the commodities categorized by their degree of containerization obtained from the Maritime Administration data analyses. From these analyses, rankings by commodity based on tonnage, value, and unit value ($ per pound or kilo) for airborne and vessel-borne trade, air penetration, and degrees of containerization have been made.

Tonnage, unit value, and air penetration data from these analyses are presented in Tables III-29E and III-30E and Figures III-14 through III-17 for 1976 imports, and in Tables III-31E and III-32E and Figures III-18 through III-21E for 1976 exports. The tables present commodity unit value versus cumulative air tons, cumulative seaborne tons, and the addition of air and seaborne. This addition,, divided by the air tonnage, represents the factor times present air by which airborne trade could grow if all seaborne goods were transferred to the air mode for that given unit value or higher. The potential air penetration is also presented. Total seaborne data and containerized seaborne data are presented separately in the tables, but together in the figures.

Historically, the higher-valued commodities have moved by air, since it is only these commodities that have shown the ability to absorb the higher cost of air transportation. From the 1976 U.S. import data presented in Tables III-29E and III-30E and Figure III-15, the following is derived:

Commodity Unit Value More Than ($/Pound)	% Moved By Air	% Moved By Sea	% Containerized and Moved by Sea
4.00	69.3	0.026	1.00
2.00	82.5	0.251	9.27
0.80	95.7	1.797	38.41
0.10	99.99	8.406	91.81

For example, under the column headed "% Moved By Air," 99.99 percent of all commodities moving by air-freight are worth 10 cents per pound or more, 95.7 percent are worth 80 cents or more, and so on. The big potential for growth in air freight lies in those commodities worth between $2.00 per pound and 80 cents and currently moving as containerized seaborn freight. If those import commodities were moved by the AACS, air freight would increase by over 7 fold. This would still result in an air penetration by weight of less than 1 percent.

Similar results are derived from Tables III-31 and -32 and Figure III-19 for 1976 U.S. export data, as follows:

TABLE III-29E. U. S. FOREIGN TRADE VERSUS UNIT VALUE

AIR AND TOTAL SEABORNE - 1976 IMPORTS

UNIT VALUE $/LB	CUM AIR TONS	CUM VESSEL TONS	AIR + VESSEL TONS	AIR + VESSEL / AIR	POTENTIAL[1] AIR PENETRATION %
70	4,700	0	4,700	1.0	0.0009
60	8,000	0	8,000	1.0	0.001
50	9,700	100	9,800	1.01	0.001
40	11,000	180	11,180	1.016	0.002
30	13,200	400	13,600	1.030	0.002
20	70,000	1,200	71,200	1.017	0.013
10	117,000	20,000	137,000	1.170	0.026
9	150,000	22,000	172,000	1.146	0.033
8	175,000	24,500	199,500	1.140	0.038
7	175,000	24,500	199,500	1.140	0.038
6	315,000	25,000	340,000	1.079	0.065
5	345,000	57,000	402,000	1.165	0.077
4	420,000	137,000	557,000	1.326	0.107
3	460,000	1,140,000	1,600,000	3.478	0.308
2	500,000	1,300,000	1,800,000	3.600	0.347
1	580,000	9,000,000	9,580,000	16.517	1.848
0.9	580,000	9,200,000	9,780,000	16.862	1.887
0.8	580,000	9,300,000	9,880,000	17.034	1.906
0.7	582,000	10,900,000	11,482,000	19.728	2.216
0.6	584,000	13,500,000	14,084,000	24.116	2.718
0.5	586,000	14,500,000	15,086,000	25.744	2.911
0.4	588,000	16,200,000	16,788,000	28.551	3.240
0.3	590,000	20,000,000	20,590,000	34.898	3.973
0.2	600,000	21,800,000	22,400,000	37.333	4.323
0.1	606,000	43,500,000	44,106,000	72.782	8.513
0	606,078	517,512,804	518,118,882	854.872	100.0

Grand Total - Vessel	517,512,804
Air	606,078
Vessel & Air	518,118,882
Actual Air Penetration - %	.117

(1) Potential Air Penetration of total trade if air obtained all vessel-borne traffic above given unit value

TABLE III-30E. U. S. FOREIGN TRADE VERSUS UNIT VALUE - AIR AND CONTAINERIZED SEABORNE - 1976 IMPORTS

UNIT VALUE $/LB	CUM AIR TONS	CUM CONT'Z'D VESSEL TONS	CONT'Z'D AIR + VESSEL TONS	CONT'Z'D AIR + VESSEL / AIR	POTENTIAL[1] AIR PENETRATION %
70	4,700	0	4,700	1.0	0.0009
60	8,000	0	8,000	1.0	0.001
50	9,700	15	9,715	1.001	0.001
40	11,000	35	11,035	1.003	0.002
30	13,200	107	13,307	1.008	0.002
20	70,000	500	70,500	1.007	0.013
10	117,000	15,700	132,700	1.134	0.025
9	150,000	17,000	167,000	1.113	0.032
8	175,000	18,600	193,600	1.106	0.037
7	175,000	19,000	194,000	1.108	0.037
6	315,000	19,000	334,000	1.060	0.064
5	345,000	46,000	391,000	1.133	0.075
4	420,000	107,000	527,000	1.254	0.101
3	460,000	880,000	1,340,000	2.913	0.258
2	500,000	990,000	1,490,000	2.980	0.287
1	580,000	3,800,000	4,380,000	7.552	0.845
0.9	580,000	3,920,000	4,500,000	7.758	0.868
0.8	580,000	4,100,000	4,680,000	8.068	0.903
0.7	582,000	4,600,000	5,182,000	8.903	1.000
0.6	584,000	5,400,000	5,984,000	10.246	1.154
0.5	586,000	6,200,000	6,786,000	11.580	1.309
0.4	588,000	6,800,000	7,388,000	12.564	1.425
0.3	590,000	8,050,000	8,640,000	14.644	1.667
0.2	600,000	8,600,000	9,200,000	15.333	1.775
0.1	606,000	9,800,000	10,406,000	17.172	2.008
0	606,078	10,674,547	11,280,625	18.612	2.177
INCORPORATING CASE STUDY RESULTS					
0.1	606,000	548,800[2]	1,154,800	1.906	0.223
0	606,078	597,775[2]	1,203,853	1.986	0.232

(1) Potential Air Penetration of total trade of Table III-33 if air obtained all containerized vessel-borne traffic above given unit value

(2) 5.6 percent penetration of containerized seaborne trade from Carrier Case Study results

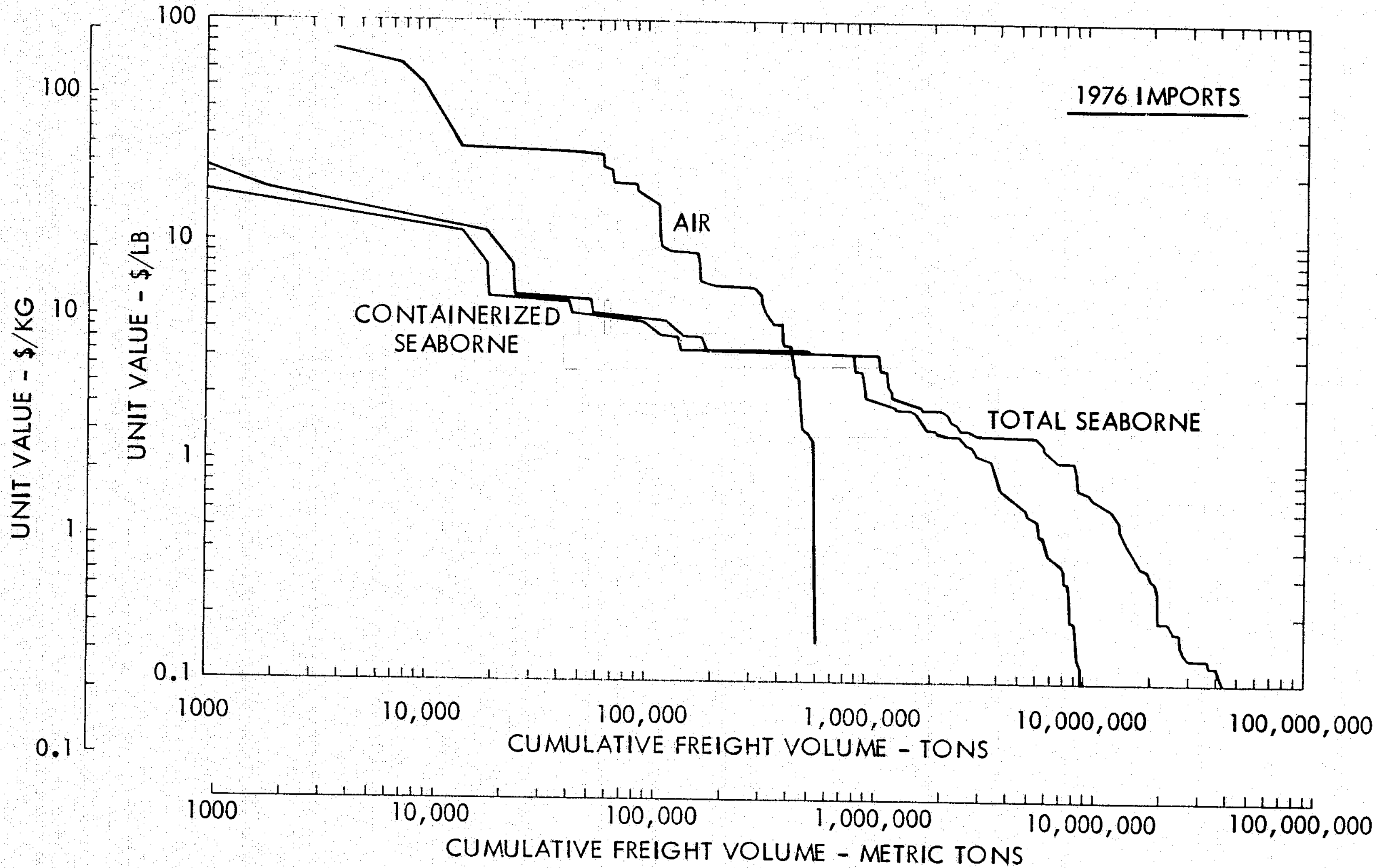


FIGURE III-14 COMMODITY UNIT VALUE OF AIR AND VESSEL VERSUS CUMULATIVE TONNAGE

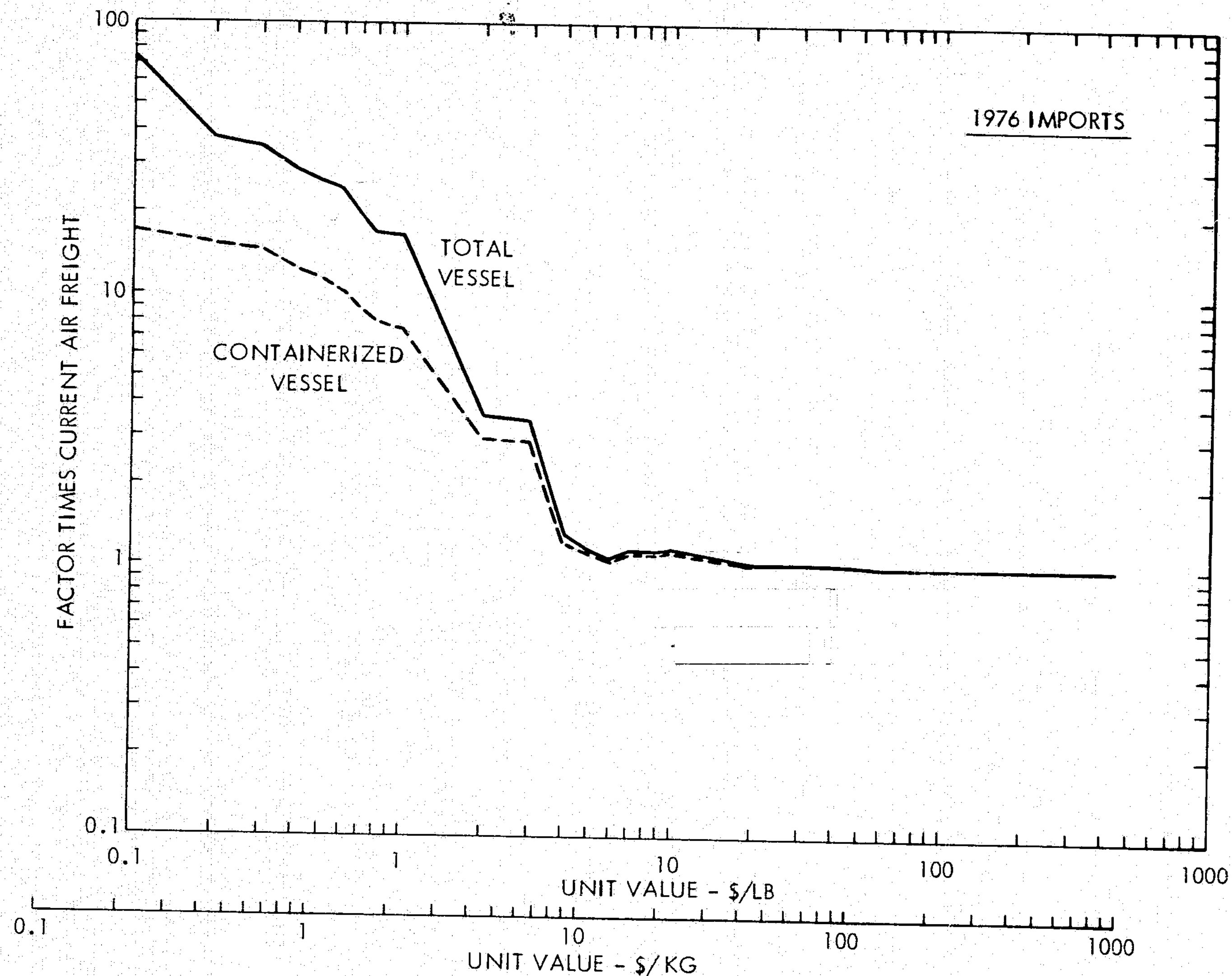


FIGURE III-15 FACTOR FOR POTENTIAL AIR FREIGHT

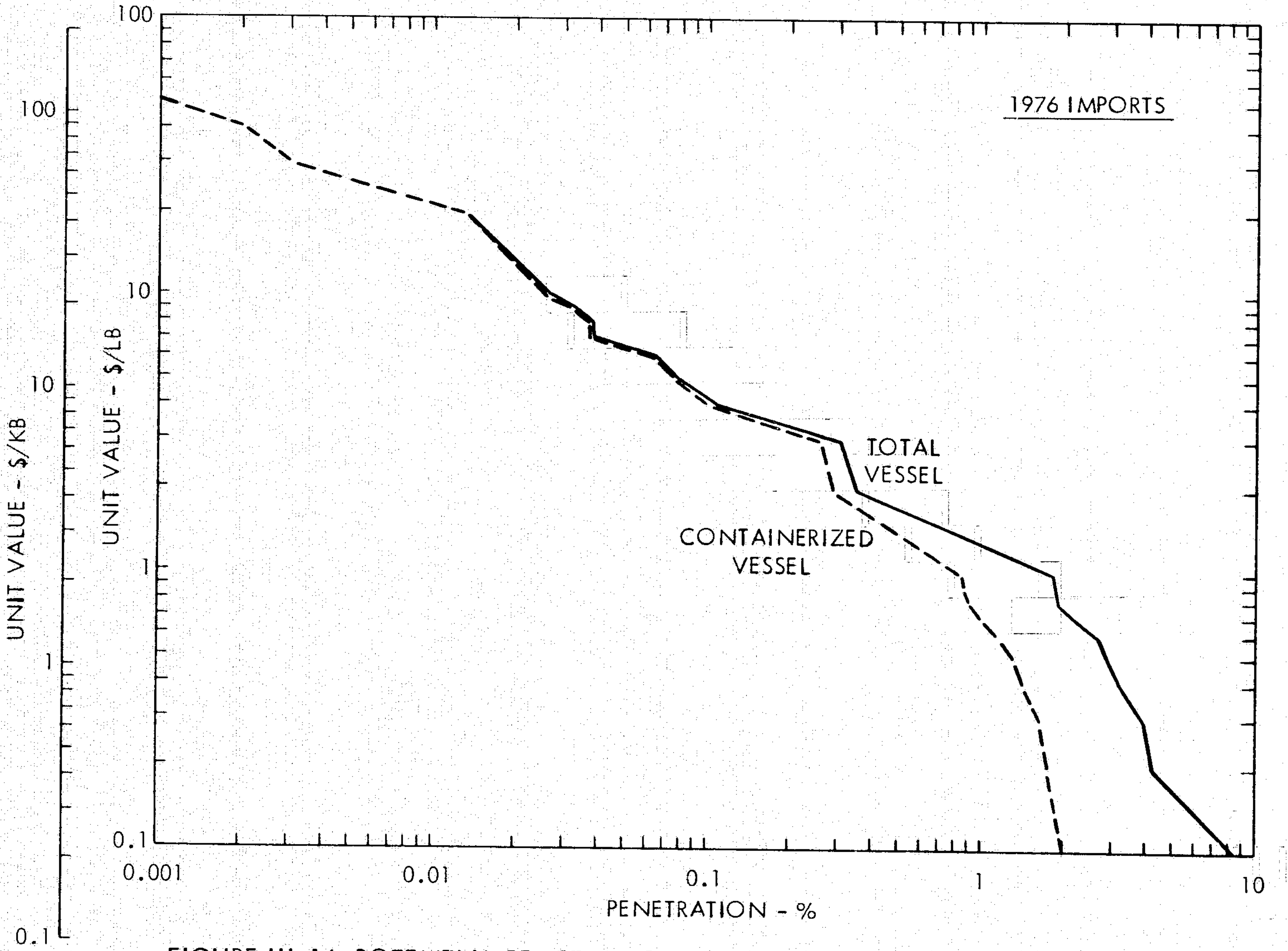


FIGURE III-16 POTENTIAL PENETRATION IF AIR OBTAINED ALL COMMODITES WORTH MORE THAN INDICATED UNIT VALUE

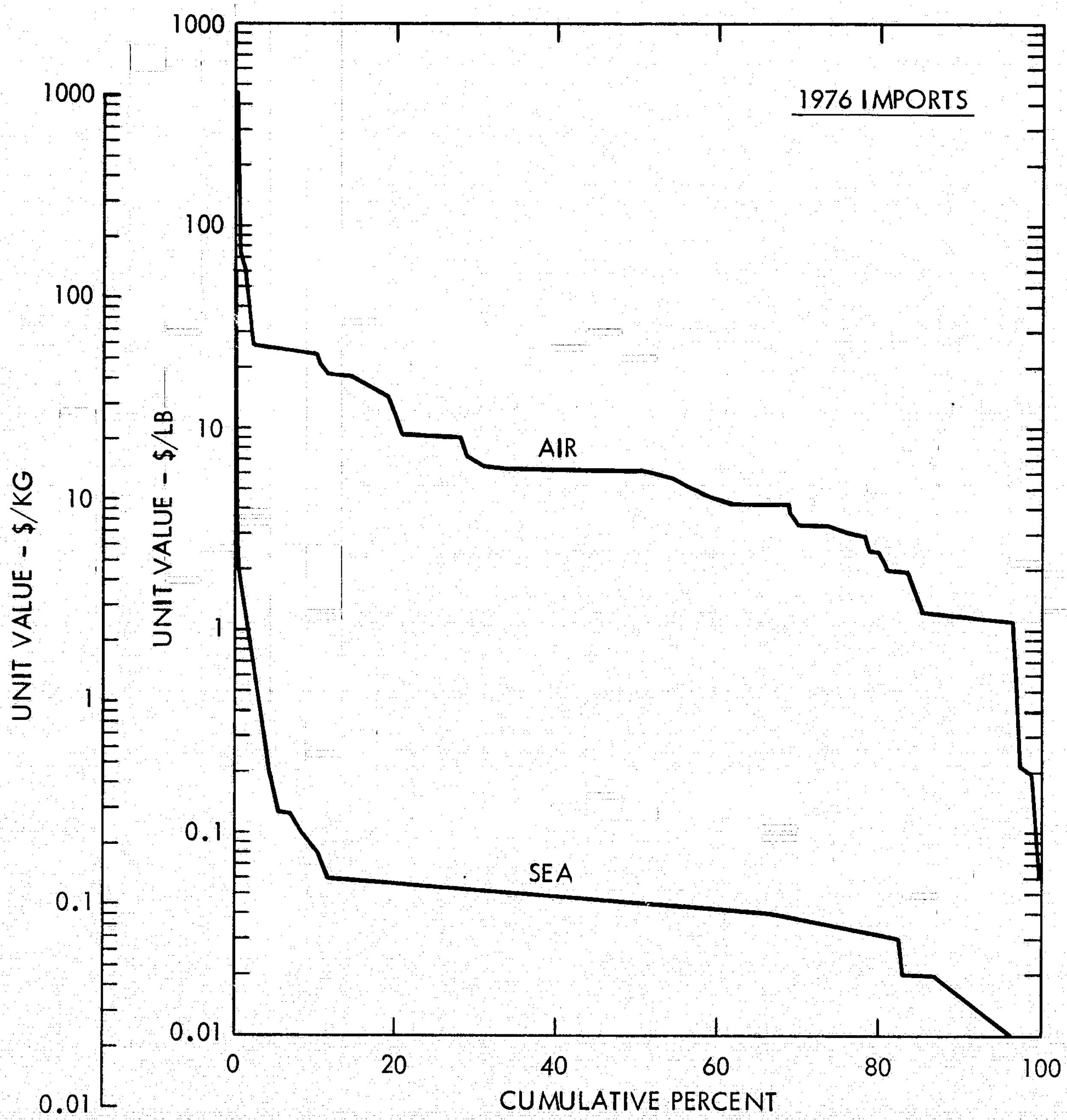


FIGURE III-17 UNIT VALUE VERSUS PERCENT OF TRADE
(WEIGHT BASIS)

TABLE III-31E. U. S. FOREIGN TRADE VERSUS UNIT VALUE - AIR AND TOTAL SEABORNE - 1976 EXPORTS

$/LB	AIR TONS	VESSEL TONS	AIR + VESSEL TONS	AIR + VESSEL / AIR	POTENTIAL[1] AIR PENETRATION OF TOTAL EXPORTS %
70	1,800	0	1,800	1.0	.0006
60	2,100	0	2,100	1.0	.0007
50	5,400	0	5,400	1.0	.001
40	12,000	5,200	17,200	1.433	.006
30	75,000	5,600	80,600	1.074	.028
20	168,000	6,000	174,000	1.035	.061
10	250,000	25,000	275,000	1.100	.096
9	270,000	25,500	295,500	1.094	.104
8	320,000	25,500	345,500	1.079	.121
7	350,000	36,500	386,500	1.104	.136
6	358,000	76,000	434,000	1.212	.153
5	360,000	127,000	487,000	1.352	.171
4	480,000	143,000	623,000	1.297	.219
3	580,000	740,000	1,320,000	2.275	.465
2	640,000	2,350,000	2,990,000	4.671	1.054
1	680,000	6,200,000	6,880,000	10.117	2.426
0.9	680,000	6,500,000	7,180,000	10.558	2.532
0.8	685,000	6,700,000	7,385,000	10.781	2.604
0.7	690,000	7,000,000	7,690,000	11.144	2.712
0.6	700,000	7,800,000	8,500,000	12.142	2.998
0.5	705,000	10,000,000	10,705,000	15.184	3.775
0.4	710,000	13,300,000	14,010,000	19.732	4.941
0.3	715,000	14,700,000	15,415,000	21.559	5.437
0.2	720,000	22,000,000	22,720,000	31.555	8.013
0.1	726,000	53,000,000	53,726,000	74.003	18.951
0	726,313	282,779,824	283,506,137	390.336	100.0

Grand Total - Vessel	282,779,824
Air	726,313
Vessel & Air	283,506,137

Actual Air Penetration - % .26

(1) Potential Air Penetration of total trade if air obtained all vessel-borne traffic above given unit value.

TABLE III-32E. U. S. FOREIGN TRADE VERSUS UNIT VALUE - AIR AND CONTAINERIZED SEABORNE - 1976 EXPORTS

$/LB	AIR TONS	CONT'Z'D VESSEL TONS	AIR + CONT'Z'D VESSEL TONS	AIR + VESSEL / AIR	POTENTIAL[1] AIR PENETRATION
70	1,800	0	1,800	1.000	.0006
60	2,100	0	2,100	1.000	.0007
50	5,400	0	5,400	1.000	.001
40	12,000	4,300	16,300	1.358	.005
30	75,000	4,400	79,400	1.058	.028
20	168,000	4,600	172,600	1.027	.060
10	250,000	9,600	259,600	1.038	.091
9	270,000	9,800	279,800	1.036	.098
8	320,000	10,000	330,000	1.031	.116
7	350,000	15,300	365,300	1.043	.128
6	358,000	35,500	393,500	1.099	.138
5	360,000	62,000	422,000	1.172	.148
4	480,000	70,000	550,000	1.145	.193
3	580,000	300,000	880,000	1.517	.310
2	640,000	820,000	1,460,000	2.281	.514
1	680,000	2,250,000	2,930,000	4.308	1.033
0.9	680,000	2,400,000	3,080,000	4.529	1.086
0.8	685,000	2,500,000	3,185,000	4.649	1.123
0.7	690,000	2,570,000	3,260,000	4.724	1.149
0.6	700,000	2,600,000	3,300,000	4.714	1.163
0.5	705,000	3,550,000	4,255,000	6.035	1.500
0.4	710,000	4,600,000	5,310,000	7.478	1.872
0.3	715,000	5,300,000	6,015,000	8.412	2.121
0.2	720,000	6,500,000	7,220,000	10.027	2.546
0.1	726,000	9,000,000	9,726,000	13.397	3.431
0	726,313	11,563,644	12,289,957	16.921	4.335
INCORPORATING CASE STUDY RESULTS					
0.1	726,000	504,000[2]	1,230,000	1.694	0.434
0	726,313	647,564[2]	1,373,877	1.892	0.485

(1) Potential Air Penetration of total trade of Table III-35 if air obtained all containerized vessel-borne traffic above given unit value.

(2) 5.6 percent penetration of containerized seaborne trade from Carrier Case Study results

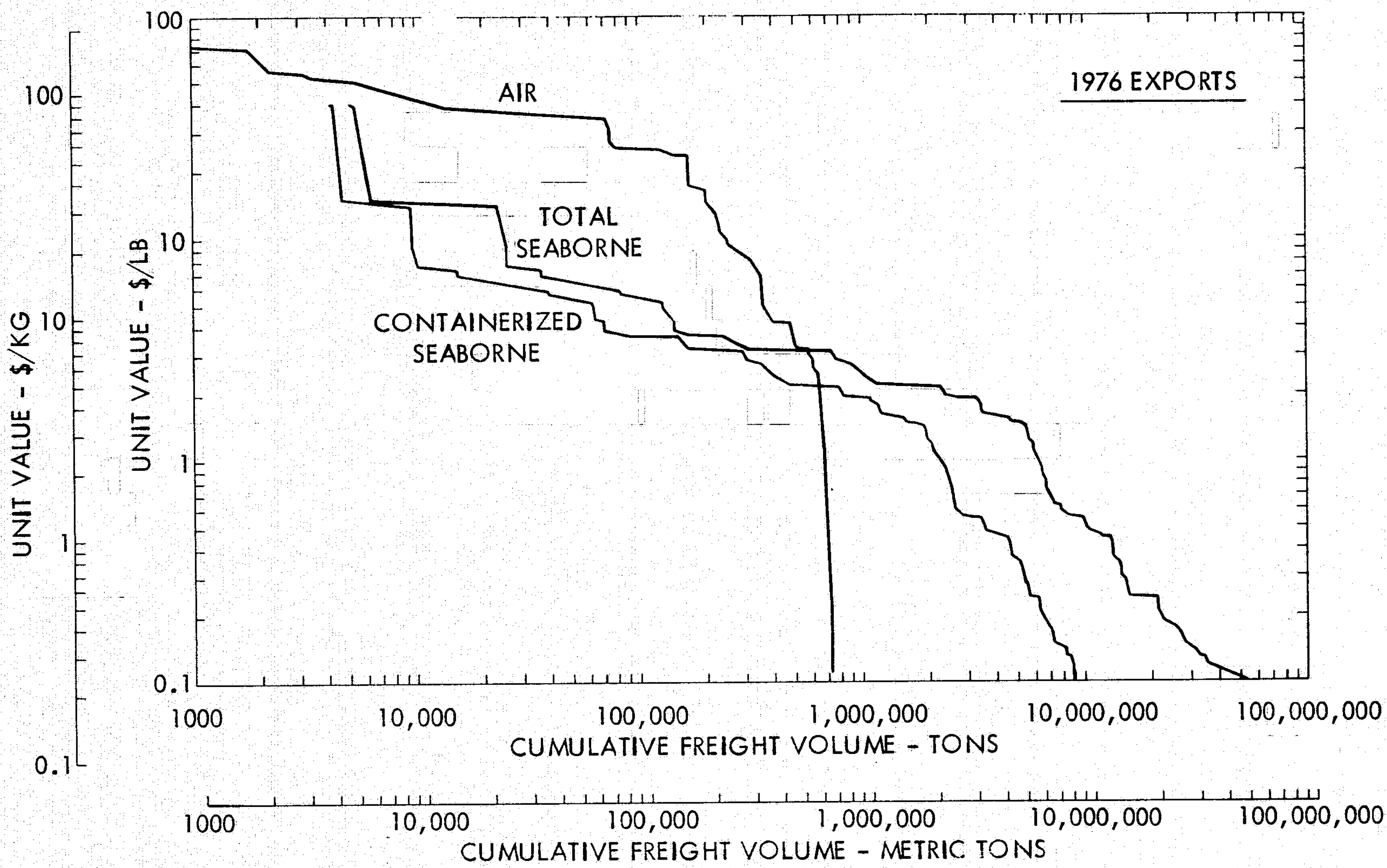


FIGURE III - 18 COMMODITY UNIT VALUE OF AIR AND VESSEL VERSUS CUMULATIVE TONNAGE

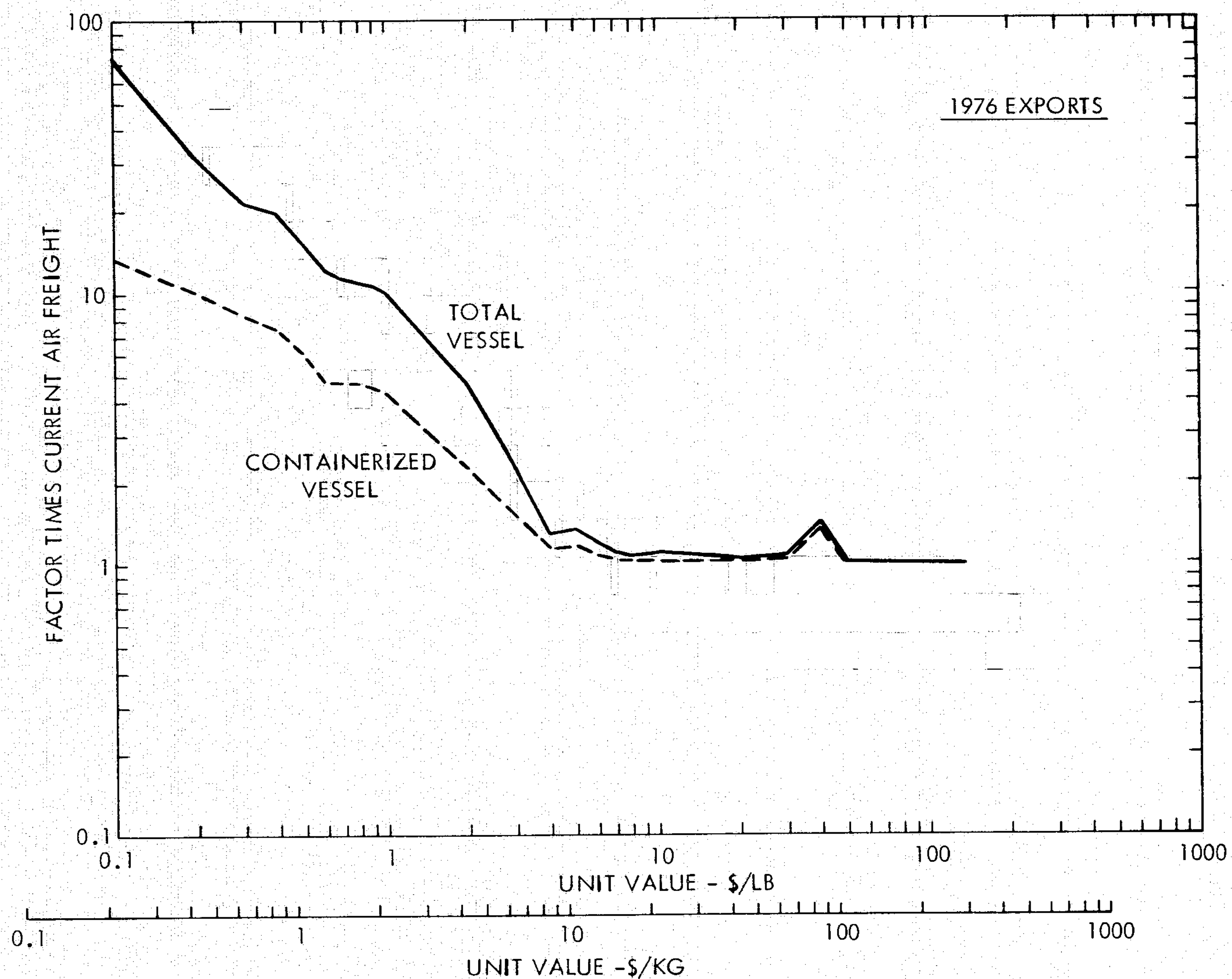


FIGURE III-19 FACTOR FOR POTENTIAL AIR FREIGHT

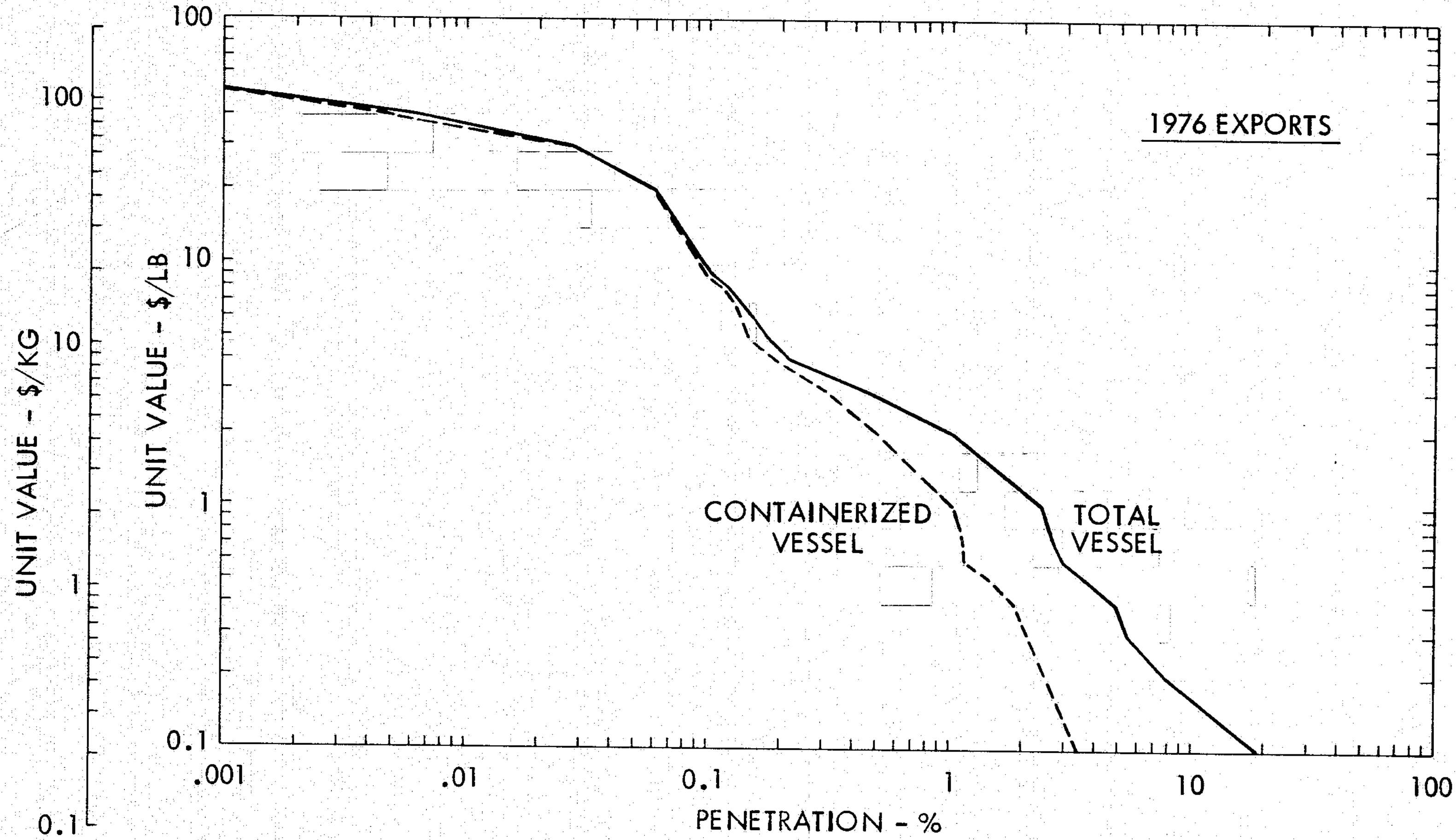


FIGURE III-20 POSSIBLE PENETRATION IF AIR OBTAINED ALL COMMODITIES WORTH MORE THAN INDICATED UNIT VALUE

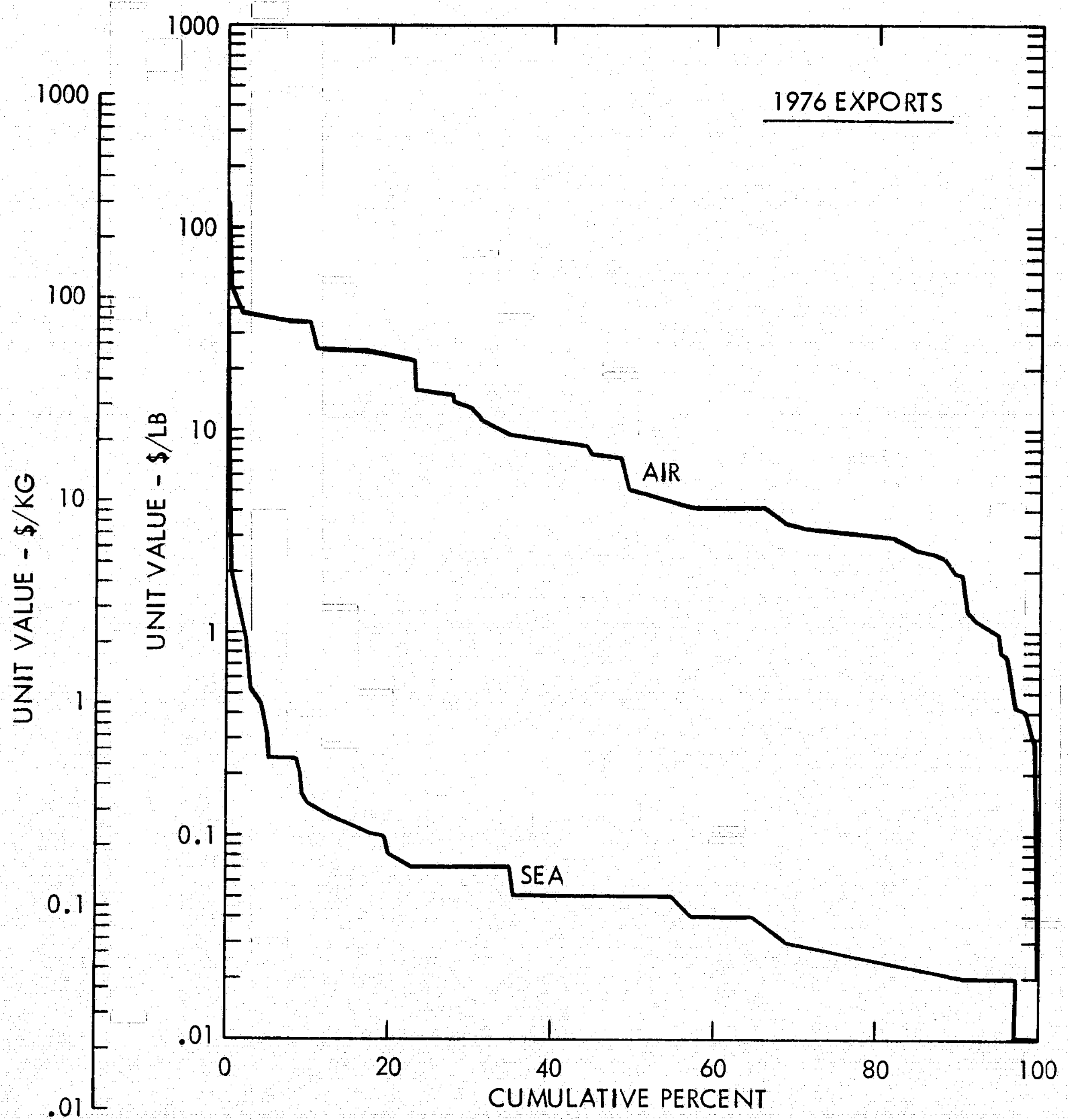


FIGURE III-21. UNIT VALUE VERSUS PERCENT OF TRADE (WEIGHT BASIS)

Commodity Unit Value More Than ($/Pound)	% Moved By Air	% Moved By Sea	% Containerized and Moved by Sea
4.00	66.1	0.051	0.61
2.00	88.1	0.831	7.09
0.80	94.3	2.369	21.62
0.10	99.96	18.742	77.83

As for the imports, the big potential for growth in air freight exports lies in those commodities worth between $2.00 per pound and 80 cents. If these export commodities were moved by the AACS, air freight would increase by almost four times, resulting in an air penetration by weight of just over 1 percent.

Suggestions have been made for years, especially within the aircraft industry, regarding the possibility of increasing air penetration to as high as 2 percent. To achieve such a penetration, the analyses presented in Tables III-30E and III-32E for 1976 imports and exports, respectively, show that everything that is containerized moving by sea and worth more than 10 cents per pound for imports and 30 cents per pound for exports would have to move by air. This is further illustrated in Figures III-16 and III-20. At such a level of air penetration, airborne trade tonnage would be 17 times current air movements for imports and 8 times current airborne exports.

Results of U.S. Case Studies as discussed in Section II indicate a 5.6 percent penetration of containerized seaborne trade could be achieved with the AACS. This results in an air penetration, Tables III-30E and III-32E, for imports and exports worth more than 10 cents per pound (22 cents per kilogram) of almost double the actual 1976 air penetration as given in Tables III-29E and III-31E.

The low value of the vast majority of seaborne trade is further illustrated in Figures III-17 and III-21 for imports and exports, respectively. Figure III-17 clearly shows that only 11 percent of U.S. imports in 1976 were worth more than 6 cents per pound (13 cents per kilogram). This is primarily due to the enormous quantities of oil imports worth less than 4 cents per pound (9 cents per kilogram). U.S. exports, Figure III-21, indicate that 20 percent of the total tonnage is worth more than 10 cents per pound (22 cents per kilogram).

As an input to the analysis of the Free-World foreign trade data to be discussed later, air penetration as a function of the degree of seaborne containerization was obtained from the computer analyses of the 1968, 1970, 1972, 1974 and 1976 annual summaries. The results are summarized in Table III-33 for both imports and exports. In general, the results show increasing air penetration over the historical data period of 1968 through 1976, and

TABLE III-33. AIR PENETRATION VS SEABORNE CONTAINERIZATION

DEGREE OF CONTAINERIZATION	1968	1970	1972	1974	1976
	% AIR PENETRATION BY WEIGHT				
IMPORTS					
0 - 5	.0045	.0058	.0097	.0098	.0107
5 - 20	.4269	.5583	.6532	.8011	.7493
20 - 40	.5841	.8250	1.0015	1.1746	1.3330
40 - 60	.9256	.9899	1.1749	1.5237	1.5763
60 - 100	3.0656	3.8255	4.9525	5.4340	5.8531
0 - 100	0.3650	0.5535	0.6726	0.7813	0.9059
EXPORTS					
0 - 5	.0256	.0219	.0204	.0201	.0202
5 - 20	.2485	.3089	.4485	.5481	.4198
20 - 40	1.8403	2.0423	2.8402	2.8607	2.7711
50 - 60	2.3103	2.7005	3.4139	4.118	3.4502
60 - 100	5.8230	6.6860	6.1309	4.7179	5.7095
0 - 100	0.4001	0.4311	0.5457	0.6991	0.6220

substantial increases in air penetration for increasing containerization of seaborne commodities for each year. For example, in U.S. imports, those commodities that have 0 to 5 percent seaborne containerization have air penetration of less than one hundredth of one percent, while those in the 60 to 100 containerized bracket have air penetration in the range of 3 to 6 percent. This represents almost a 700-fold increase in air penetration. U.S. exports reveal similar results.

From the historical data for even years from 1968 through 1976 forecasts of air penetration were made through the year 2000, based on regression analysis of the historical trends. These results are presented in summary form in Tables III-34 through III-36. Details of airborne and seaborne tonnages and the resulting air penetration are presented in Tables III-37 through III-39, and Figures III-22 through III-33.

The often quoted air penetration of less than two-tenths of one percent is seen in Table III-34 for imports and exports in the 1976 result for all commodities, namely 0.166 percent. After extracting the totally bulk commodities, such as oil, coal, grain, and ores, the commodities at the 3-digit level that have some degree of containerization (termed "containerizable") show approximately a four-fold increase in the air penetration percentage to 0.725. A further 7.5-fold increase to 5.478 percent air penetration is seen for the containerized commodities, representing a 33-fold increase over the all-commodities air penetration. This factor decreases to 23-fold in the year 2000. This illustrates that air cargo has a very significant penetration of those commodities that are containerized and moving by sea today. With this understanding, the Free-World foreign trade data, based on the OECD data to be discussed later, have been analyzed using the specific air penetration data for the various levels of containerization shown in Table III-33.

Tables III-35 and III-36 present the above discussed data for imports and exports, respectively. The air penetration for all commodities is seen to be much lower for imports than for exports. This is due to the enormous quantities of imported oil. The containerized commodities show a good balance between imports and exports.

Table III-37 presents the details for the total tonnage for imports, exports, and imports and exports for all commodities, whether bulk or containerizable. Air penetration is expressed as a percent of the total air and sea tonnage. Actual seaborne tonnage, imports and exports combined, is forecast to more than double in the same period, representing a compounded annual growth rate for the 24-year period of 3.1 percent. The air tonnage from 1976 to 2000 quadruples, representing a 6.1 percent per year annual growth. These together result in almost a doubling of air penetration from 0.166 in 1976 to 0.331 in the year 2000. From Table III-37 it is seen that the air tonnage of commodities that are classified as bulk when moving by sea is extremely small, and elsewhere in this section, "airborne" or "conventional airborne" refers to those commodities classified as seaborne containerizable. this loss in airborne tonnage is very small, and the exclusion of the bulk

TABLE III-34. AIR PENETRATION SUMMARY

IMPORTS AND EXPORTS

	1976	1980	1985	1990	1995	2000
			PERCENT			
ALL COMMODITIES	0.1662	0.2088	0.2396	0.2693	0.2993	0.3312
CONTAINERIZABLE	0.7255	0.8996	1.0445	1.1466	1.2089	1.2362
CONTAINERIZED	5.4781	6.5540	7.2932	7.6852	7.7608	7.5563

DERIVED FROM DEPARTMENT OF COMMERCE FOREIGN TRADE STATISTICS AND MARAD LONG-TERM FORECAST

TABLE III-35. AIR PENETRATION SUMMARY

IMPORTS

	1976	1980	1985	1990	1995	2000
			PERCENT			
ALL COMMODITIES	0.1170	0.1516	0.1758	0.1991	0.2221	0.2461
CONTAINERIZABLE	0.9059	1.2067	1.5292	1.8138	2.0494	2.2281
CONTAINERIZED	5.3508	6.5617	7.4559	7.9234	8.0226	7.8253

DERIVED FROM DEPARTMENT OF COMMERCE FOREIGN TRADE STATISTICS AND MARAD LONG-TERM FORECAST

TABLE III-36. AIR PENETRATION SUMMARY

EXPORTS

	1976	1980	1985	1990	1995	2000
			PERCENT			
ALL COMMODITIES	0.2562	0.3155	0.3658	0.4138	0.4623	0.5146
CONTAINERIZABLE	0.6220	0.7323	0.8028	0.8413	0.8554	0.8521
CONTAINERIZED	5.5891	6.5471	7.1452	7.4640	7.5137	7.3021

DERIVED FROM DEPARTMENT OF COMMERCE FOREIGN TRADE STATISTICS AND MARAD LONG-TERM FORECAST

TABLE III-37. AIR PENETRATION OF ALL COMMODITIES

TOTAL TRADE

	1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
	SHORT TONS (THOUSANDS) AND PERCENT									
IMPORTS										
AIRBORNE										
Bulk(1)	0.011	0.168	0.126	0.186	0.542	1.183	3.140	8.333	22.118	58.702
Containerizable(2)	215.291	309.710	465.305	528.799	605.536	915.814	1300.514	1735.484	2217.908	2745.562
Total	215.302	309.878	465.431	528.985	606.078	916.997	1303.654	1743.817	2240.026	2804.264
SEABORNE(3)	282,680	298,479	350,815	446,895	517,513	603,965	740,304	874,254	1006,247	1136,589
Air Penetration - %	0.0761	0.1037	0.1325	0.1182	0.1170	0.1516	0.1758	0.1991	0.2221	0.2461
EXPORTS										
AIRBORNE										
Bulk(1)	0.810	1.105	1.189	1.746	1.444	1.928	2.767	3.972	5.700	8.181
Containerizable	321.834	439.786	526.709	777.670	724.868	1020.622	1369.604	1759.562	2200.869	2711.147
Total	322.644	440.891	527.898	779.416	726.312	1022.550	1372.371	1763.534	2206.569	2719.328
SEABORNE	193,775	239,893	229,442	264,485	282,780	323,116	373,766	424,417	475,067	525,718
Air Penetration - %	0.1662	0.1834	0.2296	0.2938	0.2562	0.3155	0.3658	0.4138	0.4623	0.5146
IMPORTS & EXPORTS										
AIRBORNE										
Bulk	0.821	1.273	1.315	1.932	1.986	3.111	5.907	12.306	27.818	66.883
Containerizable	537.125	749.496	992.014	1306.469	1330.404	1936.436	2670.118	3495.046	4418.777	5456.709
Total	537.946	750.769	993.329	1308.401	1332.390	1939.547	2676.025	3507.352	4446.595	5523.592
SEABORNE	476,455	538,372	580,257	711,380	800,293	927,081	1114,070	1298,671	1481,314	1662,307
Air Penetration - %	0.1128	0.1393	0.1709	0.1836	0.1662	0.2088	0.2396	0.2693	0.2993	0.3312

(1) The term bulk refers to how the commodities included here are carried by sea and not how they are carried by air. The forecast for this category is based on the exponential growth rate for 1970 through 1976 for the imports and 1968 through 1976 for the exports.

(2) Containerizable again refers to the seaborne categorization. These data represent the 0 - 100% containerization as also used in Tables III-38 and III-39.

(3) The seaborne data represents the containerizable tonnage for 0 - 100% containerization from Table III-38 plus the bulk commodities. The forecast is based on regression analysis of the 1968-1976 data.

TABLE III-38. AIR PENETRATION OF CONTAINERIZABLE COMMODITIES

0 - 5% Containerization	1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
Imports - Air-Tons	1,660	1,916	4,080	3,969	4,173	6,656	9,346	12,333	15,592	19,104
- Vessel-Tons	37,014,244	32,803,286	42,042,467	40,414,924	38,833,762	42,722,006	45,534,674	48,347,343	51,160,012	53,972,680
Exports - Air-Tons	11,943	13,176	12,133	13,187	14,544	15,182	16,758	18,497	20,416	22,534
- Vessel-Tons	46,690,399	60,217,135	59,507,242	65,682,646	72,018,983	88,176,025	111,916,158	142,047,982	180,292,368	228,833,508
Air Penetration - %										
Imports	0.00448	0.00584	0.00970	0.00981	0.01074	0.01557	0.02052	0.02550	0.03046	0.03538
Exports	0.02557	0.02187	0.02038	0.02007	0.02019	0.01721	0.01497	0.01301	0.01132	0.00984
Imports & Exports										
Air-Tons	13,603	15,092	16,213	17,156	18,717	21,838	26,104	30,830	36,008	41,638
Vessel-Tons	83,704,643	93,020,421	101,549,709	106,097,570	110,852,745	130,898,031	157,450,832	190,395,325	231,452,380	282,806,188
Air Penetration - %	0.01624	0.01622	0.01596	0.01616	0.01688	0.01668	0.01657	0.01619	0.01555	0.01472
5 - 20% Containerization										
Imports - Air-Tons	48,544	62,434	84,070	107,623	99,468	145,033	188,285	233,040	279,083	326,259
- Vessel-Tons	11,322,441	11,121,167	12,786,214	13,327,007	13,175,122	14,939,923	16,861,693	19,030,666	21,478,642	24,241,508
Exports - Air-Tons	54,304	86,133	109,067	148,638	106,244	178,885	231,580	285,966	341,800	398,904
- Vessel-Tons	21,795,234	27,794,455	24,209,763	26,968,166	25,199,951	27,854,776	29,726,375	31,723,730	33,855,289	36,130,071
Air Penetration - %										
Imports	0.42691	0.55826	0.65321	0.80108	0.74931	0.96144	1.10431	1.20973	1.28268	1.32799
Exports	0.24853	0.30893	0.44848	0.54813	0.41983	0.63810	0.77301	0.89337	0.99950	1.09202
Imports & Exports										
Air-Tons	102,848	148,567	193,137	256,261	205,712	323,918	419,865	519,006	620,883	725,163
Vessel-Tons	33,117,675	38,915,622	36,995,977	40,295,173	38,375,073	42,794,699	46,588,068	50,754,396	55,333,931	60,371,579
Air Penetration - %	0.30959	0.38031	0.51933	0.63194	0.53319	0.75122	0.89317	1.01223	1.10961	1.18690
20 - 40% Containerization										
Imports - Air-Tons	23,445	30,988	45,446	53,895	58,979	85,870	117,504	151,827	188,559	227,488
- Vessel-Tons	3,990,672	3,725,005	4,492,275	4,534,701	4,365,601	4,893,434	5,376,111	5,906,399	6,488,993	7,129,052
Exports - Air-Tons	135,956	177,902	219,653	339,548	322,369	421,128	555,614	696,809	843,839	996,056
- Vessel-Tons	7,251,913	8,533,084	7,514,209	11,529,795	11,311,029	13,673,983	16,452,719	19,231,455	22,010,190	24,788,926
Air Penetration - %										
Imports	0.58406	0.82502	1.00151	0.17454	1.33298	1.72453	2.13891	2,50612	2.82377	3.09232
Exports	1.84026	2.04227	2.84014	2.86071	2.77106	2.98775	3.26671	3.49658	3.69229	3.86293
Imports & Exports										
Air-Tons	159,401	208,890	265,099	393,443	381,348	506,998	673,118	848,636	1,032,398	1,223,544
Vessel-Tons	11,242,585	12,258,089	12,006,484	16,064,496	15,676,630	18,567,417	21,828,830	25,137,854	28,499,183	31,917,978
Air Penetration - %	1.39801	1.67554	2.16026	2,39059	2.37481	2.65800	2.99137	3.26568	3.49591	3.69187

TABLE III-38. AIR PENETRATION OF CONTAINERIZABLE COMMODITIES (Continued)

40 - 60% Containerization	1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
Imports - Air-Tons	26,042	34,817	46,582	54,119	59,093	81,758	107,370	134,148	161,935	190,618
- Vessel-Tons	2,787,595	3,482,513	3,918,341	3,497,691	3,689,730	4,328,800	4,985,654	5,742,179	6,613,500	7,617,035
Exports - Air-Tons	93,364	125,441	147,333	224,332	229,135	325,674	442,931	569,451	704,234	846,518
- Vessel-Tons	3,947,797	4,519,607	4,168,386	5,223,225	6,412,031	7,107,044	8,515,065	9,923,087	11,331,108	12,739,130
Air Penetration - %										
Imports	0.92556	0.98987	1.17485	1.52370	1.57630	1.85368	2.10817	2.28285	2.39003	2.44142
Exports	2.31032	2.70053	3.41386	4.11802	3.45022	4.38162	4.94453	5.42719	5.85138	6.23097
Imports & Exports										
Air-Tons	119,406	160,258	193,915	278,451	288,228	407,432	550,301	703,599	866,169	1,037,136
Vessel-Tons	6,735,392	8,002,120	8,086,727	8,720,916	10,101,761	11,435,844	13,500,719	15,665,266	17,944,608	20,356,165
Air Penetration - %	1.74193	1.96337	2.34178	3.09411	2.77409	3.44019	3.91644	4.29839	4.60464	4.84794
60 - 100% Containerization										
Imports - Air-Tons	115,599	179,549	285,126	309,192	383,822	596,497	878,009	1,204,136	1,572,739	1,982,093
- Vessel-Tons	3,655,184	4,513,988	5,472,118	5,380,803	6,173,770	8,091,556	10,988,142	14,921,638	20,263,234	27,516,995
Exports - Air-Tons	26,267	37,132	38,522	51,964	52,575	79,753	122,721	188,839	290,580	447,135
- Vessel - Tons	424,826	518,248	589,805	1,049,480	868,254	1,532,989	2,614,363	4,458,543	7,603,612	12,967,223
Air Penetration - %										
Imports	3.08564	3.82545	4.95247	5.43395	5.85309	6.86571	7.39927	7.46715	7.20251	6.71916
Exports	5.82296	6.68587	6.13088	4.71780	5.70952	4.94518	4.48364	4.06334	3.68093	3.33325
Imports & Exports										
Air-Tons	141,866	216,681	323,648	361,156	436,397	676,250	1,000,730	1,392,975	1,863,319	2,429,228
Vessel-Tons	4,080,010	5,032,236	6,061,923	6,430,283	7,042,024	9,624,545	13,602,505	19,380,181	27,866,846	40,484,218
Air Penetration - %	3.36025	4.12810	5.06842	5.31781	5.83541	6.56502	6.85279	6.70564	6.26743	5.66076
0 - 100% Containerization										
Imports - Air-Tons	215,291	309,710	465,305	528,799	605,536	915,814	1,300,514	1,735,484	2,217,908	2,745,562
- Vessel-Tons	58,770,137	55,645,961	68,711,416	67,155,127	66,237,986	74,975,719	83,746,274	93,948,225	106,004,381	120,477,270
Exports - Air-Tons	321,834	439,786	526,709	777,670	724,868	1,020,622	1,369,604	1,759,562	2,200,869	2,711,147
- Vessel-Tons	80,110,170	101,582,531	95,989,406	110,453,312	115,810,249	138,344,817	169,224,680	207,384,797	255,092,567	315,458,858
Air Penetration - %										
Imports	0.36499	0.55349	0.67263	0.78127	0.90590	1.20674	1.52917	1.81377	2.04940	2.22812
Exports	0.40013	0.43106	0.54572	0.69914	0.62201	0.73233	0.80284	0.84131	0.85539	0.85210
Imports & Exports										
Air-Tons	537,125	749,496	992,014	1,306,469	1,330,404	1,936,436	2,670,118	3,495,046	4,418,777	5,456,709
Vessel-Tons	138,880,307	157,228,492	164,700,822	177,608,439	182,048,235	213,320,536	252,970,954	301,333,022	361,096,948	435,936,128
Air Penetration - %	0.38526	0.47443	0.59870	0.73021	0.72549	0.89959	1.04447	1.14656	1.20891	1.23624

TABLE III-39. AIR PENETRATION OF CONTAINERIZED COMMODITIES

0 – 5% CONTAINERIZATION:		1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
Percent Containerized		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Imports	Air	1,660	1,916	4,080	3,969	4,173	6,656	9,346	12,333	15,592	19,104
	Vessel	37,014,244	32,803,286	42,042,467	40,414,924	38,833,762	42,722,006	45,534,674	48,347,343	51,160,012	53,972,680
Exports	Air	11,943	13,176	12,133	13,187	14,544	15,182	16,758	18,497	20,416	22,534
	Vessel	46,690,399	60,217,135	59,507,242	65,682,646	72,018,983	88,176,025	111,916,158	142,047,982	180,292,368	228,833,508
Imports	Containerized Tons	925,356	820,082	1,051,061	1,010,373	970,844	1,068,050	1,138,366	1,208,683	1,279,000	1,349,317
	Air Penetration	0.17906	0.23309	0.38667	0.39128	0.42799	0.61933	0.81431	1.01005	1.20439	1.39606
Exports	Containerized Tons	1,167,259	1,505,428	1,487,681	1,642,066	1,800,474	2,204,400	2,797,903	3,551,199	4,507,309	5,720,837
	Air Penetration	1.01280	0.86763	0.80896	0.79667	0.80131	0.68400	0.59538	0.51816	0.45091	0.39234
Imports & Exports:											
	Air Tons	13,603	15,092	16,213	17,156	18,717	21,838	26,104	30,830	36,008	41,638
	Containerized Tons	2,092,616	2,325,510	2,538,742	2,652,439	2,771,318	3,272,450	3,936,270	4,759,883	5,786,309	7,070,154
	Air Penetration	0.64584	0.64479	0.63457	0.64264	0.67085	0.66290	0.65879	0.64353	0.61844	0.58547
5 – 20% CONTAINERIZATION:											
Percent Containerized		12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Imports	Air	48,544	62,434	84,070	107,623	99,468	145,033	188,285	233,040	279,083	326,259
	Vessel	11,322,441	11,121,167	12,786,214	13,327,007	13,175,122	14,939,923	16,861,693	19,030,666	21,478,642	24,241,508
Exports	Air	54,304	86,133	109,067	148,638	106,244	178,885	231,580	285,966	341,800	398,904
	Vessel	21,795,234	27,794,455	24,209,763	26,968,166	25,199,951	27,854,776	29,726,375	31,723,730	33,855,289	36,130,071
Imports	Containerized Tons	1,415,305	1,390,145	1,598,276	1,665,875	1,646,890	1,867,490	2,107,711	2,378,833	2,684,830	3,030,188
	Air Penetration	3.31618	4.29814	4.99718	6.06839	5.69573	7.20652	8.20057	8.92233	9.41603	9.72036
Exports	Containerized Tons	2,724,404	3,474,306	3,026,220	3,371,020	3,149,993	3,481,847	3,715,796	3,965,466	4,231,911	4,516,258
	Air Penetration	1.95428	2.41916	3.47869	4.22307	3.26278	4.88659	5.86668	6.72634	7.47314	8.11578
Imports & Exports											
	Air Tons	102,848	148,567	193,137	256,261	205,712	323,918	419,865	519,006	620,883	725,163
	Containerized Tons	4,139,709	4,864,452	4,624,497	5,036,896	4,796,884	5,349,337	5,823,508	6,344,299	6,916,741	7,546,447
	Air Penetration	2.42419	2.96362	4.00895	4.84136	4.11210	5.70956	6.72497	7.56204	8.23711	8.76689

TABLE III-39. AIR PENETRATION OF CONTAINERIZED COMMODITIES (Continued)

20 - 40% CONTAINERIZATION:		1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
Percent Containerized		30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Imports	Air	23,445	30,988	45,446	53,895	58,979	85,870	117,504	151,827	188,559	227,488
	Vessel	3,990,672	3,725,005	4,492,275	4,534,701	4,365,601	4,893,434	5,376,111	5,906,399	6,488,993	7,129,052
Exports	Air	135,956	177,902	219,653	339,548	322,369	421,128	555,614	696,809	843,839	996,056
	Vessel	7,251,913	8,533,084	7,514,209	11,529,795	11,311,029	13,673,983	16,452,719	9,231,455	22,010,190	24,788,926
Imports	Containerized Tons	1,197,201	1,117,501	1,347,682	1,360,410	1,309,680	1,468,030	1,612,833	1,771,919	1,946,697	2,138,715
	Air Penetration	1.92070	2.69815	3.26215	3.81070	4.30925	5.52609	6.79081	7.89225	8.83074	9.61405
Exports	Containerized Tons	2,175,573	2,559,925	2,254,262	3,458,938	3,393,308	4,102,194	4,935,815	5,769,436	6,603,057	7,436,677
	Air Penetration	5.88164	6.49792	8.87875	8.93903	8.67591	9.31014	10.11783	10.77609	11.33141	11.81178
Imports & Exports:											
	Air Tons	159,401	208,890	265,099	393,443	381,348	506,998	673,118	848,636	1,032,398	1,223,544
	Containerized Tons	3,372,775	3,677,426	3,601,945	4,819,348	4,702,989	5,570,225	6,548,649	7,541,356	8,549,754	9,575,393
	Air Penetration	4.51282	5.37501	6.85533	7.54764	7.50044	8.34259	9.32068	10.11486	10.77417	11.33022
40 - 60% CONTAINERIZATION											
Percent Containerized		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Imports	Air	26,042	34,817	46,582	54,119	59,093	81,758	107,370	134,148	161,935	190,618
	Vessel	2,787,595	3,482,51[illegible]	3,918,341	3,497,691	3,689,730	4,328,800	4,985,654	5,742,179	6,613,500	7,617,035
Exports	Air	93,364	125,4[illegible]	147,333	224,332	229,135	325,674	442,931	569,451	704,234	846,518
	Vessel	3,947,797	4,519,6[illegible]7	4,168,386	5,223,225	6,412,031	7,107,044	8,515,065	9,923,087	11,331,108	12,739,130
Imports	Containerized Tons	1,393,797	1,741,256	1,959,170	1,748,845	1,844,865	2,164,400	2,492,827	2,871,089	3,306,750	3,808,517
	Air Penetration	1.83415	1.96033	2.32242	3.00166	3.10369	3.63990	4.12930	4.46380	4.66848	4.76648
Exports	Containerized Tons	1,973,898	2,259,803	2,084,193	2,611,612	3,206,015	3,553,552	4,257,532	4,961,543	5,665,554	6,369,565
	Air Penetration	4.51631	5.25904	6.60234	7.91030	6.67030	8.39539	9.42313	10.29563	11.05584	11.73099
Imports & Exports:											
	Air Tons	119,406	160,258	193,915	278,451	288,228	407,432	550,301	703,599	866,169	1,037,136
	Containerized Tons	3,367,696	4,001,060	4,043,363	4,360,458	5,050,880	5,717,922	6,750,359	7,832,633	8,972,304	10,178,082
	Air Penetration	3.42421	3.85113	4.57640	6.00251	5.39842	6.65156	7.53768	8.24250	8.80389	9.24757

TABLE III-39. AIR PENETRATION OF CONTAINERIZED COMMODITIES (Continued)

60 – 100% CONTAINERIZATION:		1968	1970	1972	1974	1976	1980	1985	1990	1995	2000
Percent Containerized		80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Imports	Air	115,599	179,549	285,126	309,192	383,822	596,497	878,009	1,204,136	1,572,739	1,982,093
	Vessel	3,655,184	4,513,988	5,472,118	5,380,803	6,173,770	8,091,556	10,988,142	14,921,638	20,263,234	27,516,995
Exports	Air	26,267	37,132	38,522	51,964	52,575	79,753	122,721	188,839	290,580	447,135
	Vessel	424,826	518,248	589,805	1,049,480	868,254	1,532,989	2,614,363	4,458,543	7,603,612	12,967,223
Imports	Containerized Tons	2,924,147	3,611,190	4,377,694	4,304,642	4,939,016	6,473,244	8,790,513	11,937,310	16,210,587	22,013,596
	Air Penetration	3.80291	4.73651	6.11488	6.70141	7.21085	6.43732	9.08110	9.16288	8.84389	8.26020
Exports	Containerized Tons	339,860	414,598	471,844	839,584	694,603	1,226,391	2,091,490	3,566,834	6,082,889	10,373,778
	Air Penetration	7.17427	8.21994	7.54791	5.82851	7.03647	6.10598	5.54242	5.02809	4.55921	4.13213
Imports and Exports:											
	Air Tons	141,866	216,681	323,648	361,156	436,397	676,250	1,000,730	1,392,975	1,863,319	2,429,228
	Containerized Tons	3,264,008	4,025,788	4,849,538	5,144,226	5,633,619	7,699,636	10,882,004	15,504,144	22,293,476	32,387,374
	Air Penetration	4.16533	5.10742	6.25626	6.56005	7.18938	8.07377	8.42171	8.24386	7.71343	6.97721
0 – 100% CONTAINERIZATION											
IMPORTS:											
	Air Tons	215,291	309,710	465,305	528,799	605,536	915,814	1,300,514	1,735,484	2,217,908	2,745,562
	Containerized Tons	7,855,806	8,680,174	10,333,883	10,090,145	10,711,295	13,041,214	16,142,250	20,167,834	25,427,864	32,340,333
	Air Penetration	2.66743	3.44509	4.30870	4.97977	5.35076	6.56167	7.45589	7.92338	8.02259	7.82526
EXPORTS:											
	Air Tons	321,834	439,786	526,709	777,670	724,868	1,020,622	1,369,604	1,759,562	2,200,869	2,711,147
	Containerized Tons	8,380,994	10,214,060	9,324,200	11,923,220	12,244,393	14,568,354	17,798,536	21,814,478	27,090,720	34,417,115
	Air Penetration	3.69804	4.12796	5.34681	6.12296	5.58912	6.54708	7.14521	7.46398	7.51366	7.30211
IMPORTS & EXPORTS:											
	Air Tons	537,125	749,496	992,014	1,306,469	1,330,404	1,936,436	2,670,118	3,495,046	4,418,777	5,456,709
	Containerized Tons	16,236,800	18,894,234	19,658,083	22,013,365	22,955,688	27,609,568	33,940,786	41,982,312	52,518,584	66,757,448
	Air Penetration	3.20214	3.81545	4.80392	5.60239	5.47805	6.55397	7.29323	7.68524	7.76077	7.55629

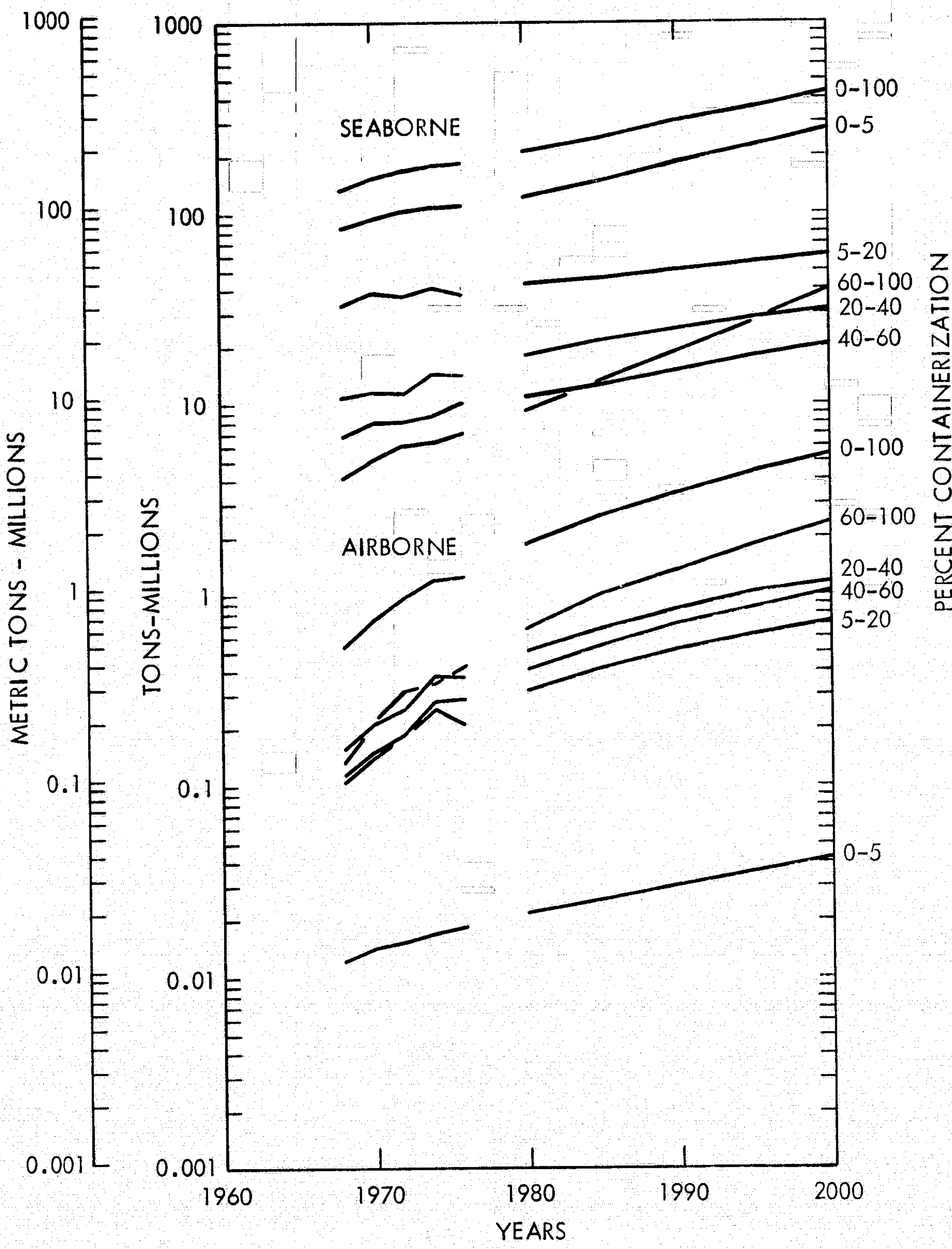


FIGURE III - 22. AIRBORNE AND CONTAINERIZABLE SEABORNE TRADE - U. S. IMPORTS AND EXPORTS

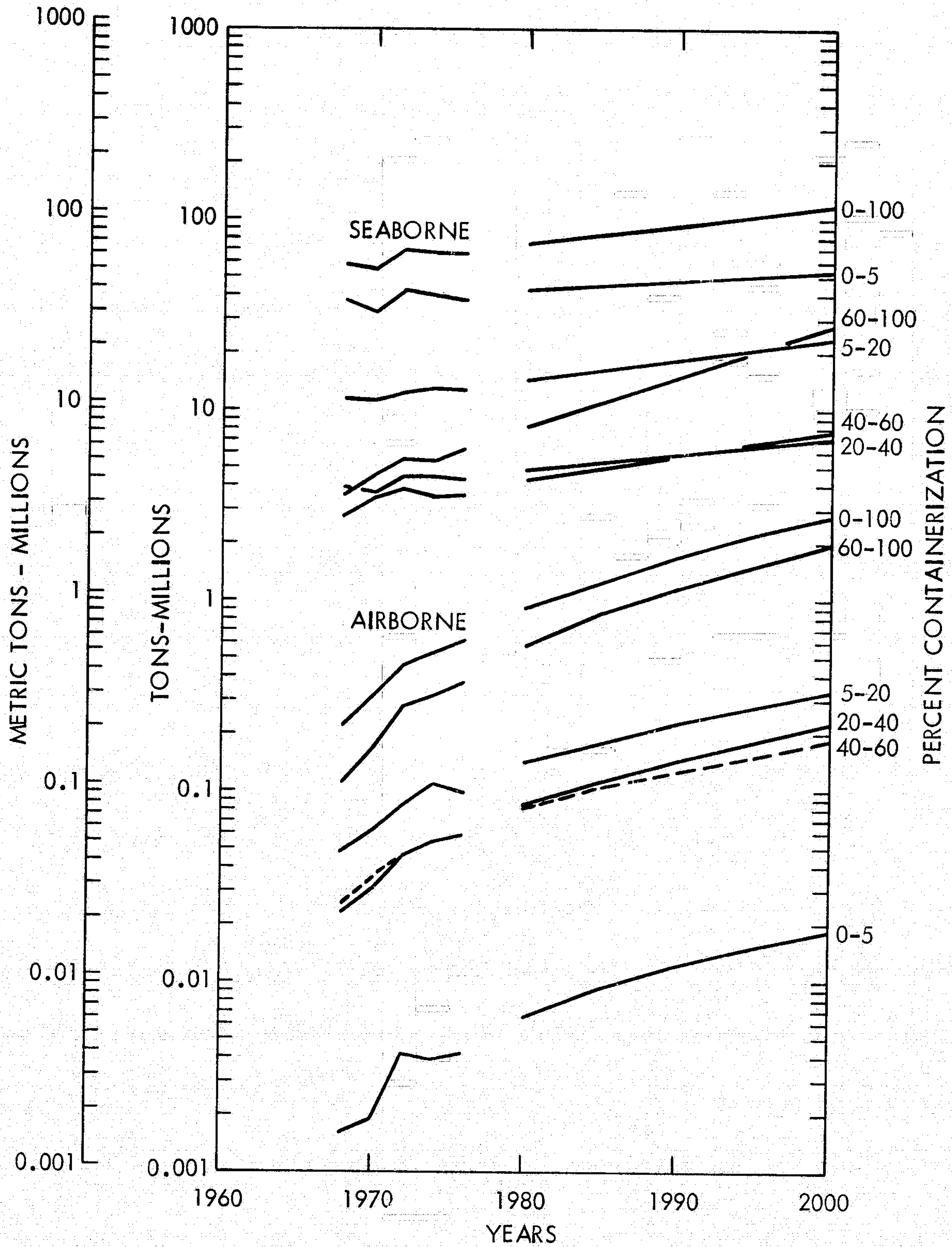


FIGURE III - 23. AIRBORNE AND CONTAINERIZABLE SEABORNE TRADE - U. S. IMPORTS

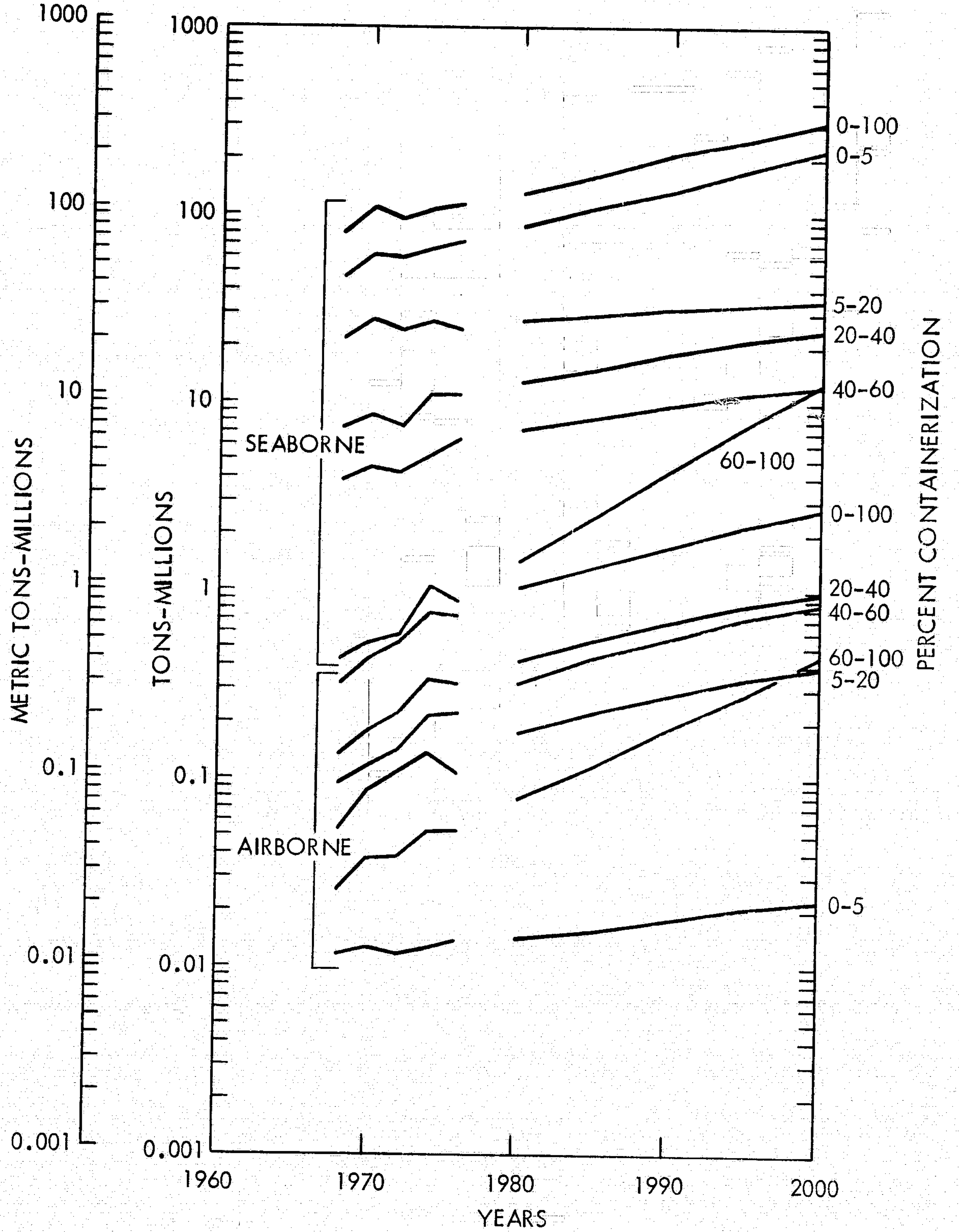


FIGURE III - 24. AIRBORNE AND CONTAINERIZABLE SEABORNE TRADE - U. S. EXPORTS

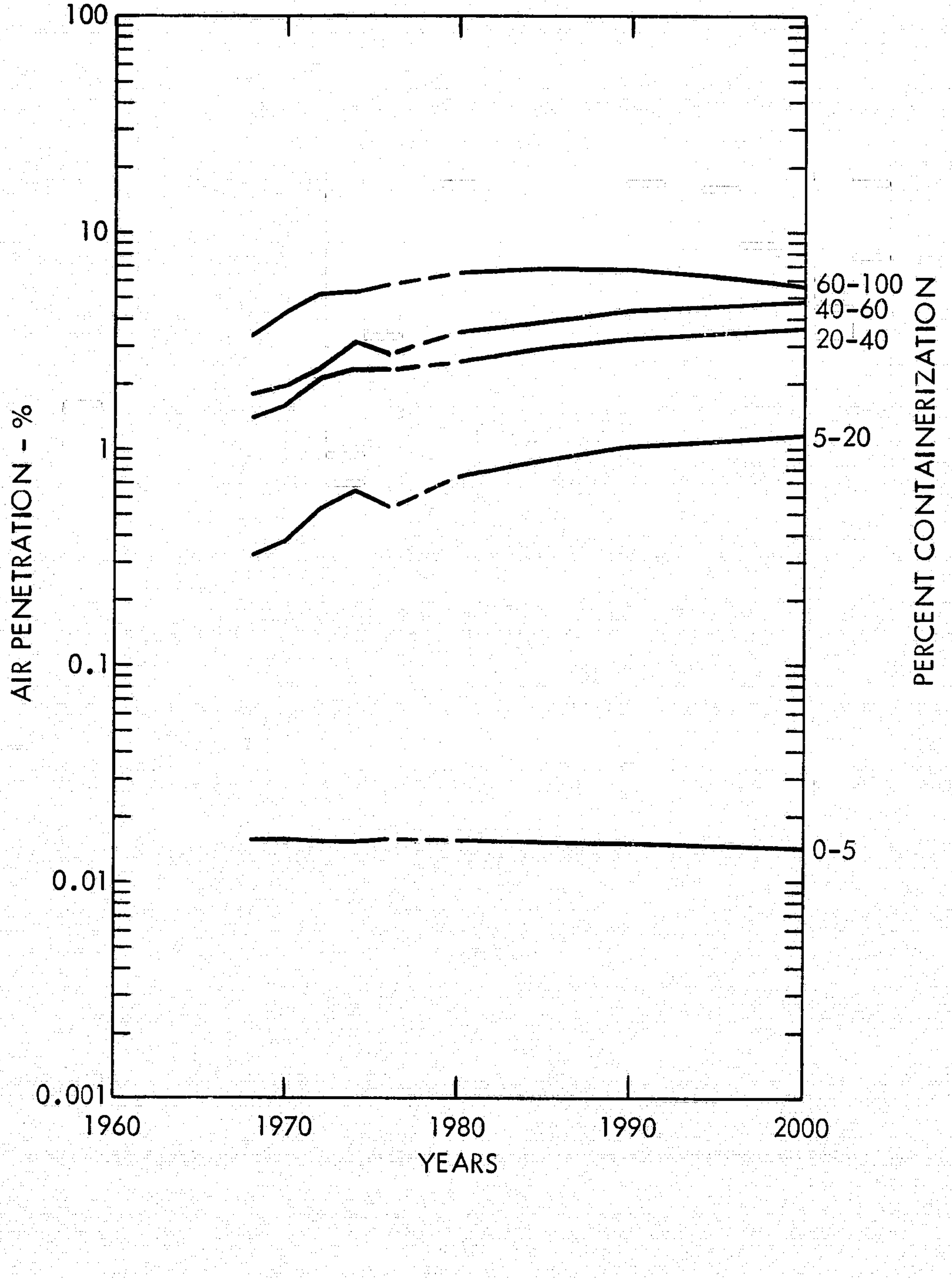


FIGURE III - 25. AIR PENETRATION OF CONTAINERIZABLE COMMODITIES
- U. S. IMPORTS AND EXPORTS

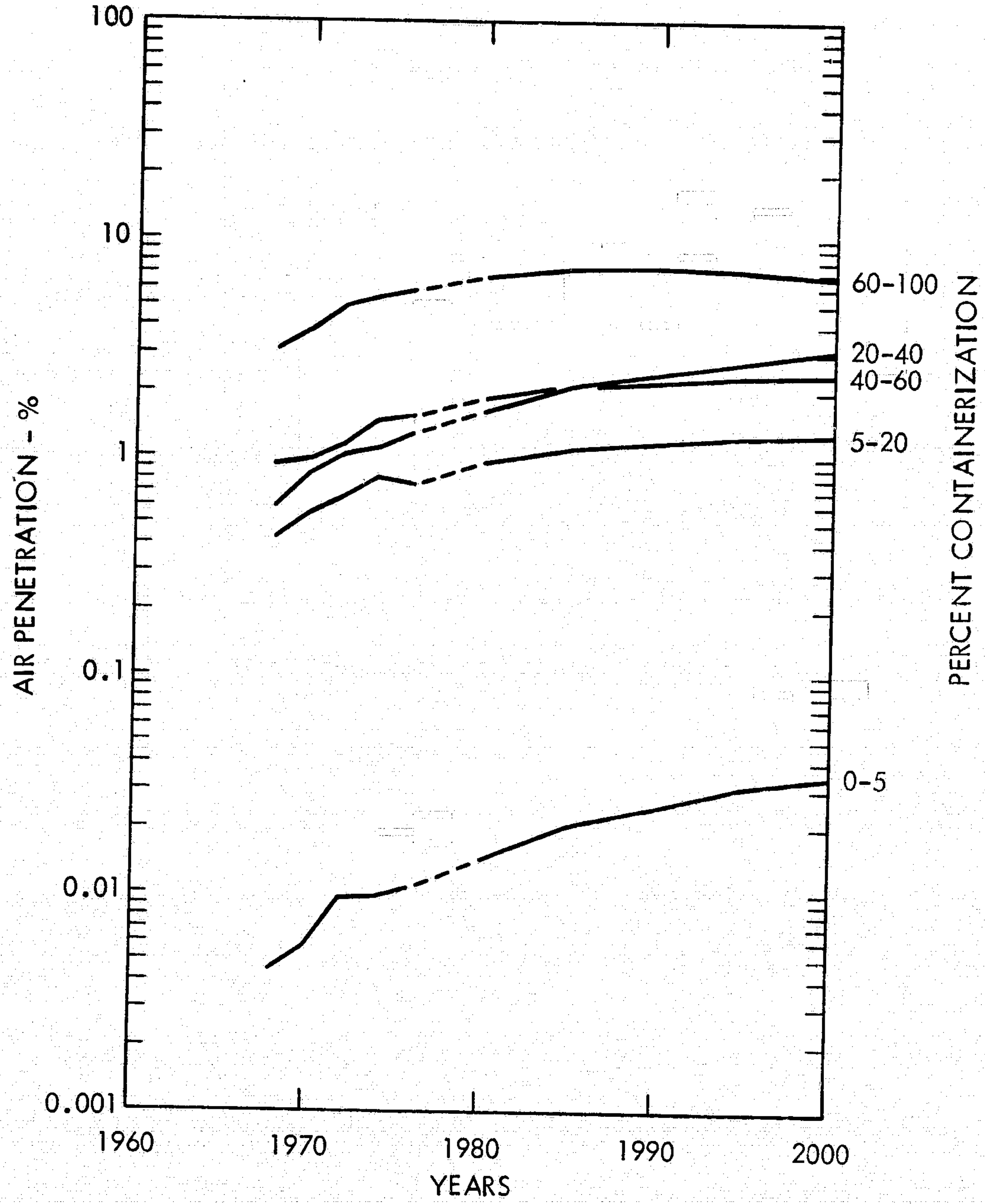


FIGURE III - 26. AIR PENETRATION OF CONTAINERIZABLE COMMODITIES - IMPORTS

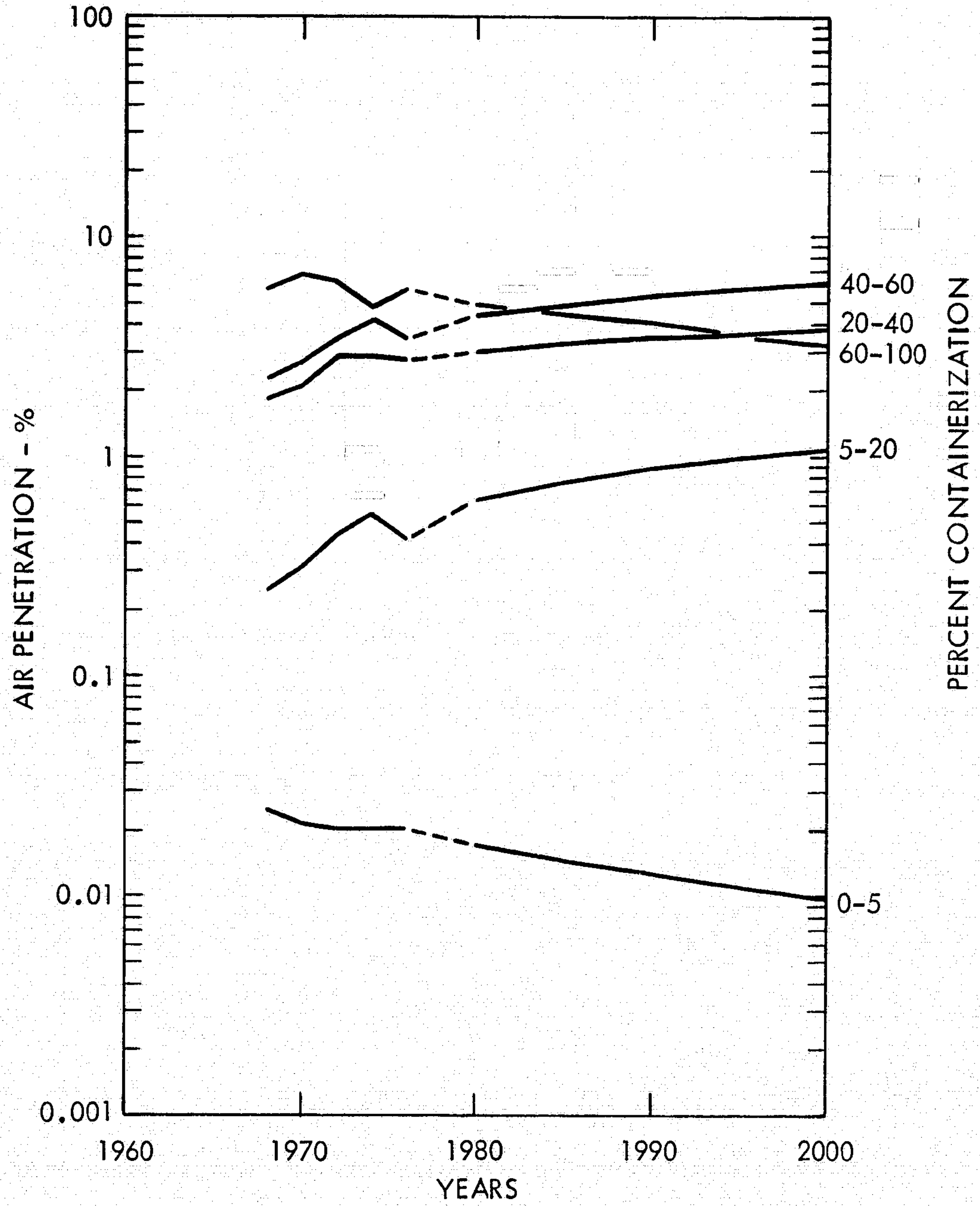


FIGURE III-27 . AIR PENETRATION OF CONTAINERIZABLE COMMODITIES - EXPORTS

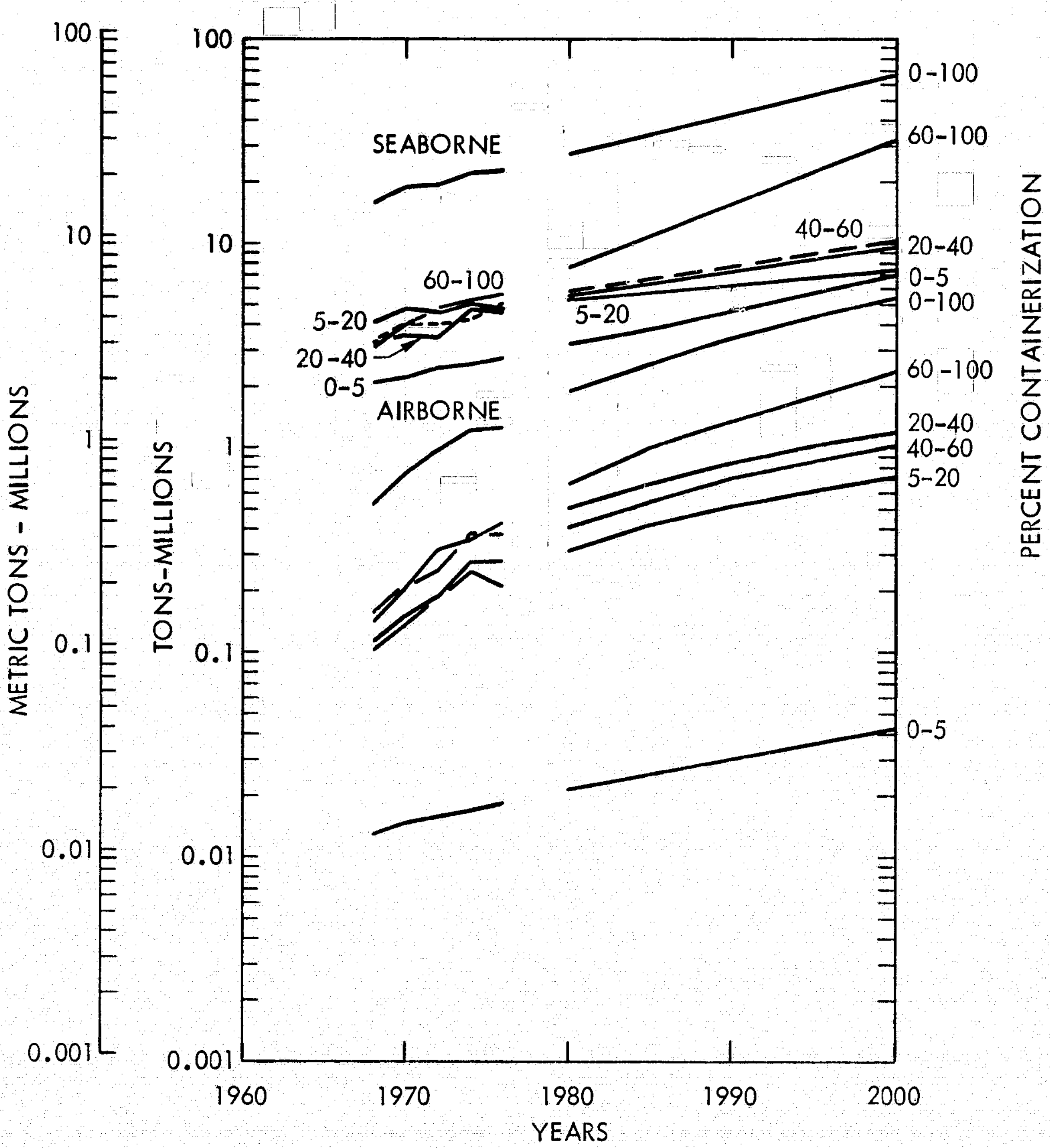


FIGURE III - 28. AIRBORNE AND CONTAINERIZED SEABORNE TRADE - U. S. IMPORTS AND EXPORTS

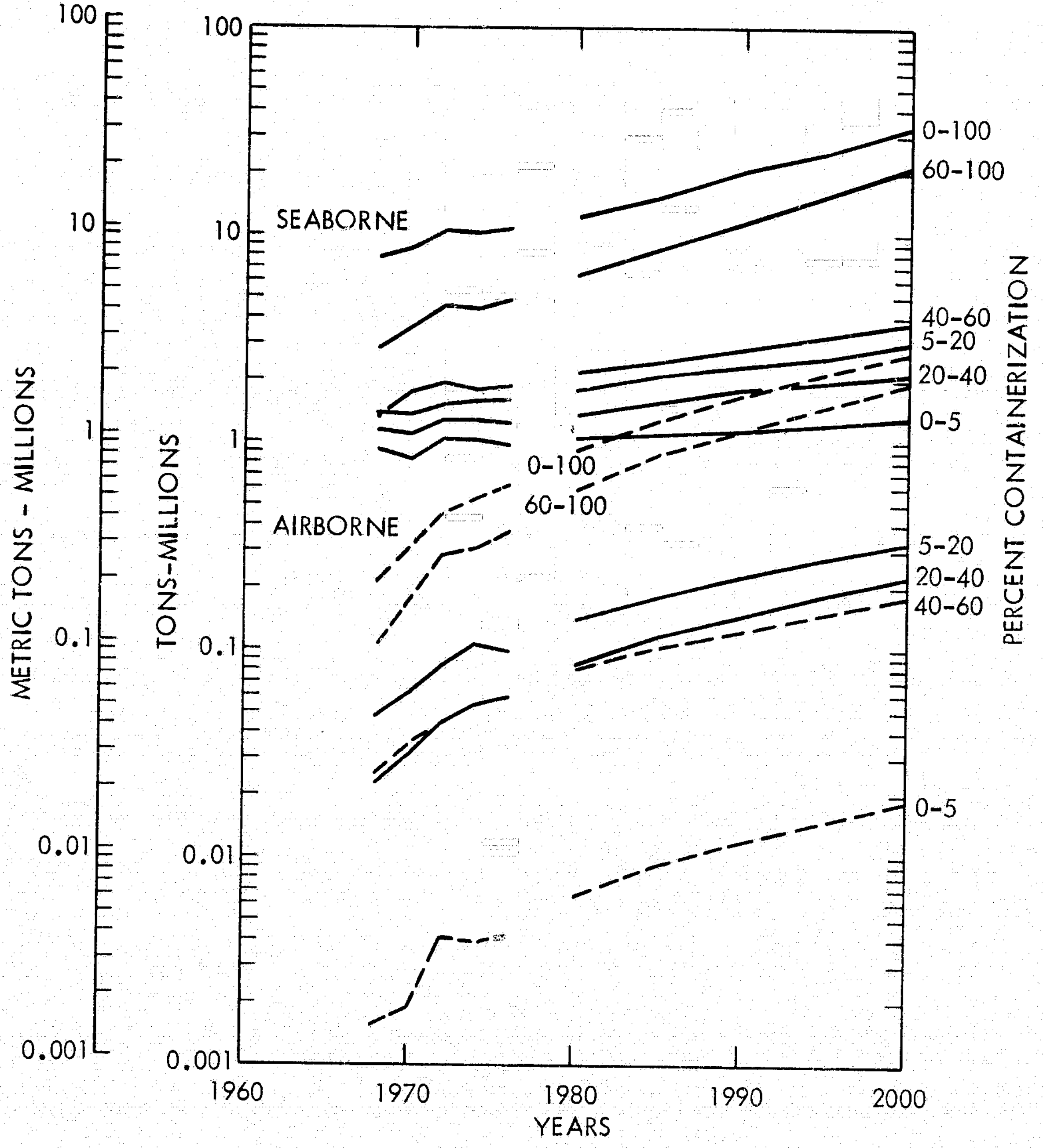


FIGURE III - 29. AIRBORNE AND CONTAINERIZED SEABORNE TRADE - U. S. IMPORTS

C-4

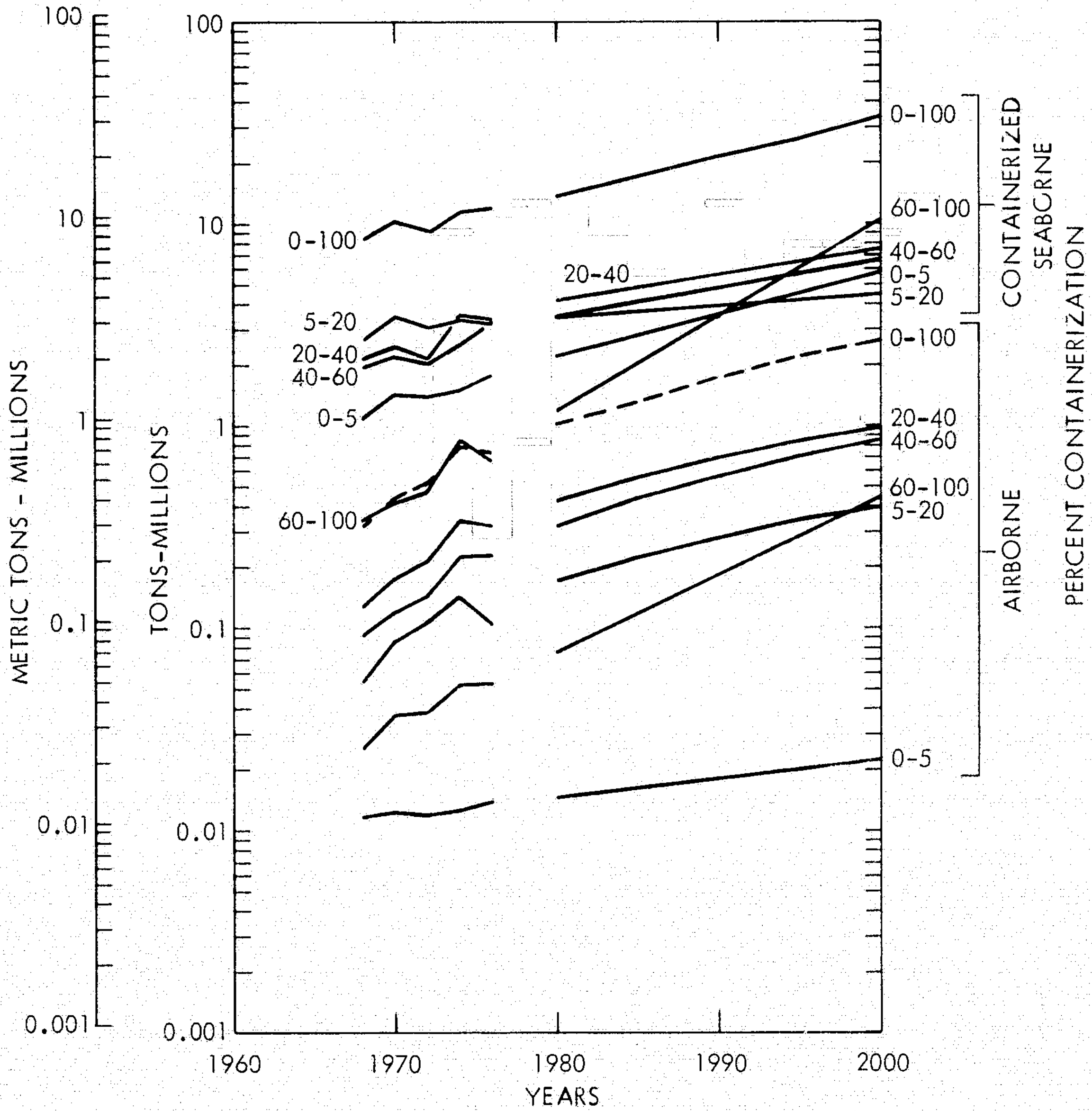


FIGURE III - 30. AIRBORNE AND CONTAINERIZED SEABORNE TRADE - U. S. EXPORTS

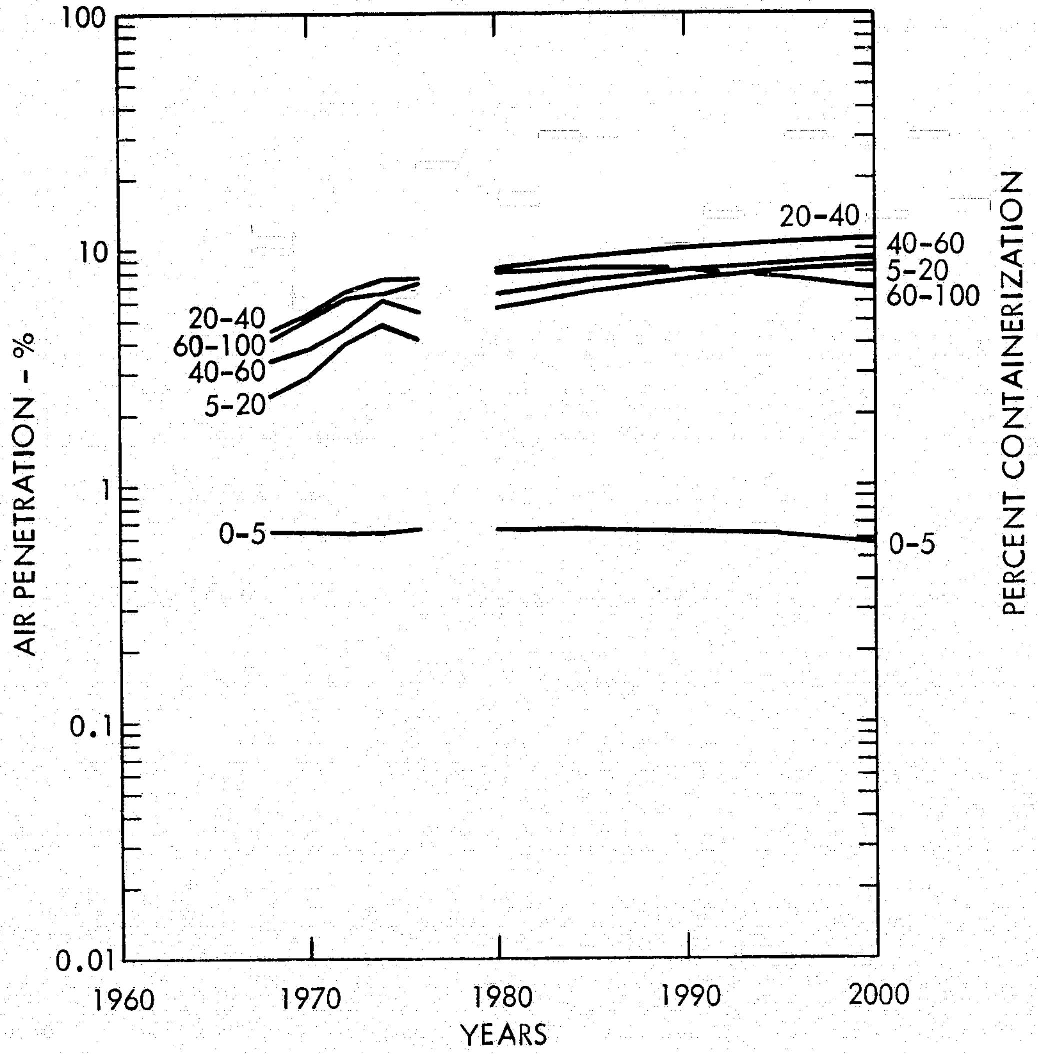


FIGURE III - 31. AIR PENETRATION OF CONTAINERIZED COMMODITIES - U. S. IMPORTS AND EXPORTS

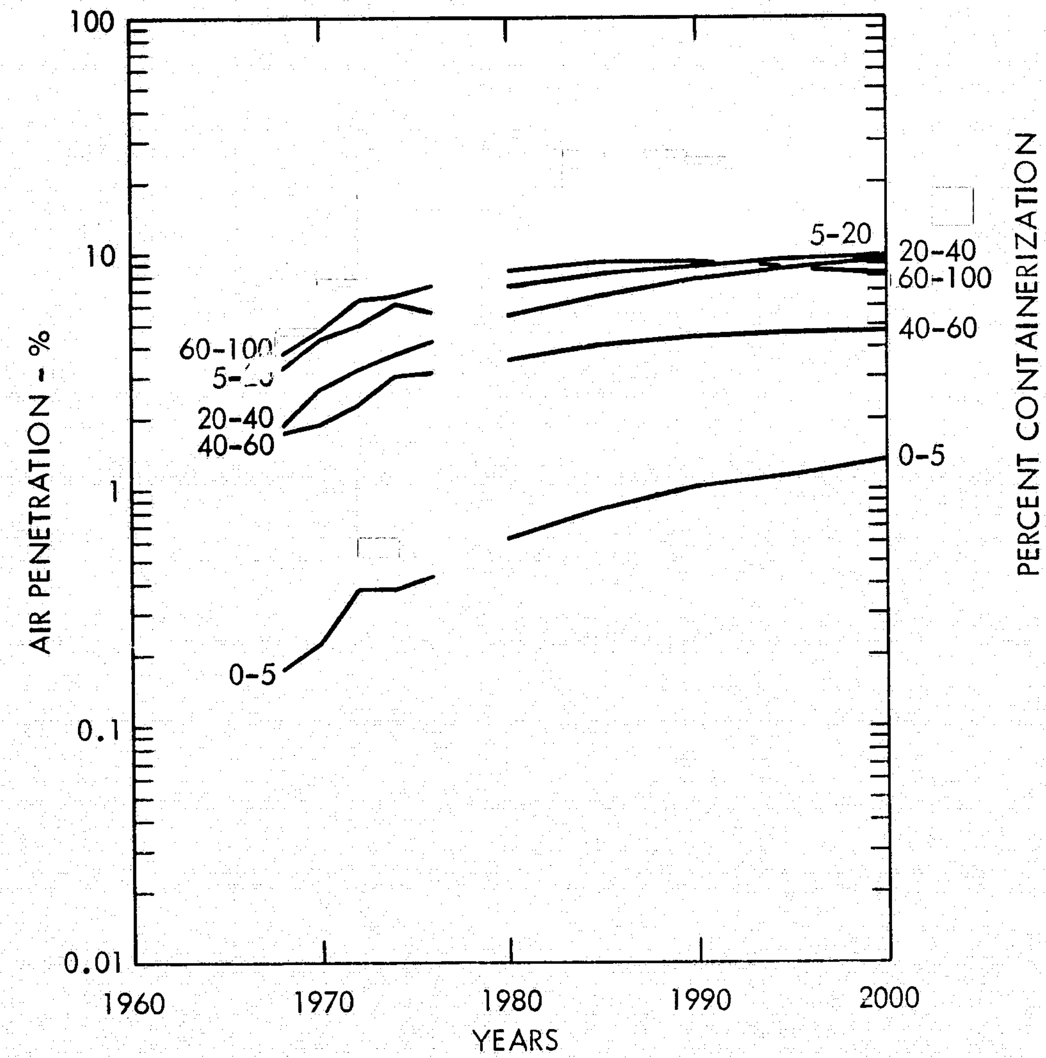


FIGURE III - 32. AIR PENETRATION OF CONTAINERIZED COMMODITIES - U. S. IMPORTS

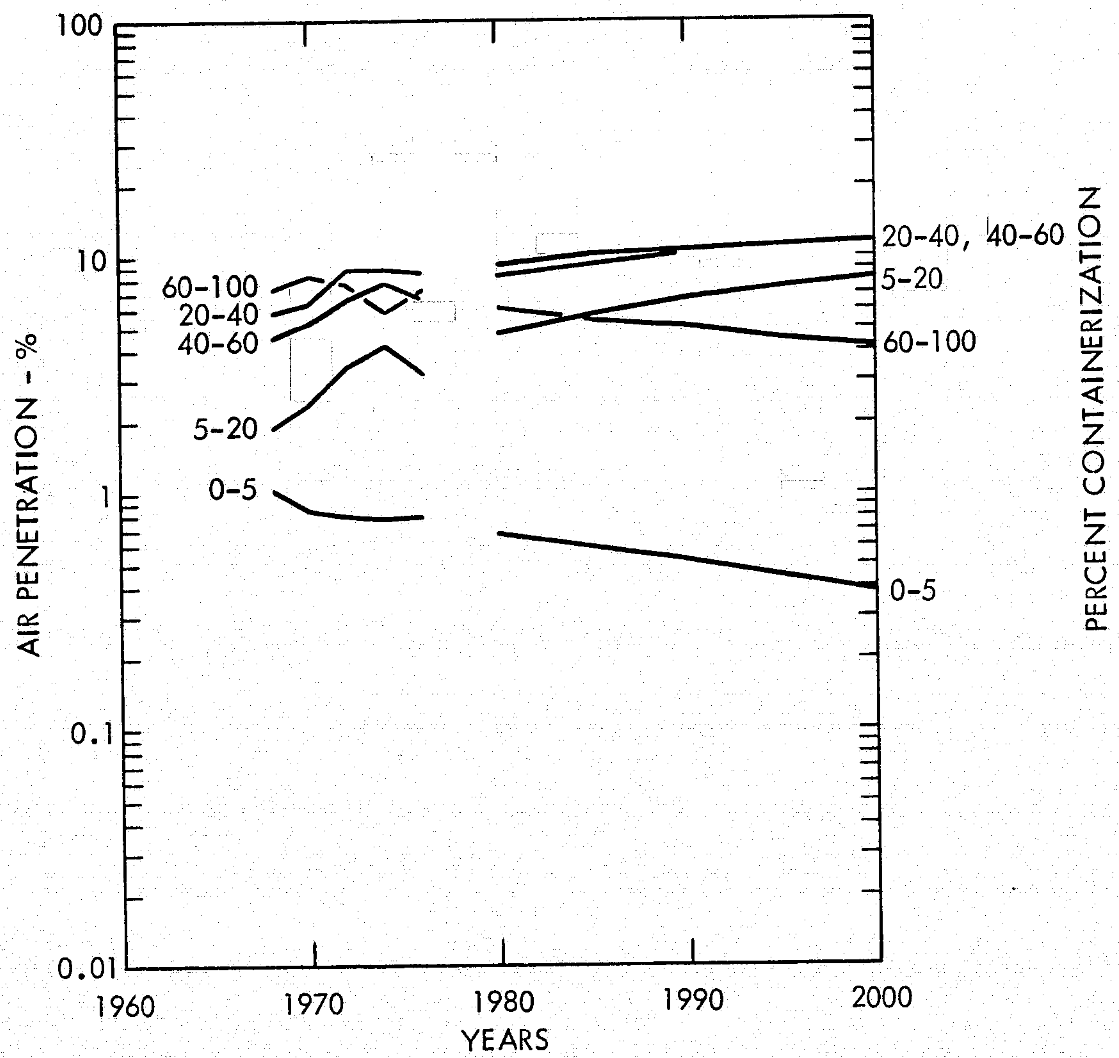


FIGURE III - 33. AIR PENETRATION OF CONTAINERIZED COMMODITIES - U. S. EXPORTS commodities aids the commodity-by-commodity comparisons through the three major foreign trade data sources of MarAd, Department of Commerce, and the OECD.

The historical data for the even years 1968 through 1976, and the forecasts through the year 2000 based on regression analysis of the historical data for the containerizable commodities, are presented in Table III-38. Forecasts are based on the airborne and vessel-borne tonnage, and air penetration is derived from these quantities. Imports and exports, separately, and imports and exports combined are presented for each range of commodity containerization. A large favorable imbalance for the U.S. is seen to occur by the year 2000 for those commodities in the 0 to 5 percent containerization for vessel-borne trade, while the reverse happens in the 60 to 100 percent containerization. The grand total for vessel-borne trade represented by 0 to 100 percent containerization reveals a ratio of 2.5 to 1 in favor of U.S. exports to U.S. imports. For airborne trade the grand total shows a good balance between imports and exports by the year 2000, although wide differences occur at the various levels of containerization.

Table III-39 presents similar details for the containerized tonnages and the respective air penetration. The grand total seaborne containerized tonnage for 0 to 100 precent containerization shows a good balance by the year 2000. It is this final containerized tonnage that is seen to be air-penetrable by the AACS, over and above the forecast for conventional air.

The tonnages and air penetration presented in Tables III-38 and III-39 for containerizable and containerized commodities, respectively, are presented graphically in a similar arrangement in Figures III-22 through III-27 and Figures III-28 through III-33. U.S. imports and exports combined, and each of them separately are presented in these figures. Again, the higher air penetration when expressed in terms of the total containerized tonnage is clearly illustrated.

As further illustration of the types of commodities, their tonnages, unit values, percent seaborne containerization, and percent of total trade, Tables III-40 through III-42 present the top 10 commodities for 1976 U.S. imports for total seaborne, seaborne-containerized, and airborne trade.

The commodities are ranked by tonnage and show that the top five seaborne commodities, Table III-40, account for almost 85 percent of the total seaborne tonnage - none of which is containerized. The next five commodities bring the total to almost 91 percent. These additional commodities have a small amount of contianerization.

The seaborne containerized data presented in Table III-41 show a different story. Unlike the concentration of total seaborne tonnage in a few commodities as previously discussed, the containerized tonnage is much more evenly distributed. The top 10 containerized commodities account for almost 34 percent of the total containerized tonnage, with alcoholic beverages heading the list with almost 10 percent.

TABLE III-40. 1976 COMMODITY RANKINGS

IMPORTS - SEABORNE

Rank	Code	Description	Total Seaborne: Unit Value $/Lb	Unit Value $/Kg	Percent of Total Seaborne	Cum Percent	Containerized: Container Penetration Percent	Percent of Containerized Tonnage	Cum Percent
1	331	Petroleum, Code	0.04	.09	55.50	55.50	0	0	0
2	332	Petroleum, Products	0.03	.07	14.70	70.20	0	0	0
3	281	Iron Ore & Concentrates	0.01	.02	9.32	79.52	0	0	0
4	283	Ores, Conc, Nonferrous	0.02	.04	3.55	83.07	0	0	0
5	273	Stone, Sand, and Gravel	0.00	.00	1.75	84.82	0	0	0
6	276	Crude Minerals, Nes	0.01	.02	1.49	86.32	2.5	1.81	1.81
7	674	Iron or Steel Plates	0.13	.29	1.38	87.69	2.5	1.67	3.48
8	061	Sugar, Syrups, Molasses	0.09	.2	1.33	89.02	0	0	3.48
9	513	Inorganic Chem. Elem.	0.06	.13	0.89	89.91	2.5	1.08	4.56
10	673	Iron or Steel Bars	0.12	.27	0.61	90.53	2.5	0.74	5.30

TOTAL SEABORNE TONNAGE - 517,512,804 TONS
469,479,720 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE - 10,711,295 TONS
9,717,124 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

TABLE III-41. 1976 COMMODITY RANKINGS

IMPORTS - SEABORNE CONTAINERIZED

Rank	Code	Description	Unit Value $/Lb	Unit Value $/Kg	Percent of Containerized Tonnage	Cum Percent	Container Penetration Percent	Air Penetration Percent
1	112	Alcoholic Beverages	0.35	.78	9.51	9.51	80.0	0.03
2	051	Fruits, Fresh	0.08	.18	3.39	12.90	12.5	0.21
3	732	Road Motor Vehicles & Parts	1.31	2.91	3.16	16.06	12.5	0.32
4	724	Telecommunications Appar.	3.12	6.93	3.15	19.21	80.0	7.86
5	011	Meat, Fresh, Chilled or Froz.	0.56	1.24	3.04	22.25	50.0	0.40
6	851	Footwear	1.80	4.0	2.73	24.98	80.0	10.29
7	841	Clothing, Etc. Not Fur	3.21	7.13	2.47	27.45	80.0	23.25
8	629	Rubber, Mfrs, Finished, Nec	1.04	2.31	2.35	29.80	80.0	0.26
9	031	Fish, Fresh or Simply Pres.	0.73	1.62	2.07	31.87	30.0	2.00
10	694	Nails, Screw, Nuts, Bolts, Etc.	0.47	1.04	2.01	33.88	30.0	0.11

TOTAL SEABORNE TONNAGE 517,512,804 TONS
469,479,720 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE - 10,711,295 TONS (2.07 PERCENT)
9,717,124 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

TABLE III-42. 1976 COMMODITY RANKINGS

IMPORTS - AIRBORNE

Rank	Code	Description	Unit Value $/Lb	Unit Value $/Kg	Total Airborne Percent of Total Airborne	Total Airborne Cum Percent	Air Penetration Percent	Seaborne Container Penetration Percent	Seaborne Containerized Percent of Containerized Tonnage	Seaborne Containerized Cum Percent
1	841	Clothing, Etc. Not Fur	6.25	13.80	16.51	16.51	23.25	80.0	2.47	2.47
2	851	Footwear	4.27	9.48	6.90	23.41	10.29	80.0	2.73	5.21
3	990	Est. Value Under $251	1.22	2.71	6.66	30.07	40.07	12.5	0.07	5.28
4	724	Telecommunications Appar.	9.00	20.00	5.91	35.98	7.86	80.0	3.15	8.43
5	729	Electrical Machinery Nes	25.48	56.62	4.79	40.77	19.59	80.0	0.89	9.32
6	292	Veg. Materials, Nes, Crude	1.36	3.02	4.33	45.10	9.08	12.5	0.31	9.63
7	894	Baby Carriages, Toys, Games	3.39	7.53	3.43	48.53	7.63	80.0	1.89	11.51
8	719	Mach. & Appliance, Nec	6.35	14.11	3.27	51.80	4.67	50.0	1.90	13.41
9	714	Office Machines & Parts	14.79	32.86	3.03	54.83	22.02	80.0	0.49	13.90
10	861	Sci., Med. Apparatus, Nec	18.25	40.55	2.66	57.50	33.88	80.0	0.24	14.13

TOTAL AIRBORNE TONNAGE 606,078 TONS
549,825 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE - 10,711,295 TONS
9,717,124 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

Airborne trade, Table III-42, is presently more heavily concentrated in the top 10 commodities than seaborne containerized, accounting for almost 58 percent of total airborne tonnage. Clothing, footwear, and low-value goods account for over 30 percent. It is also seen that most of the top 10 airborne commodities also have a high degree of seaborne containerization.

Tables III-43 through III-45 present similar data for U.S. Exports, however, the commodity mix is quite different. The total seaborne tonnage distribution, Table III-43, shows that the top 10 commodities account for almost 75 percent, with only 3 commodities having any significant degree of containerization.

Table III-44 shows the seaborne containerized tonnage distribution with the top 10 commodities accounting for almost 50 percent. The level of containerization in the top 10 export containerized commodities is between 30 and 50 percent compared with 80 percent for imports.

Table III-45 shows the top 10 airborne commodities, accounting for almost 52 percent of the total airborne tonnage. Again, as in imports, the airborne commodities also have a significant level of containerization for the seaborne movement of the same commodity description.

For both imports and exports, the three groupings of the respective top 10 commodities - total seaborne, seaborne containerized, and airborne - show three distinct levels of unit value. The seaborne commodities are generally worth less than 10 cents per pound (22 cents per kilogram), with a maximum of 13 cents. The seaborne containerized commodities are generally worth less than $1.00 per pound ($2.20 per kilogram), with a maximum of $3.21 ($7.07) for imports and $2.16 ($4.76) for exports. The airborne commodities are, with only two exceptions, worth more than $3 per pound (6.60 per kilogram) with a maximum of $35 ($77).

Free-World International - The major sources of data for the Free-World international cargo demand is the OECD (Organization for Economic Co-operation and Development) foreign trade data. The OECD is a ministerial level organization of the 24 industrial countries: the U.S.A., Canada, Japan, Australia, New Zealand, Austria, Belgium, Luxembourg, Denmark, Finland, France, Germany (F.R.), Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

The OECD member countries report to the OECD both value and quantity data on exports to and imports from approximately 160 partner countries. Depending on the commodity, up to 23 of these partner countries are other OECD member countries, the remainder being non-member countries from Argentina to Zaire. The trade data are consolidated by the OECD and made available to the public in published, microfiche, and computer tape forms in several formats and levels of detail. The most detailed format is Series C, which forms the source of data for this study. Series C printed reports provide only value data at the 1- and 2-digit levels of commodities based on the Standard International Trade Classification code and value and quantity at the 3- and

TABLE III-43. 1976 COMMODITY RANKINGS

EXPORTS - SEABORNE

			Total Seaborne					Containerized	
			Unit Value						
Rank	Code	Description	$/Lb	$/Kg	Percent of Total Seaborne	Cum Percent	Container Penetration Percent	Percent of Containerized Tonnage	Cum Percent
1	321	Coal, Coke, and Briquets	0.02	.04	21.39	21.39	0	0	0
2	044	Corn or Maize, Unmilled	0.05	.11	17.09	38.48	0	0	0
3	041	Wheat, Unmilled	0.07	.15	10.33	48.80	0	0	0
4	221	Oil Seeds, Oil Nuts, Kernels	0.10	.22	6.17	54.97	0.36	0.54	0.54
5	242	Wood, In the Rough	0.03	.07	4.67	59.64	0.48	0.55	1.09
6	332	Petroleum Products	0.04	.09	3.68	63.32	12.5	11.24	12.33
7	271	Fertilizers, Crude	0.02	.04	3.36	66.68	0	0	12.33
8	081	Feeding - Stuff for Animals	0.07	.15	2.98	69.65	3.25	2.36	14.69
9	631	Wood Veneers, Plywood Boards	0.02	.04	2.91	72.57	0.10	0.07	14.77
10	561	Fertilizers, Manufactured	0.04	.09	2.40	74.96	2.50	1.46	16.23

TOTAL SEABORNE TONNAGE - 282,779,825 TONS
256,533,540 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE - 12,244,393 TONS
11,107,927 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

TABLE III-44. 1976 COMMODITY RANKINGS

EXPORTS - SEABORNE CONTAINERIZED

Rank	Code	Description	Unit Value $/Lb	Unit Value $/Kg	Percent of Containerized Tonnage	Cum Percent	Container Penetration Percent	Air Penetration Percent
1	332	Petroleum Products	0.04	.09	11.24	11.24	12.5	0.03
2	251	Pulps and Waste Prod.	0.14	.31	8.44	19.68	30.0	0
3	581	Plastic Mat'ls, Syn. Resins	0.46	1.02	5.37	25.05	50.0	0.96
4	512	Organic Chemicals	0.24	.53	5.10	30.15	12.5	0.15
5	054	Veg. Fresh, Chld, Froz.	0.13	.29	3.92	34.07	50.0	0.51
6	276	Crude Minerals, Nes	0.04	.09	3.27	37.34	12.5	0.02
7	641	Paper & Paperboard	0.18	.40	3.03	40.37	15.1	0.23
8	732	Road Motor Vehicles & Parts	1.53	3.40	2.88	43.25	30.0	3.84
9	719	Mach & Appliance Nec	2.16	4.80	2.86	46.11	30.0	5.62
10	211	Hides & Skins, Undressed	0.35	.78	2.76	48.87	50.0	0.04

TOTAL SEABORNE TONNAGE - 282,779,828 TONS
256,533,540 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE - 12,244,393 TONS
11,107,927 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

TABLE III-45. 1976 COMMODITY RANKINGS

EXPORTS - AIRBORNE

Rank	Code	Description	Unit Value $/Lb	Unit Value $/Kg	Total Airborne Percent of Total Airborne	Total Airborne Cum Percent	Air Penetration Percent	Seaborne Container Penetration Percent	Seaborne Containerized Percent of Containerized Tonnage	Seaborne Containerized Cum Percent
1	719	Mach & Appliance Nec	8.29	18.4	9.05	9.05	5.62	30.0	2.86	2.86
2	931	Spec. Transactions Not Class.	4.19	9.3	8.20	17.26	26.62	12.5	0.18	3.04
3	714	Office Machines & Parts	25.02	55.6	6.40	23.66	80.60	50.0	0.05	3.09
4	732	Road Motor Vehicles & Parts	3.17	7.0	6.10	29.76	3.84	30.0	2.88	5.97
5	729	Electrical Machinery Nes	35.08	71.9	5.03	34.80	15.63	30.0	0.51	6.48
6	861	Sci. Med. Apparatus, Nec	16.31	36.2	4.52	39.32	42.19	50.0	0.19	6.67
7	718	Mach for Spec. Industr.	7.39	16.4	3.68	43.00	3.67	30.0	1.82	8.49
8	724	Telecommunications Appar.	23.81	52.9	3.09	46.09	34.68	50.0	0.18	8.68
9	734	Aircraft and Spacecraft	34.69	77.0	3.05	49.14	57.60	30.0	0.04	8.72
10	711	Power Gen'g. Machinery	23.99	53.3	2.75	51.89	8.04	30.0	0.59	9.31

TOTAL AIRBORNE TONNAGE - 726,312 TONS
658,899 METRIC TONS

TOTAL SEABORNE CONTAINERIZED TONNAGE -12,244,393 TONS
11,107,927 METRIC TONS

SOURCE: Department of Commerce Foreign Trade Data

4-digit levels. The Series C computer tapes provide the value and quantity data by commodity at the 4-digit level for 1961 through 1969 and the 5-digit level for 1970 through 1975. To reduce the final output for this study, these data were aggregated to the 3-digit level.

To gain improved understanding of the OECD data and the relative magnitudes of the foreign trade of the OECD member countries and their trading partners, a cursory analysis was made of the 1974 value data. Details of this analysis are presented in Appendix F, Table I-1 through I-13. This analysis also served to produce the country/region-pair matrix to reduce data extraction from the Series C computer tape to a workable level. These country/region pairs are listed in Figure III-34.

The OECD arrangement of 24 reporting countries was simplified by considering OECD Europe as an entity; thus, the 24 reporting countries reduced to 6 reporting countries or regions: U.S., Canada, OECD Europe, Japan, Australia, and New Zealand. However, since minimal data were available for New Zealand as a reporting country, it was dropped. New Zealand was included as a trading partner with the other OECD reporting countries. The non-OECD trade partners were aggregated to 4 regions - Middle East, Africa, Less-Developed Far East (this area excludes Japan and Australasia), and Less-Developed America (or Latin America). The trade value of these trading partners accounts for 90 percent of OECD imports from the entire world and almost 85 percent of OECD exports to the entire world. These data, including the world data, exclude the trade within OECD Europe.

Data Resources Inc. of Washington, D.C. were contracted to extract from their OECD Series C computer system the foreign trade data for the country-pair combinations and commodity groupings outlined in Appendix F. The commodities were regrouped, rather than listing them in numerical order of the SITC code, based on the degrees of containerization developed from the MarAd analyses described at the beginning of the discussion of U.S. and Foreign International Transportation. The degree of containerization by commodity is detailed in Appendix F, Table I-14. the level of maturity of seaborne containerization for U.S. trade is assumed to be achievable by the rest of the free-world by the 1990's, thus giving some optimism for the AACS demand. However, this optimism is offset by other conservative factors to be discussed later.

Applying the MarAd percentage of containerization by commodity to the OECD data is an approximation in that any given commodity in U.S. import trade can have a level of containerization different from that of the same commodity in U.S. export trade. This had to be simplified in the OECD analyses, since the OECD data, in addition to presenting U.S. foreign trade, includes trade between two foreign countries not involving the U.S., thus requiring a single value of percent containerization. Many commodities exhibit the same level of containerization for both imports and exports and thus a single value is available. Where differences exist in the level of containerization for imports versus exports, the higher level of containerization was generally

01	U.S. -	OECD Europe
02		Japan
03		Canada
04		Australia
05		L/Developed Far East
06		Middle East
07		Africa
08		L/Developed America
09	OECD Europe -	Japan
10		Canada
11		Australia
12		New Zealand
13		L/Developed Far East
14		Middle East
15		Africa
16		L/Developed America
17	Japan -	Canada
18		Australia
19		L/Developed Far East
20		Middle East
21		Africa
22		L/Developed America
23	Canada -	L/Developed Far East
24		L/Developed America
25	Australia -	L/Developed Far East

Note: To keep track of imports and exports, a three-digit code system is used. The first digit is either 1 or 2, i.e. 1 for imports, 2 for exports. The next two digits describe the country/region-pair as listed above. The code 1 or 2, for imports or exports refers to the OECD reporting country, namely the U.S., OECD Europe, Japan, Canada and Australia as listed above.

FIGURE III-34. OECD COUNTRY/REGION - PAIR GROUPINGS chosen. Where the directional tonnage imbalance in U.S. trade is large, the level of containerization of the higher trade flow tonnage was chosen.

Returning to the basic OECD foreign trade data for approximately 160 countires, the value data are standardized by using an appropriate exchange rate for each year and converting the value of each member country's imports and exports into U.S. dollars. Tasks of aggregation and comparison for value data are thus greatly simplified. Given the diversity of data collection techniques and reporting methods in the OECD member countries, the method for dealing with commodity quantity aggregations is much more difficult. Although by far the majority of commodity quantities are reported in metric tons, significant exceptions exist. From DRI's experience with the Trade Series C data, it appears that, if a member country reports their commodity to a higher level of disaggregation, say the 7-digit level, it is sometimes not possible for the OECD to aggregate these data to the 4- or 5-digit level due to inconsistencies in the units of quantity. Therefore, quantity data for these reporting countries are not available on the tapes, and inconsistencies exist across OECD reporting countires. A second, and only slightly less troubling, problem stems from the fact that the OECD Trade Series C data base is cross-sectional in conception. In other words, a cross-sectional report is published each year, describing trade for that year between the OECD members and their partners. Occasionally since 1961, when publication began, some reporting countries changed the unit of measures in which they reported import and/or export volumes for specific commodities. This creates considerable difficulties in attempting to deal with the data in the time series format required for making extrapolations.

Recognizing all of these problems and the fact that the OECD Trade Series C data base is still the best single source of foreign trade data available with which to examine commodity trade between countries, a methodology was devised by which the available data could be used to approximate the unavailable quantity data. Since the European OECD reporting countries had excellent quantity data available, proxy trade volumes were developed for those reporting countries and their trading partner for which trade quantity data were unavailable. Proxy trade quantities were obtained by dividing the average unit value of the commodity in OECD Europe into the value of trade in that commodity in the country for which no quantity data were available.

Wherever possible, a similar method was used to obtain proxies to fill gaps within a time series when the unit of measure had changed from year to year. The rule used in applying proxies was determined by the percentage of actual data reported in metric tons for a given set of partners. DRI found the actual volumes in the inconsistencies to be small, so that if 90 percent or more of the number of series in the aggregate were reported in metric tons, the actual data were used. Visual inspection of these series was necessary to assure consistency. For a few commodities, this methodology proved to be unworkable where unit values varied greatly across countries or where the reporting units in OECD Europe were not metric tons. In such cases, there was no alternative but to exclude the commodity as not having been reported in tons.

Once all of these tests had been made, the task of extrapolating the series was approched. Due to budget and time constraints, DRI and Lockheed jointly decided to employ a linear technique. To represent the 3-digit level aggregations for the 25 country pairs, imports and exports, 6000 final time series extrapolations were required. It must be recognized that these 6000 time series were obtained from aggregations of approximately three million time series in the basic OECD trade tapes.

Since the solution using the linear technique required non-zero data within each series, zero elements within the series were replaced by the mean of adjacent period volumes (e.g., missing data for 1968 were replaced by the mean of the observations for 1967 and 1969) and leading and trailing observations containing zeros were truncated. Finally, a linear regression was performed on each resulting series to derive the extrapolated or forecasted values. Since the extrapolation or forecast was based on the best linear fit through the historical time series points, the forecast of the tonnage for each commodity did not commence from the historical data point for 1975. Since the forecast data were developed for 5-year increments from 1975, the growth for the final historical point to 1980 does not appear to be compatible with the growth between 1980 and the year 2000. The final output from the OECD foreign trade data Series C, the forecast at the 3-digit level commodity aggregation by degree of containerization, provided good results for the 0-5 percent through the 60-100 percent containerization. Due to problems with the units of quantity, the output provided unacceptable results for the 15 liquid and dry bulk commodities. Since these would have been eliminated anyway, the loss does not detract from the overall value of the results. Thus, the analysis of the OECD data represents only containerizable and containerized commodities.

The OECD data are not available for the separate modes, but since the country/region pairs analyzed mostly represent intercontinental trade, the data represent just two modes: air and sea. Air penetration derived from regression analyses of the Department of Commerce U.S. foreign trade data by modes, presented in Table III-46, is applied to the OECD data to isolate the conventional air - the air cargo system as known today. This air penetration is seen to be a function of the degree of containerization, and different values are available for U.S. imports and exports. In applying these data to the non-U.S. OECD foreign trade, an average has been used based on the combined imports and exports. The resulting conventional air cargo is then subtracted from the total OECD data to give the OECD containerizable seaborne trade by degrees of containerization. From these data, the estimated free-world seaborne containerized tonnages are obtained.

The Advanced Air Cargo System concept is based on the requirement to move by air the 8 x 8-foot (2.44 x 2.44-meter) and larger cross-section intermodal containers. The analysis of Case Study results (as presented in Section II) shows that 5.6 percent of seaborne containerized trade would be eligible for the AACS, and due to the container size trend to 8 x 8.5-foot (2.44 x 2.6-meter) containers (see Figure IV-3), would not be compatible with belly holds or conventional cargo aircraft derived from passenger aircraft. This

TABLE III-46. AIR PENETRATION FOR OECD DATA ANALYSIS

Degree of Containerization %/Years	1973[1]	1974	1975[1]	1980	1985	1990	1995	2000
U. S. IMPORTS								
0 - 5	0.0097	0.0098	0.0103	0.0156	0.0205	0.0255	0.0305	0.0354
5 - 20	0.7271	0.8011	0.7752	0.9614	1.1043	1.2097	1.2827	1.3280
20 - 40	1.0880	1.1745	1.2538	1.7245	2.1389	2.5061	2.8238	3.0923
40 - 60	1.3493	1.5237	1.5500	1.8537	2.1082	2.2829	2.3900	2.4414
60 - 100	5.1932	5.4340	5.6435	6.8657	7.3993	7.4672	7.2025	6.7192
U. S. EXPORTS								
0 - 5	0.0202	0.0201	0.0201	0.0172	0.0150	0.0130	0.0113	0.0098
5 - 20	0.4983	0.5481	0.4840	0.6381	0.7730	0.8934	0.9995	1.0920
20 - 40	2.8229[2]	2.8607	2.7883[2]	2.9878	3.2667	3.4966	3.6923	3.8629
40 - 60	3.7659	4.1180	3.7841	4.3816	4.9445	5.4272	5.8514	6.2310
60 - 100	5.4243	4.7178	5.2137	4.9452	4.4836	4.0633	3.6809	3.3333
IMPORTS & EXPORTS (FOR R.O.W.)								
0 - 5	0.0161	0.0162	0.0165	0.0167	0.0166	0.0162	0.0156	0.0147
5 - 20	0.5756	0.6319	0.5826	0.7512	0.8932	1.0122	1.1096	1.1869
20 - 40	2.2139	2.3906	2.3212	2.6580	2.9914	3.2657	3.4959	3.6919
40 - 60	2.7179	3.0941	2.9341	3.4402	3.9164	4.2984	4.6046	4.8479
60 - 100	5.1931	5.3178	5.5766	6.5650	6.8528	6.7056	6.2674	5.6608

(1) 1973 & 1975 data were obtained by linear interpolation between 1972/1974 and 1974/1976 respectively.
(2) Obtained by linear interpolation between 1972 and 1976 - excluding the actual data point for 1974 because of the initial data problems.

result has been applied to the estimated OECD containerized tonnages to give the AACS demand - the demand for the dedicated all-cargo aircraft. This demand is used as input to the MACRO optimization model to arrive at the numbers of aircraft.

Appendix F, Tables II-1 through II-33, obtainable from NASA, present the detailed results of analyses of the OECD data from the total all-modes total cargo by trading partners and degrees of containerization to the demand for the Advanced Air Cargo System and total air cargo demand.

Table II of Appendix F presents the total free-world data. To simplify reference to and extraction from the Appendix F data for specific world regions, Tables III through V provide separate outputs for U.S. only trade, OECD European only trade, and Japanese only trade. Since the MACRO optimization model is limited in the number of region-pairs it can handle, an additional aggregation is presented as MACRO Regional Grouping in Table VI. Figure III-35 presents these country/region-pair groupings and how they are obtained from the OECD data analyses. The choice of the country/region pair groupings is based on IATA regions, and as such U.S. - Canada and Australia - L/Developed Far East are not included. Since much of the U.S. - Canada trade is over short distances, it does not meet the scenario guidelines for the AACS. The Australia-L/Developed Far East represents only a small percentage of the total Free-World traffic and, since it is not included in the IATA based regions, the pair was excluded from the MACRO analyses.

Results of the analyses for the Free-World for seaborne containerizable freight, seaborne containerized freight, and the demand for the AACS are presented in Figure III-36 through 38 for imports and exports, imports, and exports, respectively. As discussed previously, the demand for the AACS has been established as 5.6 percent of the seaborne containerized freight.

The resulting average annual growth rate for 1975 through the year 2000 for the AACS imports and exports combined, had it been in service in 1975, is 3 percent. This is considered to be the low forecast for the Free-World international AACS. This is seen to be in addition to the continuation of international air cargo as known today which is predominantly carried in passenger aircraft.

Comparisons of the three separate data sources - OECD (U.S. trade only), Department of Commerce, and MarAd - have been made for seaborne containerizable, and seaborne containerized commodities. Also, conventional airborne data are compared with OECD (U.S. trade only) and Department of Commerce, since the MarAd data does not include any airborne data. These comparisons are presented in Tables III-47E through III-49E for tonnages, and Tables III-50 through III-52 for annual growth rates.

Table III-47 shows for seaborne containerizable commodities by the year 2000 that the OECD (U.S. trade only) compares favorably with MarAd for imports, but is conservative for exports. For seaborne containerized tonnages in Table III-48, by the year 2000 the comparisons show close correlation of

1. IMPORTS

North Atlantic (1.01 + 2.10)
North Pacific (1.02 + 1.04 + 1.05 + 2.17 + 1.23)
North - South America (1.08 + 1.24)
U. S. - Middle East & Africa (1.06 + 1.07)
Europe - Far East/Australia (1.09 + 1.11 + 1.12 + 1.13)
Europe - Africa (1.15)
Europe - Middle East (1.14)
Europe - L/Dev. America (1.16)
Japan - L/Dev Far East & Australia (1.19 + 1.18)
Japan - Africa & Middle East (1.21 + 1.20)
Japan - L/Dev America (1.22)

2. EXPORTS

North Atlantic (2.01 + 1.10)
North Pacific (2.02 + 2.04 + 2.05 + 1.17 + 2.23)
North - South America (2.08 + 2.24)
U. S. - Middle East & Africa (2.06 + 2.07)
Europe - Far East/Australia (2.09 + 2.11 + 2.12 + 2.13)
Europe - Africa (2.15)
Europe - Middle East (2.14)
Europe - L/Dev America (2.16)
Japan - L/Dev Far East & Australia (2.19 + 2.18)
Japan - Africa & Middle East (2.21 + 2.20)
Japan - L/Dev America (2.22)

NOTE: The three-digit code system used above is as described in Figure III-34. In the cases of the North Atlantic and North Pacific care is needed in establishing the correct directional flow as follows:

- North Atlantic is represented by the U.S. plus Canada trading with OECD Europe. U.S. imports from OECD Europe are coded 1.01, but Canadian imports from OECD Europe are found under 2.10 since they are reported as OECD Europe exports to Canada.
- North Pacific is similarly arranged such that Canadian imports from Japan are found under 2.17 - Japanese exports to Canada.

FIGURE III-35. COUNTRY/REGION - PAIR GROUPINGS FOR MACRO INPUTS

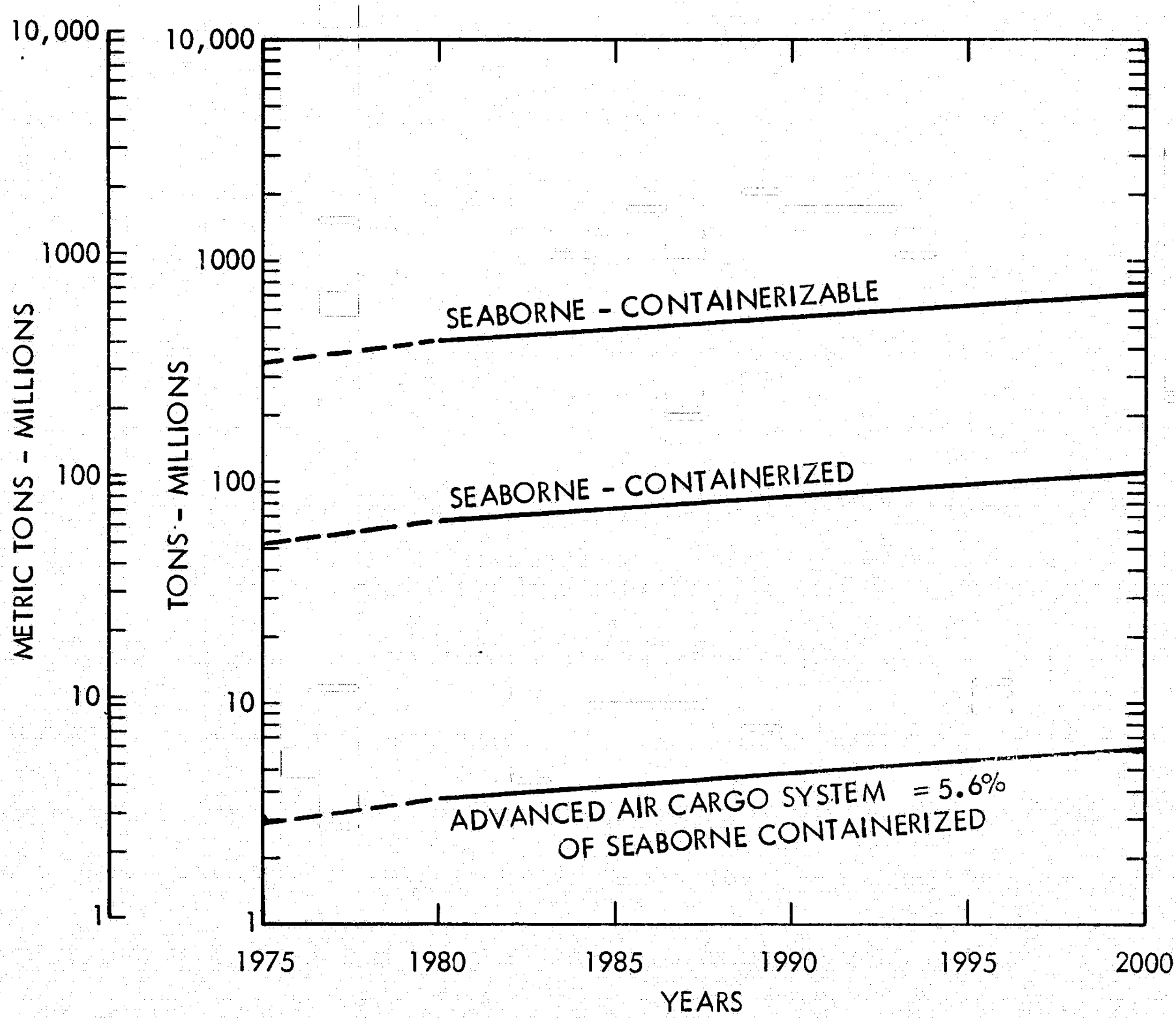


FIGURE III - 36. FREE-WORLD INTERNATIONAL CARGO DEMAND - IMPORTS AND EXPORTS

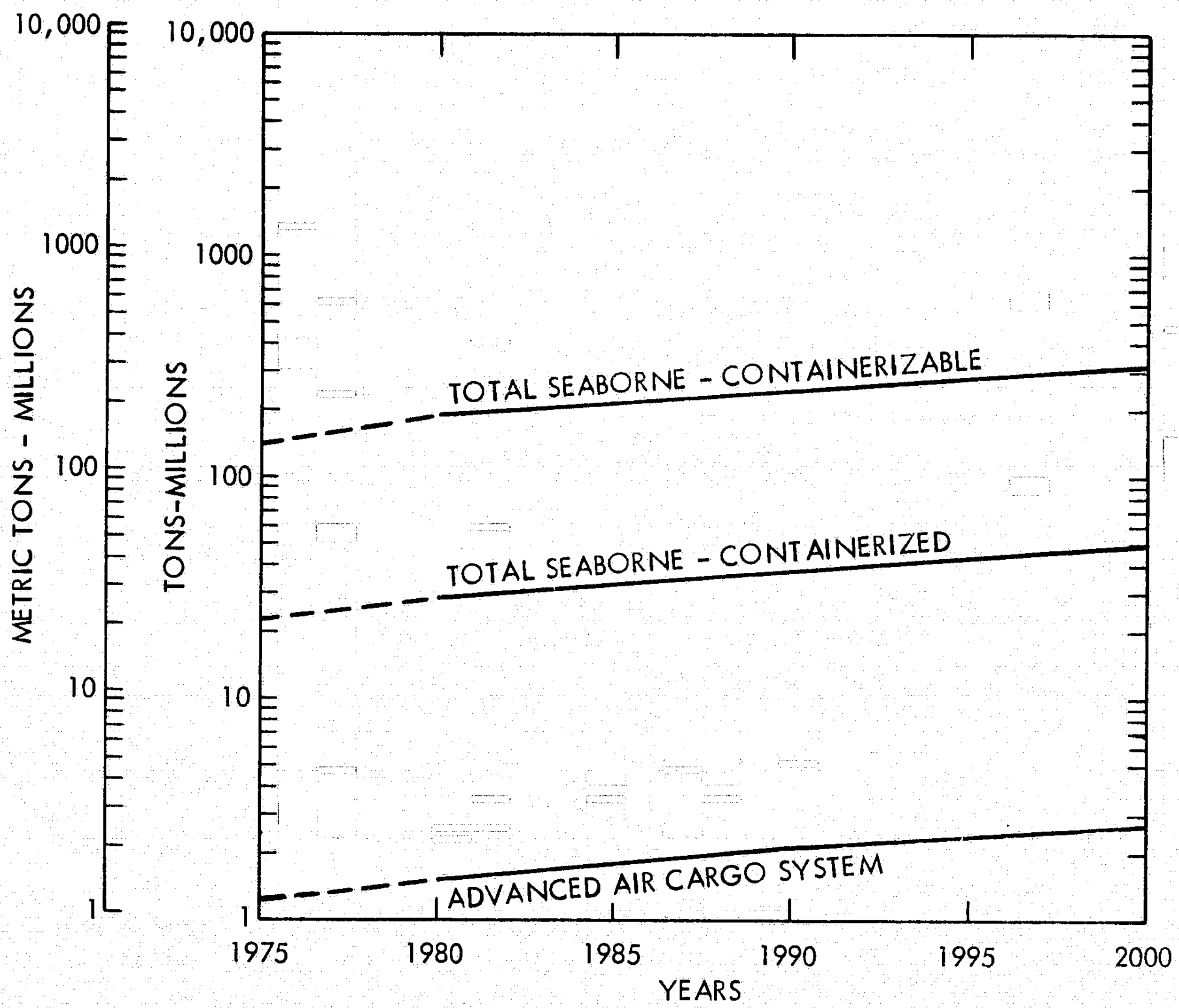


FIGURE III - 37. FREE-WORLD INTERNATIONAL CARGO DEMANDS - IMPORTS

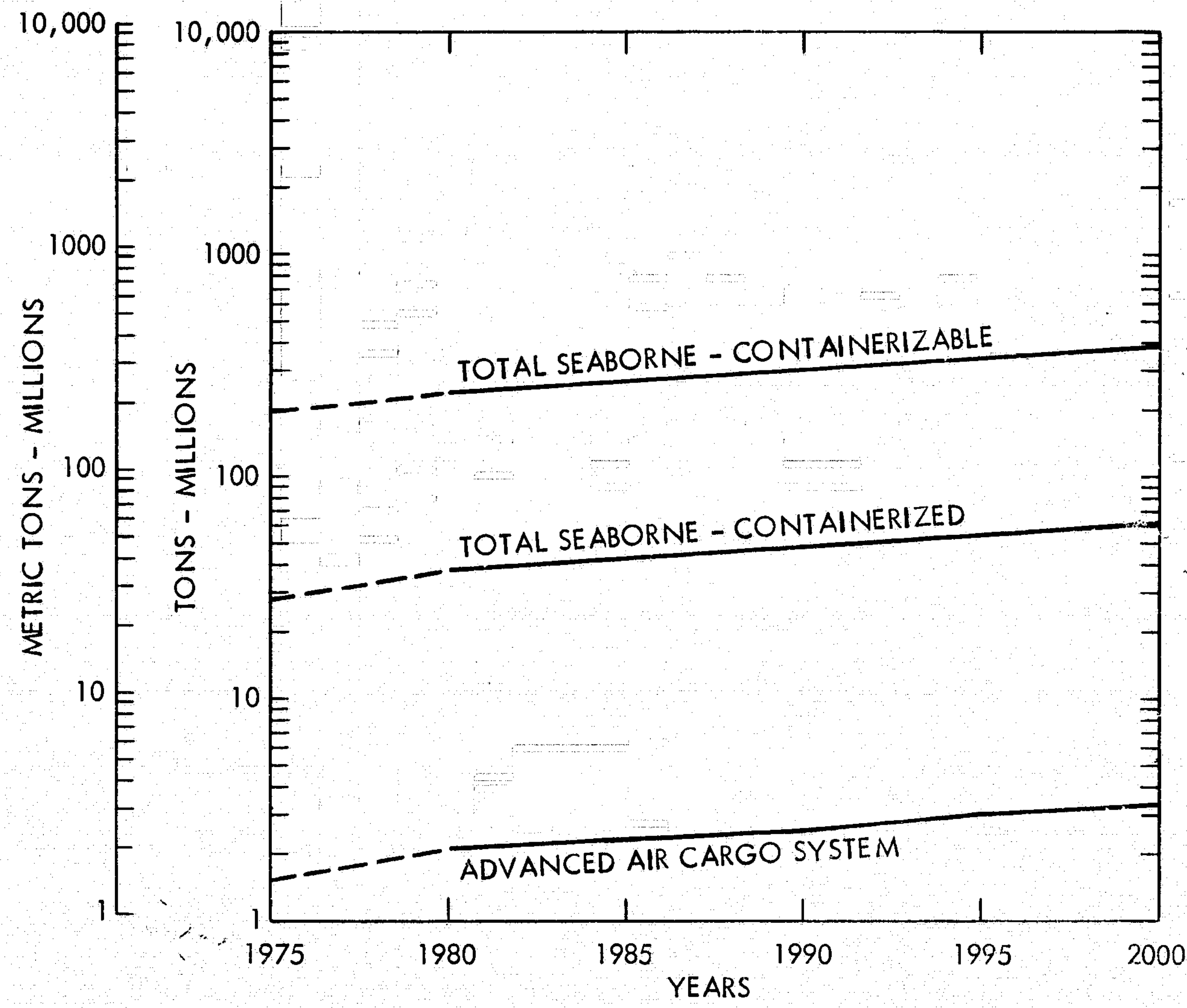


FIGURE III - 38. FREE-WORLD INTERNATIONAL CARGO DEMAND - EXPORTS

TABLE III-47E. SUMMARY COMPARISONS OF OECD DATA ANALYSES

OECD/DOC/MARAD COMPARISON - SEABORNE CONTAINERIZABLE

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (MILLIONS)							
IMPORTS								
OECD (U. S. ONLY)	102.5	88.4	70.9	97.7	113.1	131.7	151.4	171.7
DOC	n.a.	67.2	n.a.	75.0	83.7	93.9	106.0	120.5
MARAD	68.9	67.4	56.3	81.2	100.4	115.7	143.7	182.1
EXPORTS								
OECD (U. S. ONLY)	118.4	103.4	84.5	120.3	139.2	159.2	179.6	200.4
DOC	n.a.	110.5	n.a.	138.3	169.2	207.4	255.1	315.5
MARAD	109.7	110.4	104.4	138.8	175.8	217.2	275.2	351.5
IMPORTS & EXPORTS								
OECD (U. S. ONLY)	220.9	191.8	155.5	218.1	252.3	290.9	330.9	372.2
DOC	n.a.	177.6	n.a.	213.3	253.0	301.3	361.1	435.9
MARAD	178.6	177.8	160.7	220.0	275.9	332.9	418.8	533.6

TABLE III-48E. SUMMARY COMPARISONS OF OECD DATA ANALYSES

OECD/DOC/MARAD COMPARISON - SEABORNE CONTAINERIZED

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (MILLIONS)							
IMPORTS								
OECD (U.S. ONLY)	25.4	16.5	13.3	16.5	18.6	21.6	24.8	28.1
DOC	n.a.	10.1	n.a.	13.0	16.1	20.2	25.4	32.3
MARAD	10.3	9.9	8.5	12.9	16.3	19.9	25.5	33.1
EXPORTS								
OECD (U.S. ONLY)	18.1	12.9	10.3	14.6	16.8	19.2	21.6	24.2
DOC	n.a.	11.9	n.a.	14.6	17.8	21.8	27.1	34.4
MARAD	10.7	11.5	10.7	14.2	17.6	21.5	26.9	34.1
IMPORTS & EXPORTS								
OECD (U.S. ONLY)	43.5	29.3	23.6	31.1	35.3	40.8	46.4	52.3
DOC	n.a.	22.0	n.a.	27.6	33.9	42.0	52.5	66.8
MARAD	20.9	21.5	19.2	27.2	34.0	41.4	52.4	67.3

TABLE III-49E. SUMMARY COMPARISONS OF OECD DATA ANALYSES

OECD/DOC COMPARISON - CONVENTIONAL AIRBORNE

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (THOUSANDS)							
IMPORTS								
OECD (U.S. ONLY)	1399.1	888.3	722.3	1059.9	1352.6	1700.2	2027.7	2333.2
DOC	n.a.	528.8	n.a.	915.8	1300.5	1735.5	2217.9	2745.6
EXPORTS								
OECD (U.S. ONLY)	1268.0	1149.8	682.5	1048.8	1296.0	1564.9	1844.7	2143.2
DOC	n.a.	777.7	n.a.	1020.6	1369.6	1759.6	2200.9	2711.1
IMPORTS & EXPORTS								
OECD (U.S. ONLY)	2667.0	2038.1	1404.8	2108.6	2648.6	3265.1	3872.4	4476.3
DOC	n.a.	1306.5	n.a.	1936.4	2670.1	3495.1	4418.8	5456.7

TABLE III-50. GROWTH RATE COMPARISONS OF OECD DATA ANALYSES

OECD/DOC/MARAD COMPARISON - SEABORNE CONTAINERIZABLE

	1974-80	1980-90	1990-2000	1974-2000
		ANNUAL PERCENT		
IMPORTS				
OECD (U. S. ONLY)	1.7	3.0	2.7	2.6
DOC	1.8	2.3	2.5	2.3
MARAD	3.2	3.6	4.6	3.9
EXPORTS				
OECD (U. S. ONLY)	2.6	2.8	2.3	2.6
DOC	3.8	4.1	4.3	4.1
MARAD	3.9	4.6	4.9	4.6
IMPORTS & EXPORTS				
OECD (U. S. ONLY)	2.2	2.9	2.5	2.6
DOC	3.1	3.5	3.8	3.5
MARAD	3.6	4.2	4.8	4.3

TABLE III-51. GROWTH RATE COMPARISONS OF OECD DATA ANALYSES

OECD/DOC/MARAD COMPARISON - SEABORNE CONTAINERIZED

	1974-80	1980-90	1990-2000	1974-2000
IMPORTS				
OECD (U. S. ONLY)	0	2.7	2.7	2.1
DOC	4.3	4.5	4.8	4.6
MARAD	4.5	4.4	5.2	4.8
EXPORTS				
OECD (U.S. ONLY)	2.1	2.8	2.3	2.4
DOC	3.5	4.1	4.7	4.2
MARAD	3.6	4.2	4.7	4.3
IMPORTS & EXPORTS				
OECD (U. S. ONLY)	1.0	2.8	2.5	2.3
DOC	3.9	4.3	4.7	4.4
MARAD	4.0	4.3	5.0	4.5

TABLE III-52. GROWTH RATE COMPARISONS OF OECD DATA ANALYSES

OECD/DOC COMPARISON - CONVENTIONAL AIRBORNE

	1974-80	1980-90	1990-2000	1974-2000
	ANNUAL PERCENT			
IMPORTS				
OECD (U. S. ONLY)	3.0	4.8	3.2	3.8
DOC	9.6	6.6	4.7	6.5
EXPORTS				
OECD (U. S. ONLY)	-1.5	4.1	3.2	2.4
DOC	4.6	5.6	4.4	3.5
IMPORTS & EXPORTS				
OECD (U. S. ONLY)	0.6	4.5	3.2	3.1
DOC	6.8	6.1	4.6	4.7

all three sources for imports. The OECD (U.S. trade only) remains conservative for exports, with close correlation between DOC and MarAd. Conventional airborne data, Table III-49, again show the OECD (U.S. trade only) to be conservative.

The growth rate comparisons presented in Tables III-50 through III-52 clearly show the relatively conservative results of the OECD data analysis. Although the DOC growth rates are higher than the conservative OECD estimates, Table III-52, both projections by the year 2000 are below forecasts (ref. 22) based on historical airline traffic statistics. The conservative forecasts have been generated at the commodity level, and in spite of their conservatism, based on the shippers' views, the AACS will be needed for the forecasts to be achieved. If these conservative forecasts indeed prove to be conservative and the demand for air cargo more nearly equals the airline traffic trends, by the year 2000 the demand for the AACS is seen to be even greater, since the economics and efficiency of the AACS will be essential. Also, the additional demand identified from penetrating the seaborne containerized traffic via the use of intermodal container systems can be satisfied to some extent via the Boeing 747 Freighter but even today over 80 percent of 40-foot (12.2-meters) containers are 8.5 feet (2.6 meters) high or higher. In view of these trends to increase container volume and considering the Case Study results which verify that the user requires container volumes equal to or greater than today's there is a definite requirement for an aircraft with a larger cargo hold than the 747F provides.

Tables III-53E through III-55E present U.S. tonnage as a percentage of the free-world tonnage for seaborne containerizable, seaborne containerized commodities and conventional airborne, respectively. The results show that U.S. trade for the non-bulk commodities amounts to approximately 50 percent of the OECD free-world total. This clearly shows the importance of the U.S. market in establishig the need for future air cargo systems.

The final results that are used in the MACRO optimization model to establish aircraft requirements are presented in Tables III-56 through III-61. The number of region pairs or routes are limited to those that MACRO can handle and are aggregated from the greater number of country/region-pairs presented in Appendix F, Tables II through V. The results show the growing emphasis of the Far East, Japan and Less-Developed Far East, as a trading area with the U.S. and OECD Europe. The low forecast, Tables III-56 through III-58 represent the conservative forecast from the OECD data analysis and incorporates the Case Study findings that ocean carriers using air as a substitute service would produce a 5.6 percent penetration of the seaborne containerized tonnage. The high forecast, Tables III-59 through III-61, incorporates the higher overall growth rate of 5 percent per year established from the MarAd analyses and the higher penetration of seaborne containerized tonnage of 10 percent as suggested by the Case Studies of European shippers. Table III-62 presents extracts from the ref. 23 forecast. All of these results are combined in Figure III-39. The results show that, between now and 1990, a pent-up demand exists for the AACS. There appears to be an incompatibility between the two approaches in that the traditional trend forecast shows a large demand

TABLE III-53E. U. S. WORLD RELATIONSHIP SUMMARY FROM OECD DATA ANALYSES

SEABORNE-CONTAINERIZABLE

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (MILLIONS) AND PERCENT							
IMPORTS								
U. S. ONLY	102.5	88.4	70.9	97.7	113.1	131.7	151.4	171.7
WORLD TOTAL	231.0	205.6	148.4	195.0	217.2	247.8	281.3	315.9
U. S. - PERCENT	44.4	43.0	47.8	50.1	52.1	53.1	53.8	54.4
EXPORTS								
U. S. ONLY	118.4	103.2	84.5	120.3	139.2	159.2	179.6	200.4
WORLD TOTAL	234.7	222.7	199.3	239.4	272.2	308.7	347.5	388.8
U. S. - PERCENT	50.4	46.3	42.4	50.3	51.1	51.6	51.7	51.5
IMPORTS & EXPORTS								
U. S. ONLY	220.9	191.5	155.5	218.1	252.3	290.9	330.9	372.2
WORLD TOTAL	465.7	428.3	347.7	434.4	489.4	556.5	628.8	703.9
U. S. - PERCENT	47.4	44.7	44.7	50.2	51.6	52.3	52.6	52.9

TABLE III-54E. U. S. - WORLD RELATIONSHIP SUMMARY FROM OECD DATA ANALYSES

SEABORNE - CONTAINERIZED

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (MILLIONS) AND PERCENT							
IMPORTS								
U. S. ONLY	25.4	16.5	13.3	16.5	18.6	21.6	24.8	28.1
WORLD TOTAL	43.0	31.8	23.2	29.3	32.6	37.7	43.4	49.3
U. S. - PERCENT	59.1	51.9	57.3	56.3	57.1	57.3	57.1	57.0
EXPORTS								
U. S. ONLY	18.1	12.8	10.3	14.6	16.8	19.2	21.6	24.2
WORLD TOTAL	47.2	31.8	28.6	37.9	42.7	48.2	54.1	60.3
U. S. - PERCENT	38.3	40.3	36.0	38.5	39.3	39.8	39.9	40.1
IMPORTS & EXPORTS								
U. S. ONLY	43.5	29.3	23.6	31.1	35.3	40.8	46.4	52.3
WORLD TOTAL	90.2	63.6	51.8	67.2	75.3	86.0	97.6	109.7
U. S. - PERCENT	48.2	46.1	45.6	46.3	46.9	47.4	47.5	47.7

TABLE III-55E. U. S. - WORLD RELATIONSHIP SUMMARY FROM OECD DATA ANALYSES

CONVENTIONAL AIRBORNE

	1973	1974	1975	1980	1985	1990	1995	2000
	SHORT TONS (THOUSANDS) AND PERCENT							
IMPORTS								
U. S. ONLY	1399.1	888.3	722.3	1059.9	1352.6	1700.2	2027.7	2333.2
WORLD TOTAL	2385.7	1995.2	1312.1	1953.2	2443.4	3021.1	3583.4	4098.5
U. S. - PERCENT	58.6	44.5	55.0	54.3	55.4	56.3	56.6	56.9
EXPORTS								
U. S. ONLY	1268.0	1149.8	682.5	1048.8	1296.0	1564.9	1844.7	2143.2
WORLD TOTAL	3027.0	2444.4	1764.4	2778.1	3418.9	4054.6	4673.7	5279.9
U. S. - PERCENT	41.9	47.0	38.7	37.8	37.9	38.6	39.5	40.6
IMPORTS & EXPORTS								
U. S. ONLY	2667.0	2038.1	1404.8	2108.6	2648.6	3265.1	3872.4	4476.3
WORLD TOTAL	5412.7	4439.6	3076.5	4731.3	5862.3	7075.7	8257.2	9378.3
U. S. - PERCENT	49.3	45.9	45.7	44.6	45.2	46.1	46.9	47.7

TABLE III-56. AACS DEMAND - 1975 - LOW

IMPORTS AND EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Metric Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	378	1686	343	2462	12.5
North Pacific	6370	10,252	400	2548	363	3721	18.8
North-South America	5320	8562	258	1373	234	2004	10.2
U.S.-Middle East & Africa	7000	11,265	81	567	73	822	4.2
Europe - Far East/Australia	10,500	16,898	262	2751	237	4005	20.4
Europe - Africa	3300	5311	299	987	272	1445	7.3
Europe - Middle East	2500	4023	145	363	132	531	2.7
Europe - L/Developed America	5300	8530	184	975	167	1425	7.2
Japan - L/Dev. Far East & Australia	2500	4023	329	823	299	1203	6.1
Japan - Africa & Middle East	8000	12,875	97	776	88	1133	5.7
Japan - L/Developed America	11,000	17,703	60	660	54	956	4.9
Total	5419*	8716*	2493	13,509	2261	19,707	100.0

* Average

TABLE III-57. AACS DEMAND - 1990 - LOW

IMPORTS AND EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Metric Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	509	2270	462	3316	10.2
North Pacific	6370	10,252	784	4994	711	7289	22.6
North-South America	5320	8562	418	2224	379	3245	10.0
U. S. - Middle East & Africa	7000	11,265	162	1134	147	1656	5.1
Europe - Far East/Australia	10,500	16,898	385	4043	349	5897	18.2
Europe - Africa	3300	5311	441	1455	400	2124	6.6
Europe - Middle East	2500	4023	185	463	168	676	2.1
Europe - L/Developed America	5300	8530	191	1012	173	1476	4.6
Japan - L/Dev. Far East & Australia	2500	4023	644	1610	584	2349	7.3
Japan - Africa & Middle East	8000	12,875	193	1544	175	2253	7.0
Japan - L/Developed America	11,000	17,703	126	1386	114	2018	6.3
Total	5482*	8820*	4038	22,135	3662	32,299	100.0

* Average

TABLE III-58. AACS DEMAND - 2000 - LOW

IMPORTS AND EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Metric Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	619	2761	561	4027	9.7
North Pacific	6370	10,252	1050	6689	952	9760	23.6
North-South America	5320	8562	529	2814	480	4110	9.9
U. S. - Missle East & Africa	7000	11,265	218	1526	198	2230	5.4
Europe - Far East/Australia	10,500	16,898	463	4862	420	7097	17.1
Europe - Africa	3300	5311	512	1690	464	2464	6.0
Europe - Middle East	2500	4023	230	575	209	841	2.0
Europe - L/Developed America	5300	8530	227	1203	206	1757	4.2
Japan - L/Dev. Far East & Australia	2500	4023	867	2168	786	3162	7.6
Japan - Africa & Middle East	8000	12,875	270	2160	245	3154	7.6
Japan - L/Developed America	11,000	17,703	175	1925	159	2815	6.8
Total	5499*	8850*	5160	28,373	4680	41,417	100.0

*Average

TABLE III-59. AACS DEMAND - 1975 - HIGH

IMPORTS AND EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Metric Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	675	3011	612	4393	12.5
North Pacific	6370	10252	714	4548	648	6643	18.9
North - South America	5320	8652	461	2453	418	3579	10.2
U. S. - Middle East & Africa	7000	11,265	144	1008	131	1476	4.2
Europe - Far East/Australia	10,500	16,898	467	4904	424	7165	20.3
Europe - Africa	3300	5311	535	1766	485	2576	7.3
Europe - Middle East	2500	4023	260	650	236	949	2.7
Europe - L/Developed America	5300	8530	329	1744	298	2542	7.2
Japan - L/Dev. Far East & Australia	2500	4023	588	1470	533	2144	6.1
Japan - Africa & Middle East	8000	12,875	174	1392	158	2034	5.8
Japan - L/Developed America	11,000	17,703	106	1166	96	1699	4.8
Total	5415*	8715*	4453	24,112	4039	35,200	100.0

* Average

TABLE III-60. AACS DEMAND - 1990 - HIGH

IMPORTS AND EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	1213	5410	1100	7896	10.3
North Pacific	6370	10,252	1868	11,899	1695	17,377	22.6
North - South America	5320	8562	996	5299	904	7740	10.1
U. S. - Middle East & Africa	7000	11,265	385	2695	349	3931	5.1
Europe - Far East/Australia	10,500	16,898	916	9618	831	14,042	18.2
Europe - Africa	3300	5311	1052	3472	954	5067	6.6
Europe - Middle East	2500	4023	441	1103	400	1609	2.1
Europe - L/Developed America	5300	8530	455	2412	413	3523	4.6
Japan - L/Dev. Far East & Australia	2500	4023	1533	3833	1391	5596	7.3
Japan - Africa & Middle East	8000	12,875	459	3672	416	5356	7.0
Japan - L/Developed America	11,000	17,703	299	3289	271	4798	6.2
Total	5480*	8733*	9617	52,702	8724	76,935	100.0

*Average

TABLE III-61. AACS DEMAND - 2000 - HIGH

IMPORTS & EXPORTS

	Miles	Kilometers	Tons (000)	STSM (Millions)	Metric Tons (000)	MTKM (Millions)	% of Total STSM
North Atlantic	4460	7178	1787	7970	1621	11,636	9.7
North Pacific	6370	10,252	3031	19,307	2750	28,193	23.5
North-South America	5320	8562	1528	8129	1386	11,867	9.9
U. S. - Middle East & Africa	7000	11,265	630	4410	572	6444	5.4
Europe - Far East/Australia	10,500	16,898	1338	14,049	1214	20,514	17.1
Europe - Africa	3300	5311	1555	5132	1411	7494	6.2
Europe - Middle East	2500	4023	664	1660	602	2422	2.2
Europe - L/Developed America	5300	8530	655	3472	594	5067	4.2
Japan - L/Dev. Far East & Australia	2500	4023	2503	6258	2271	9136	7.6
Japan - Africa & Middle East	8000	12,875	779	6232	707	9103	7.6
Japan - L/Developed America	11,000	17,703	506	5566	459	8126	6.8
Total	5488*	8832*	14,976	82,185	13,587	120,003	100.0

*Average

for belly cargo, especially beyond 1990, to the extent of eliminating the demand for the AACS. However, based on the results of the Case Studies, the AACS and its resulting economics will be required to provide the capacity to move 15 million tons in the year 2000 rather than the lower holds of passenger aircraft.

Figure III-39 presents pictorially the AACS trade flows with the width of the bars being proportional to the ton-miles for the given route. The developing nations will continue to trade heavily with the industrial world but are not expected to displace the predominance of the trade between the industrial-world partners.

Figure III-40 compares the region paired high and low forecasts as derived from the penetration of seaborne containerized trade flows with the current air freight reported by the International Air Transport Association. Again, the emphasis of the Far East is clearly illustrated, with the North Pacific becoming the number one trade route, displacing the North Atlantic to number three.

A separate and independently developed Lockheed forecast of ICAO carrier air cargo (ref. 23) is introduced for comparative purposes with the conventional forecast derived from the OECD data incorporating air penetration data from U.S. Department of Commerce Foreign Trade Data. Extracts from the Reference 23 ICAO carrier traffic forecast are presented in Table III-62.

All of the results are summarized in Figure III-41. The lower curve represents the conventional forecast derived from OECD data incorporating air penetration data from U.S. Department of Commerce Foreign Trade Data as discussed in preceding sections. The middle curve represents the AACS low (3.0 percent growth, 5.6 percent penetration) demand and the upper solid curve represents the AACS high (5.0 percent growth, 10 percent penetration) demand derived from the Case Studies. The AACS demands are additive to the conventional forecast. The dashed lines represent the ICAO carriers overall traffic forecast, with the lower ICAO curve (labeled belly) representing the total traffic carried in passenger related operations, and the area between these two representing the traffic for all-cargo operations. The results suggest that a pent-up demand currently exists for the AACS operation and is forecast to continue through the late 1980's for the low AACS demand and through the early 1990's, with the high AACS demand. After this period, the AACS demand would appear to challenge the all-cargo traffic share forecast for ICAO carriers. However, based on the results of the case studies, the AACS and its resulting economics will be needed to provide the required capacity.

Values for the lower and upper boundaries in millions of tons (millions of metric tons) for different periods are:

AACS Demand-1990 Low
Imports & Exports

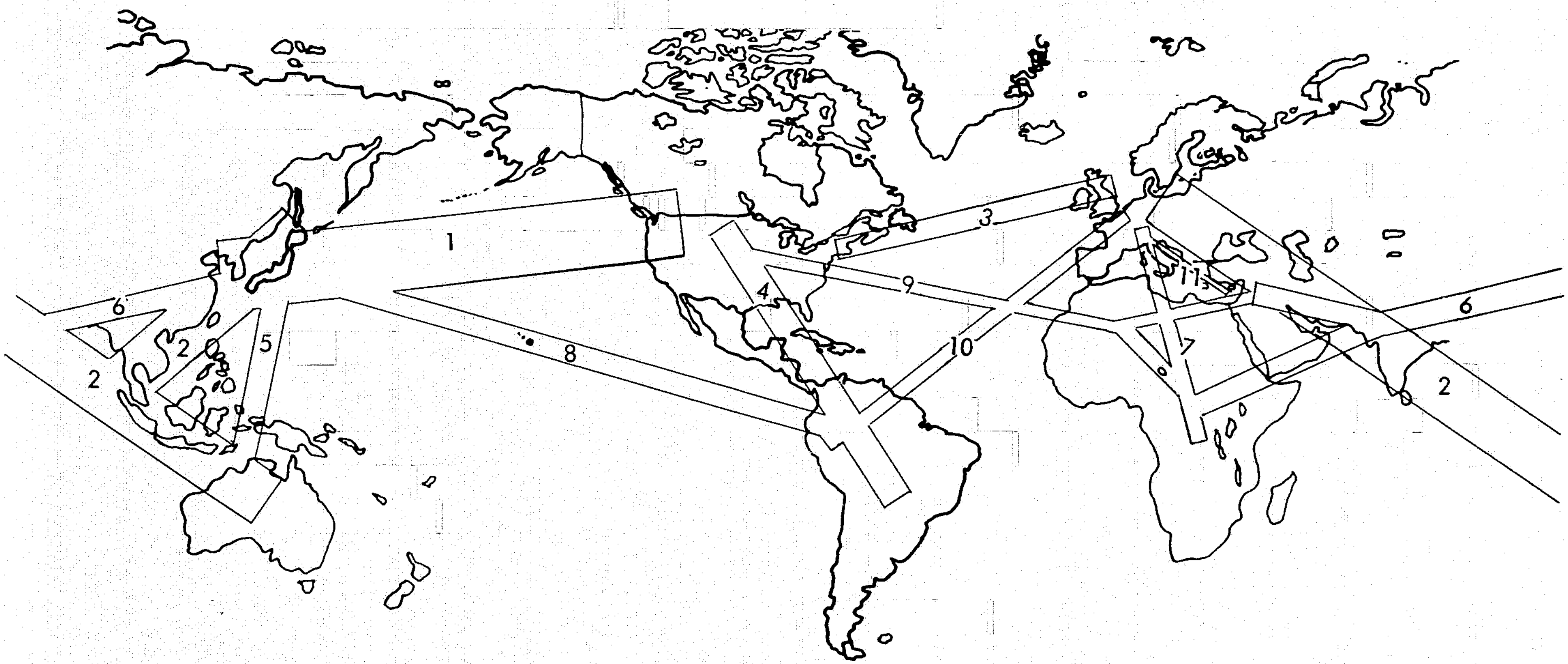


FIGURE III-39 AACS DEMAND

AACS Demand 1990

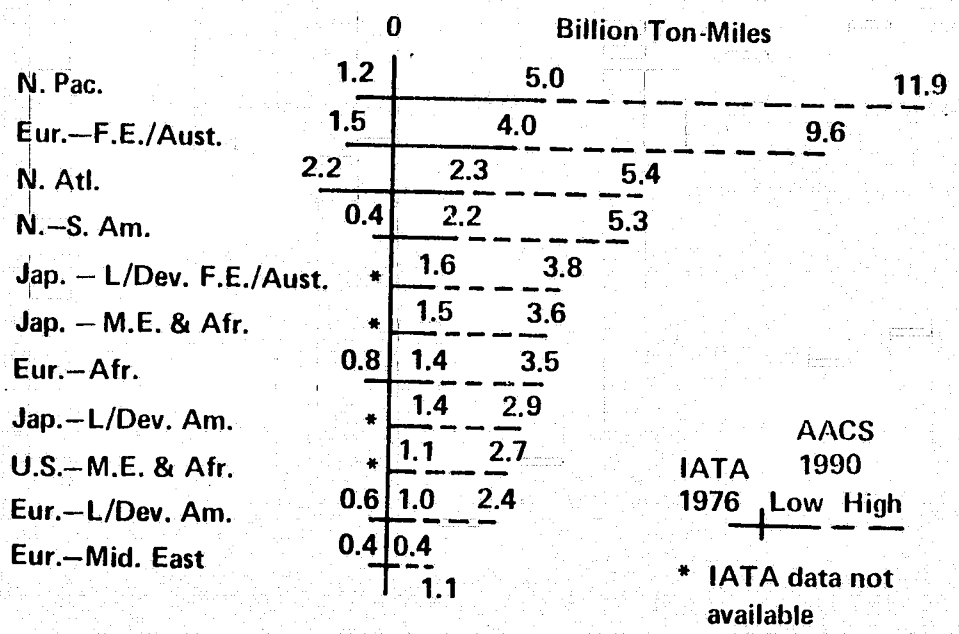


FIGURE III-40.

TABLE III-62. EXTRACTS FROM AIRLINE TRAFFIC TREND FORECAST[1]

ICAO FREE-WORLD INTERNATIONAL

	1975	1990	2000
Revenue metric ton-kilometers	13,501	88,197	263,774
Revenue ton-miles	9,247	60,410	180,671
Revenue tons[2] - total	1,687,000	11,023,000	32,969,000
- belly	1,100,000	8,202,000	24,150,000

(1) Source - Reference III-9.

(2) Derived from ton-miles based on 5480 miles average distance.

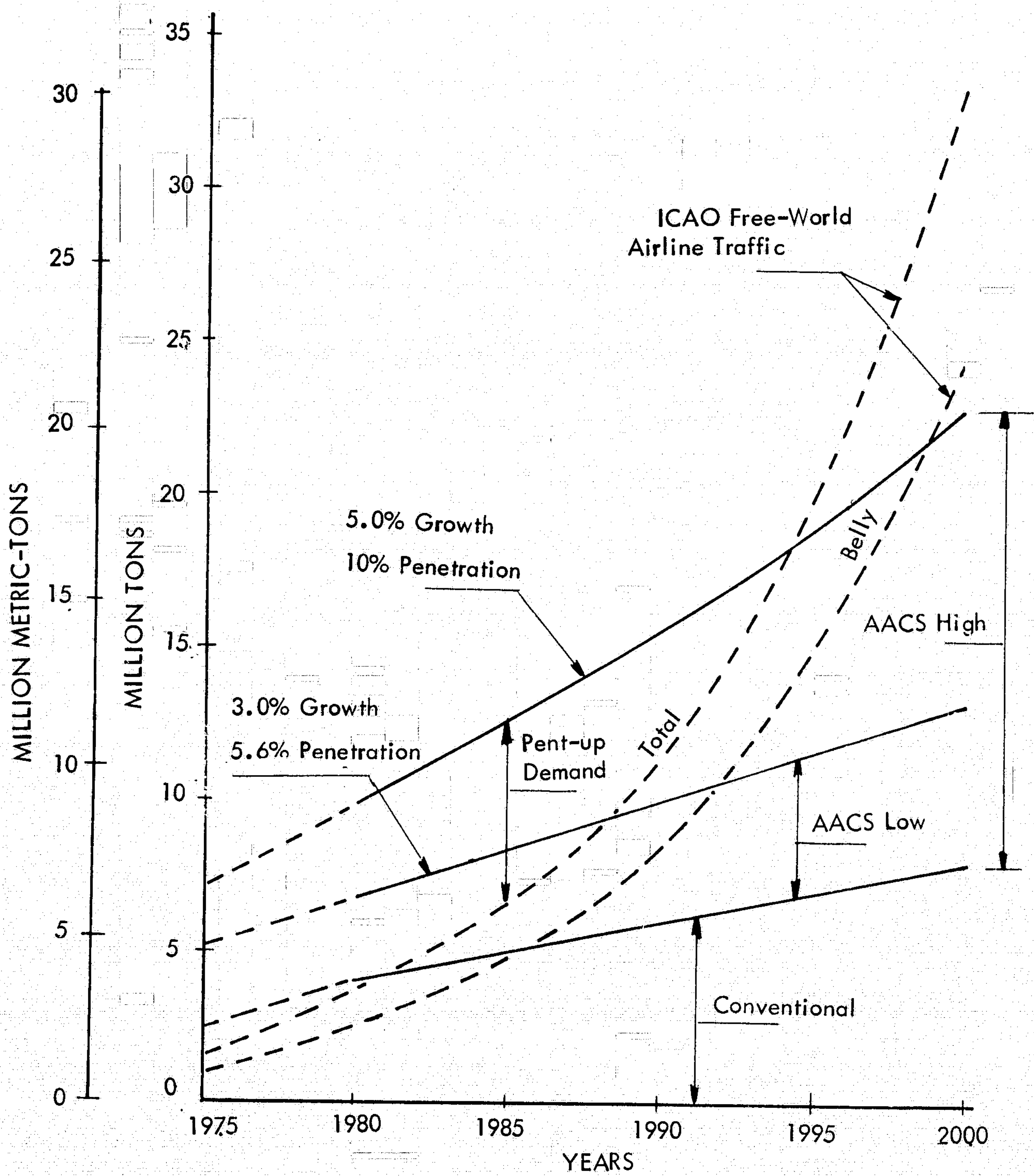


FIGURE III-41. INTERNATIONAL DEMAND FOR AACS

	1980		1990		2000	
	Million Tons	Million Metric Tons	Million Tons	Million Metric Tons	Million Tons	Million Metric Tons
Lower Boundary	2.75	2.47	4.03	3.63	5.16	4.64
Upper Boundary	5.75	5.12	9.67	8.70	14.90	13.41

Summary of Findings

In analyzing the U.S. Domestic results, a number of forecasts were used. Using the Department of Transportation forecast, "Trends and Choices," the total All Modes forecast was derived. According to this analysis, the total cargo transported for all commodities, all modes, over all distances will amount to 8 billion tons (7.2 billion metric tons) in 1990. A belly forecast from the Air Transport Association's (ATA) publication of January 1978 shows an air cargo belly forecast amounting to 6 million tons (5.4 million metric tons) for 1990. To achieve this, the ATA belly cargo forecast requires a doubling of belly hold load factor by 1990. The AACS Case Study forecast of air cargo demand shows a 1972 demand of 9.7 million tons (8.7 million metric tons). This forecast was made using correlation analysis with the 1972 Census of Transportation, along with the Case Studies, at a 45 percent rate reduction. The analysis leads to a penetration of the Advanced Air Cargo System potential market demand of 19 percent, which when the AACS is fully operable, is postulated to remain constant. The AACS potential market is defined as the manufactured goods moving by truck or rail more than 800 miles (1288 km) and generating revenues more than 3 cents per ton mile (4.32 cents per metric ton-km). The assumption made here is that if an AACS were introduced during or before 1990 this system would replace the present-day all-cargo system. Therefore, the cargo demand forecast by ATA as all-cargo, would be available to the new AACS.

Examining the growth of the advanced air cargo system more carefully, it is seen that with the AACS in operation the total air cargo market demand would grow to 14 million tons (12.6 million metric tons) by 1990. The market demand available to the AACS in 1990 is the difference between 14 million tons (12.6 million metric tons) and the ATA belly forecast (Figure III-12) of 6 million tons (5.4 million metric tons) or 8 million tons (7.2 million metric tons). The forecast is based on the total transportation demand, which is in turn based on the forecasted growth of the U.S. economy and represents the domestic low market demand forecast. Another issue to consider beside the economy is the ATA belly forecast, which is predicted to double by the year 2000 without the AACS. The effect of the existence of the AACS on belly loads was not evaluated. However, if belly load factors do not double, but remain the same, then an additional 2 million tons (1.8 million metric tons) would be available for the advanced system. This is a 25 percent increase over the 8 million tons (7.2 million metric tons) discussed previously, or a total of 10 million tons (9.9 million metric tons) and represents the high domestic market demand forecast.

The factor of air penetration, as influenced by yield, was also examined. Air cargo yield, which is the resulting revenue per ton mile representing the averaging of rates, has declined from 65 cents per ton-mile (1976 dollars) (93.6 per metric ton-km) in 1947 to 32 cents per ton-mile (46 per metric ton-km) in 1976. It was postulated by Boeing that airlines could remain profitable in the future with improved equipment if yield in current dollars remained constant. So, with 5 percent per year inflation, the constant dollar yield would continue to decline at 5 percent per year. It was also established that, as the constant dollar yield declined, air penetration increased.

From the analyses described above, three things are apparent. The first is that, in order that the ATA belly forecast be achieved, a 15 percent reduction in yield by 1991 is required. The second is that, by extrapolating the air cargo historical yield trend data, the indication is that the demand of 14 million tons (12.6 million metric tons) is feasible by 1988. Finally, at a 45 percent reduction in rate or yield, a very close correlation is seen between the airfreight market projected for the AACS by the Case Study results, and the airfreight market projected on the basis of historical rate elasticity trend data. These are characteristics of the U.S. domestic analysis.

Another set of data was necessary to derive the Free World International Forecast. The Free World demand for the AACS was derived through analysis of Organization for Economic Cooperation and Development (OECD) foreign trade data. The demand forecast also incorporated input from the Maritime Administration's (MarAd) long-term forecast, along with analysis of Department of Commerce (DOC) total U.S. Foreign trade data. The basic data were broken up into major world regions in order to simplify it from the individual trade flows of trading partners. The commodity data were also aggregated to simplify output to the 3-digit level of commodity classifications, from 4- and 5-digit levels. At the 3-digit level there were 180 commodity descriptions. The commodities were grouped into bulk and non-bulk commodities based on current seaborne levels of containerization found in analysis of U.S. international trade flows by the Maritime Administration. These OECD data, reduced to 6000 time series, and were forecasted to the year 2000 based on regression of the historical trends of 1961 through 1975. This resulted in a 3.0 percent-per-year growth rate in seaborne containerized trade. By applying the U.S. Flag Carrier Case Study results of 5.6 percent penetration of seaborne containerized trade to this OECD data forecast, the low forecast for the AACS is obtained.

The growth rates from MarAd long-term seaborne trade forecast were used to establish an AACS high forecast through the year 2000. The MarAd long-term forecast shows a total of 745 million tons (671 million metric tons) in 1990 and 916 million tons (824 million metric tons) in the year 2000 for U.S.

seaborne imports. For seaborne exports, the forecast shows 459 million tons (413 million metric tons) in 1990 and 675 million tons (608 million metric tons) in the year 2000. Of these, the combined air-penetrable imports and exports amounted to 2.8 percent in 1975, 3.4 percent in 1990, and 4.2 percent in the year 2000. This results in an overall growth rate of 5.0 percent per year for the total air penetrable tonnage. This higher growth rate of 5 percent per year was applied to the last historical data point for the OECD data, 1975. The high forecast was combined with the 10 percent penetration of seaborne containerized trade obtained from the International Case Studies to obtain the high forecast for the AACS.

The results of these forecasts are shown in Figure III-41 where a conventional air cargo forecast has been established by the lower curve of the graph through the year 2000. There are no data available from either IATA or the OECD forecast that would identify what percentage of current conventional air cargo goes in the bellies of passenger aircraft or by all-cargo aircraft. The conventional air cargo system assumes today's type of operation with derivative aircraft, e.g. 747F's, functioning during the post-1990 period. Therefore, the AACS generated air cargo demand is in addition to the conventional air cargo forecast. The conventional forecast was derived from OECD Data incorporating air penetration data from Department of Commerce U.S. Foreign Trade data. No analysis was made to determine to what extent the AACS would penetrate the current conventional air cargo market. The middle curve derived from OECD Series C data, represents a growth rate of approximately 3 percent per year. These results reflect a 5.6 percent penetration of the seaborne containerized tonnage established through the Case Studies as the demand for the AACS. Figure III-40 shows a 4.03-million ton (3.63 million metric ton) increase in demand for the AACS low forecast over the conventional forecast for 1990 and a 5.16-million ton (4.64 million metric ton) increase by the year 2000. The upper curve is based on a 5 percent growth rate derived from the MarAd long-term forecast and represents a 10 percent average seaborne penetration as indicated by the international case studies. Here an increase in demand of 9.67 million tons (8.70 million metric tons) is projected for the AACS high over the conventional forecast for 1990 and a 14.90-million ton (13.41-million metric ton) increase by 2000. These increases in demand are in all cases in addition to the growth of current conventional air cargo.