AIR CARGO FORECAST AT LOGAN
BOSTON, MASSACHUSETTS
THROUGH THE YEAR 2000

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ABSTRACT

Traditionally, little attention has been paid to the literature on air cargo forecast, mainly because the infrastructure of the air cargo industry is quite often ignored by the airline executives, and insufficient research has been done by people in the academic sector. Only a few agencies such as Federal Aviation Adminstration and Air Transport Association of America have done some forecast studies regionally and nationally. As for any air cargo business, estimates should essentially be seen as representative of one reasonable, defensible future for a particular air cargo activity, and not as the final word on the matter. In the writer's opinion, therefore, air cargo forecast at Logan International Airport would indicate a comprehensive insight for the Massachusetts Port Authority, airlines, and others affected by Logan Airport's Bird Island Flats (BIF) developments on how the future New England area air cargo traffic might be handled.

Chapter 1 will introduce the purpose of the study and will briefly summarize the findings of each chapter as followed.

Chapter 2 will review the historic trends of the air cargo industry since the beginning of commercial air cargo development in the 1950s.

Chapter 3 will develop a supply-determined air cargo forecast based upon fleet-mix, load factor, aircraft size, service type, and other variables; deregulation and its effects to the industry will also be analyzed.

Chapter 4 will produce a demand-determined air cargo forecast using regression techniques.

Finally, Chapter 5 will provide alternative ways of estimating whether the projected air cargo activities through the year 2000, under certain assumptions, would be accommodated by the proposed BIF land use planning, with particular emphasis on the cargo land area.

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1.0 INTRODUCTION AND SUMMARY

1.1 PURPOSE OF THE STUDY

This study is intended to examine the way in which future New England area air cargo traffic might be handled at Logan International Airport. The study has also included in-depth examination of the possibilities for the greater use of supplementary airports, besides the Logan International Airport, in the New England region.

This Logan air cargo activities forecast attempts to accomplish three main purposes. First, it outlines the current level of air cargo activities at Logan, which represents New England's regional and international economic activities, mostly in high-value commodities. Second, it gives annual forecasts for the coming two decades in terms of scheduled domestic, international, and commuter air freight, express, and mail through the use of two methodologies: a fleet forecast and a demand forecast. As we read in many major air cargo news reports, air cargo analysts expect that air cargo activities will continue to grow throughout this century. It is expected that there must be more airport land, as well as more facilities, before the air cargo demand becomes saturated. BIF is the site provided under the current development, maintenance, and other supportive services for the airport activities. Therefore, the third purpose of this study is to try to integrate the projected air cargo activities into the proposed BIF land use development plan with different assumed constraints to see if, in essence, this land expansion would meet the expected growth of air cargo activities at Logan.

1.2 BACKGROUND (Chapter 2)

The air cargo industry has attained a massive size, representing huge investments in aircraft and facilities. When the revenue per ton-miles of air cargo are compared with the revenue per passenger-miles of air passenger travel, the revenue percentage from cargo operations has increased from 11.7 percent in 1962 to 17 percent in 1978 in the world scheduled freight market. It is important that carriers know their markets, competition, and potential in order to make intelligient business decisions. Furthermore, air cargo forecasts may provide information for planning to feed not only airliners but airport operators as well. It is equally important for the airport operators to have a clear and reasonable understanding of the air cargo development at their own airports.

Logan Airport, which serves the U.S.-New England regional market, has similar characteristics of air cargo growth to other markets of the world. These markets grew strongly in the 1960s, spurred by the productivity and efficiency of the jet freighter. In the 1970s, growth was generally at a lower rate and was more erratic, but even those who were disappointed that the air cargo breakthrough failed to materialize must admit that few industries have maintained strong average growth rates as high as air cargo for so long a period (see Table 2.2.1 for growth rates comparison).

Airport planners indeed cannot overlook air cargo, for growth rates in this sector have consistently exceeded passenger growth rates, and even following the unpredictable increase of oil prices in 1973, cargo traffic continued a high-level growth in a period when passenger travel showed faltering growth rates, and even declines.

The first stage in the study was an examination of the historic trends of the U.S. and Logan air cargo industry. The historic trends of the U.S. and Logan were essential for the background study of air cargo forecast, the future developments at Logan, land use, and other implications.

1.3 A SUPPLY-DETERMINED AIR CARGO FORECAST (Chapter 3)

The certificated carriers carry cargo by two major aircraft types: all-cargo type, and the combination of passengers and cargo on the main deck and/or cargo at a lower deck-- combi type. The payload capacity of all-cargo carrier types can be easily determined. However, it requires a certain amount of judgment to determine the payload capacity of combination carrier types. For instance, an airline may eliminate more passenger seats if cargo demand for a particular flight is more than expected in the combi service. Airline policy may shift during the forecasting period. There may be more replacement of combi aircraft by all-cargo aircraft. Also, there may be new entries of certificated all-freighter into the Logan market and some withdrawal of business, such as happened to United and TWA Airlines' cargo service in recent years.

The supply of air cargo service depends on the scheduling and routing decisions of the cargo carriers. A multistage process, which involves estimation of major input cost variables and fleet composition, is necessary in order to measure the supply of service. Other factors may be considered as constraints to the supply function. Analysis of the issues of technological improvements is carried out before the impact of the supply of air cargo service is evaluated. Hence, the analysis in Chapter 3.2 attempts to be critical.

Deregulation may have an enormous impact on the certificated cargo rates and the market structure itself. Before doing any projection of cargo demand, we need to analyze the impact of deregulation on the scheduled domestic, international, and commuter services. Chapter 3.3 gives a preliminary judgment on this issue.

At present, the commuter airlines, which have had imposed upon them less stringent aircraft construction and maintenance standards, but more restrictions as to the size of aircraft, operate in a fashion similar to trunks and local service carriers. They publish schedules and fly freight and mail between small cities and hub airports involving trips of between 50 and 125 miles in length. Also, because commuter carriers are not required to have a Certificate of Public Convenience and Necessity, they can determine their routes, fares, and rate structure alone. However, the restriction on payload capacity of the small aircraft reduces the potential to earn substantial revenues, even though the market may support the freight service of larger aircraft. Many industry analysts believe that because of the effect of deregulation, commuter freight service may have a higher growth rate than that of the certificated freighters. This high growth rate is acceptable to many forecast analysts. Thus, Chapter 3.3.2 demonstrates the importance of commuter air cargo service to the New England business community. Also, because of Logan's hub function to many New England industries, commuter air cargo plays a feeder service role to the Logan air cargo activities.

The assumptions underlying the fleet forecast method require judgments on certain aspects such as split ratio of combi and all-cargo operations, load factors on different service, and aircraft types. From the fleet forecast of freight and express tonnages at Logan, the results are somewhat optimistic for the long-term, and more realistic for the short-term. In 1990 the forecast total is about 335 thousand tons of freight and express, a 37 percent increase from 244 thousand tons of freight and express in 1980; and in 2000 the forecast is for 596 thousand tons of freight and express, a 78 percent increase from 1990. The forecasts of total mail (domestic, international, and commuter) at Logan Airport in 1990 are 52 thousand tons in 1980; and the forecast for 2000 is 63 thousand tons, a 21 % increase from 1990. It is essential to separate mail forecast from freight and express forecast, due to the different nature of these two markets. A regression technique is applied to determine the demand of mail, whereas the fleet forecast menthod provides the freight and express tonnage outcome based upon critical in-depth judgment of the supply-side of the market.

1.4 A DEMAND-DETERMINED AIR CARGO FORECAST (Chapter 4)

Social variables, which have been found to be so critical in passenger demand forecast, are absent in the analysis of freight operations, greatly simplifying the prediction procedure. However, the forecasting of freight operations by air and even other modes is in its infancy, reflecting the great scarcity of historical data at a necessary level of detail. Consequently, aggregated forecasts at the regional level are more easily made than disaggregated forecasts of air freight movements between specific origins and destinations.

The Logan air cargo demand forecasting study uses readily available cargo activity data. The major data sources for Logan air cargo market analysis are the Massport Aviation Department's traffic statistics and the U.S.

Department of Commerce, of which the former is the most reliable source for the forecast data input; the latter is often utilized because of its transportation mode detail.

Fleet forecasts of the certificated freighters depend on the demand for cargo capacity by the shippers who rely heavily on the growth in trade of the region with other regions of the nation and abroad. For instance the commuter freighters' fleet forecasts depend mainly on the economy of New England. Hence, instead of only doing fleet forecasts by each freight service type as in chapter 3, total annual air freight and express tonnages are also projected by demand forecast methods and are analyzed by domestic versus international, and enplanements versus deplanements.

Because of the time and data availability constraints, the use of commodity disaggregation in the air cargo forecasting model is not considered. The methods used involve multiple regression analysis, though these methods do not represent a technical advance. Nonetheless, the projections should provide a realistic and useful planning guide for Massport and other Logan air cargo-related businesses.

There are three independent variables being adopted in the demand forecast functions: total New England earnings, real average freight revenue by service type, and real average fuel cost by service type. The resulting forecasts of air freight and express demand (without mail) at Logan are lower than in the supply-determined forecasts. In the years 1990 to 2000 they are 323 thousand tons to 495 thousand tons, compared with 335 thousand tons to 596 thousand tons of the supply forecasts; and in 1980 to 1990, the two forecast results are quite comparable: 215 thousand tons in 1980 to 323 thousand tons in 1990 of the demand forecast; and 244 thousand tons in 1980 to 335 thousand tons in 1990 of the supply forecast. All these forecasts are assumed without a drastic change in technology and economic conditions. From the author's point of view, the air cargo tonnage is likely to turn out to be closer to the supply forecast targets for the specific design purpose of BIF land use.

Forecasting so far ahead involves considerable uncertainties and the need for caution is suggested in considering projects involving long lead times and high capital investment, such as the BIF project at Logan. The forecasts and techniques will be kept under close review and further research will be undertaken into those areas of the forecasting process that are subject to particular uncertainty.

1.5 THE BIF LAND USE PLANNING-- CARGO FACILITIES AT LOGAN (Chapter 5)

It is unlikely that the existing cargo handling area at the northern part of the airport will be able to fulfill the space needs after the early 1980s. The North/South cargo split land use plan adapted by Massport in the BIF land use development planning is likely to provide adequate terminal apron capacity for the expected growth of tonnage until the year 2000.

This study considers cargo forecasts at Logan of 288 thousand tons in 1980 and 667 thousand tons in 2000 to be realistic, and such volumes should be well accommodated in the year 2000 and beyond.

For the longer term, i.e. 20 to 50 years ahead, other optional air cargo facilities developments, which are identified in Chapter 3.2 of the study, might be given serious consideration. Unless it were considered that the air cargo forecasts provided in this study should not be the primary concern, or unless the approved BIF cargo area were considered too large in capacity and therefore be diverted for other development purposes, decisions on the starting dates for the BIF cargo terminal developments would not be changed.

Uncertainties about the future growth of air cargo and the economic situation are very relevant, but if the cargo volume appears likely to be over the forecast range of this study, longer term cargo land use options other than those based on existing and the BIF cargo facilities cannot be ruled out or delayed. Otherwise, Massport would lose tremendous revenue to pay back their more than 12 million dollars of investment at BIF. It is not within the scope of this study to justify any chaos situations that may occur when supplier cannot meet the needs of the shippers. Additional works need to be proposed to measure the impact of under- or over-estimations of the air cargo forecasts.

2.0 HISTORIC BACKGROUND OF AIR CARGO DEVELOPMENT

The air cargo industry is still in its underdeveloped stage compared to the cargo volume transported by the surface modes. Air cargo service was initiated in the U.S. in the late 1920s with the air mail service. World War II promoted the growth of air cargo with the transport of critical military supplies. With the advent of high-speed turbo-engine aircraft in the late 1950s, the future of air cargo appeared bright.

Air cargo is a door-to-door service. Air cargo volume generated by U.S. carriers increased from around 0.3 billion ton-miles in 1950 to 6.0 billion ton-miles in 1974 (ref.1). Internationally, the airlines fly mail and freight to more than a hundred cities in countries throughout the world. Domestically, the airlines' coverage reaches some 600 U.S. airports directly and is extended to more than ten thousand other communities through the combined use of air and truck.

About half of the current U.S. air freight volume of about 3.5 million tons a year is carried in the combi jets. With the introduction of widebody combi jets, the airlines' cargo airlift capability has been increased enormously. In particular, each of the widebody combi, when carrying a full load of passengers and their baggage, still has enough space remaining in its cargo bins to accommodate about two-thirds the cargo load of a standard body jet freighter. Even with this growth in tonnage volume, the volume of goods transported by air between the U.S. and Europe in 1973 represented less than 0.5 percent of the total carriage (ref. 2). However, of the total $9 billion value of the cargo transported by all modes, the air share is around 25 percent in value. Air cargo carriage is therefore an important factor in the balance of trade. To make an assessment of the future of air cargo at Logan, historic trends of the U.S. and Logan air cargo development have to be analyzed before air cargo forecasts are attempted.

2.1 HISTORIC TRENDS OF THE U.S. AIR CARGO INDUSTRY

Since 1960, the U.S. air cargo traffic has grown at a rate exceedingly higher than that of the surface cargo traffic. This high growth rate, however, cannot reflect the importance of air cargo industry in the U.S. transportation service. The share of freight revenue captured by the air mode, as seen in Tables 2.1.1 and 2.1.2, is only one to two percent of the national total; or, simply speaking, truck revenue is consistently sixty times more than that of air cargo.

Air cargo in the U.S. is a growing industry, but it has not grown in the manner or at the rate forecast. Figure 2.1.1 shows the breakdown of ton-miles in all

Table 2.1.1 Estimated National Air Freight Bills for Selected Years Between 1965 and 1975

(millions of dollars)

Freight Categories	Year				
	1965	1970/65 Overall change	1970	1975/70 Overall change	1975
Domestic Air	428	1.68	720	1.49	1,073
International Air	280	1.61	451	1.70	765
Total Air	708	1.65	1,171	1.57	1,838
Total Non-Air (Rail, Truck and Vessel)	63,340	1.41	89,372	1.55	138,788

Source: Transportation Facts and Trends, 13th Edition, p.4 (Washington, D.C. : Transportation Association of America, 1977)

Table 2.1.2 National Air Freight Bills as a Percentage of Total Freight Bills for Selected Years Between 1965 and 1975 (percent)

Freight Categories	Year		
	1965	1970	1975
Domestic Air	0.68	0.80	0.77
International Air	0.44	0.50	0.55
Total Air	1.12	1.30	1.32
Total Non-Air (Rail, Truck and Vessel)	98.88	98.70	98.68
Total Freight	100.0	100.0	100.0

Source: Calculated from Table 2.1.1

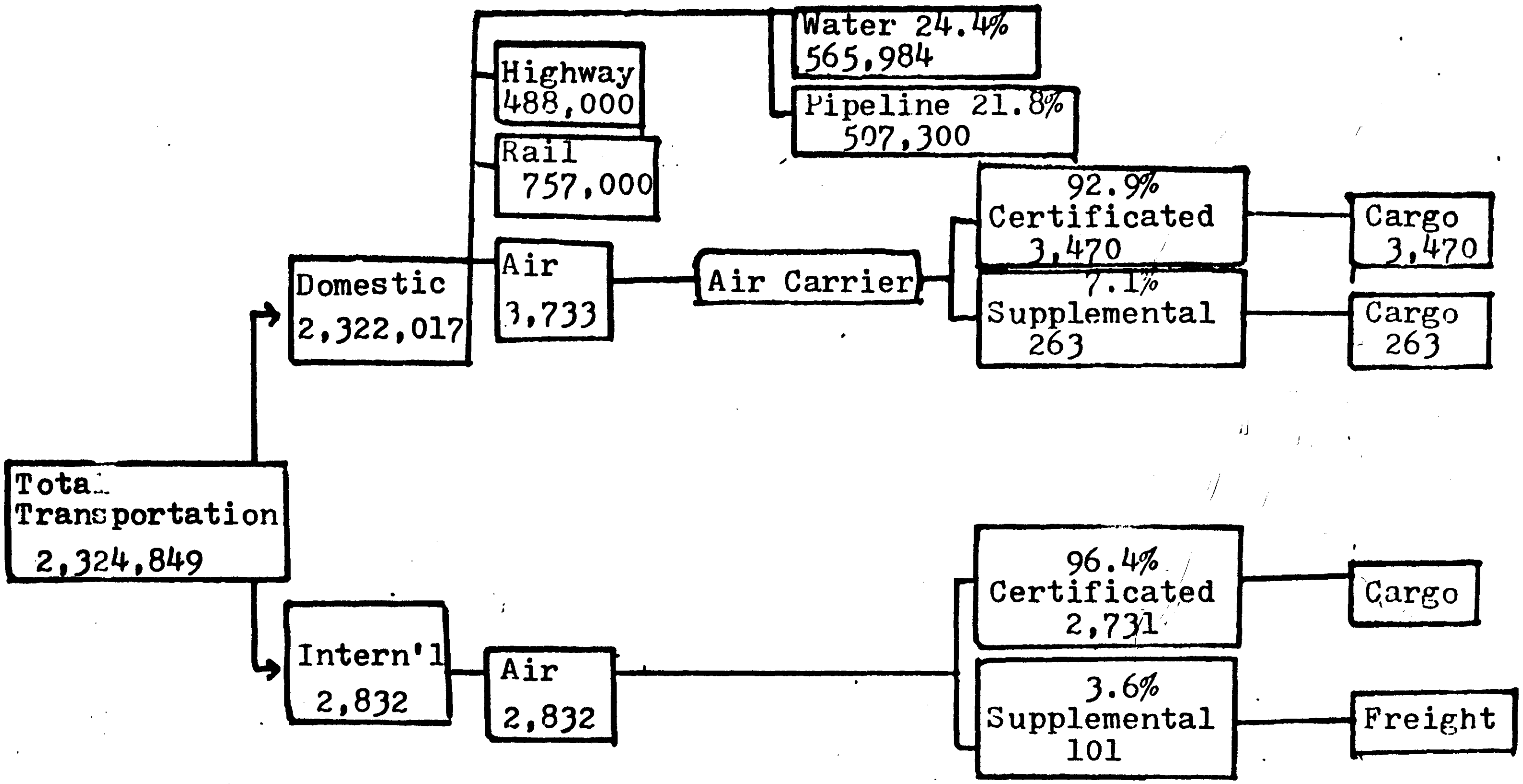


Figure 2.1.1: CARGO TON-MILES AT US MARKETS (millions), 1975

Source: National Statistics, DOT-TSC Nov 1977, Fig.6.

freight modes in the year 1975. Between the years 1960 and 1975, tonnage of domestic cargo grew at an average of 10 percent annually. The air cargo share of domestic ton-miles grew from 0.07 percent in 1960 to nearly 0.2 precent in 1973. Because the increase of ton-milesis mainly due to the increase in tonnage, the average domestic length of haul increasedonly 9.3 percent between the years 1960 and 1973 (ref. 3).

A considerable slowdown of air ton-miles since 1973 reflected the failure of air cargo growth due to factors such as environmental restrictions, difference in expectations and viewpoints of the people in the related industry, etc. This failure to attain the expected growth rate is mainly caused by an interlocking set of internal and external factors. To many optimistic analysts, deregulation, containerization, and terminal improvement in handling all shipment service under a more competitive environment may stimulate and relieve this interlocking set of factors.

For an indepth discussion of promoting the U.S. air cargo industry, the rate structure must be addressed first. Market penetration, for instance, is dependent upon the optimal rate setting relative to other transport modes. Table 2.1.3 indicates time trends in the average revenue per ton-mile of domestic air cargo relative to other cargo modes. This table also compares the absolute levels of

Table 2.1.3: TRANSPORTATION REVENUE Vs. GENERAL PRICE TRENDS

(in cents)

Average Revenue Per Ton-Mile vs. Wholesale Prices

Year	Rail (Class 1) Revenue	Rail (Class 1) Index	Truck (Class 1) (Common) Revenue	Truck (Class 1) (Common) Index	Air (Domestic) (Scheduled) Revenue	Air (Domestic) (Scheduled) Index	Oil Pipe Line Revenue	Oil Pipe Line Index	Wholesale Prices Index 1967 = 100	Wholesale Prices Index
1947	1.08	100	4.85	100	24.18	100	.292	100	76.5	100
1948	1.25	116	5.15	106	20.10	83	.299	102	82.8	108
1949	1.34	124	5.24	108	19.67	81	.310	106	78.7	103
1950	1.33	123	5.01	103	18.10	75	.315	108	81.2	107
1951	1.34	124	5.17	107	19.01	79	.320	110	91.1	119
1952	1.43	132	5.62	116	19.78	82	.328	112	88.6	116
1953	1.48	137	5.73	118	20.66	85	.322	110	87.4	114
1954	1.42	121	5.83	120	21.85	90	.319	109	87.6	115
1955	1.37	127	5.80	120	21.15	87	.322	110	87.8	115
1956	1.38	128	5.97	123	20.66	85	.317	109	90.7	119
1957	1.45	134	6.14	127	21.39	88	.313	107	93.3	122
1958	1.46	135	6.19	128	22.62	94	.318	109	94.6	124
1959	1.45	134	6.28	129	22.76	94	.314	108	94.8	124
1960	1.40	130	6.31	130	22.80	94	.315	108	94.9	124
1961	1.37	127	6.30	130	22.08	91	.315	108	94.5	124
1962	1.35	125	6.41	132	21.31	88	.320	110	94.8	124
1963	1.31	121	6.38	132	21.72	90	.318	109	94.5	124
1964	1.28	119	6.66	137	20.97	87	.304	104	94.7	124
1965	1.27	118	6.46	133	20.46	85	.279	96	96.6	126
1966	1.26	117	6.34	131	20.21	84	.269	92	99.8	130
1967	1.27	118	6.65	137	19.90	82	.259	90	100.0	131
1968	1.31	121	6.93	143	19.97	83	.257	88	102.5	134
1969	1.35	125	7.08	146	21.03#	87	.266	91	106.5	139
1970	1.43	132	7.46	154	21.91	91	.271	93	110.4	144
1971	1.59	147	7.85	162	22.61r	94	.285	98	114.0r	149
1972	1.62	150	8.00	165	22.75	94	.265	93	119.1	156
1973	1.62	150	8.34r	172	23.31	96	.291r	100	134.7	177
1974	1.85	171	9.00	186	25.92	107	.315r	108	160.1	209
1975	2.04	189	9.90(e)	204	28.22	117	.386	132	174.9	229
1976	2.19	203			31.81	132			182.9	239

** Includes AMTRAK and Auto-Train, as will future years.
.. See "Source Data" page for 1973-1954 average revenue per ton-mile ' . ICC-regulated barge lines.
\# 1969 revised to include Alaska and Hawaii as will all future years. · Excludes Commutation (p) Preliminary (e) Estimated r Revised

Source: Transportation Facts and Trends, 13th edition (Washington, D.C.:Transportation Association of America, 1977), p.7.

competing cargo modes.

The average gross revenue per ton-mile of air cargo figures in 1976 is more than three times that of truck freight and more than 13 times than of rail. However, the average gross revenue per ton-mile figures tend to overstate the air cargo rate disadvantage because of different kinds of commodities carried by each mode, i.e. rail carries mainly bulk commodities, truck have a large load components, and air cargo carries mainly small shipments. One study shows that air is almost twice as costly as truck and more than twice as expensive as train when comparing modal transportation costs for similar commodities.
Truck line-haul costs are almost three times higher than air line-haul costs but terminal and pick-up and delivery costs are much higher for air (ref. 4). Hopefully, to overcome this rate disadvantage, increased containerization of air cargo could lower these handling costs.

With the rate disadvantage being examined, the following expectations as stated in another study may give us the future outlook of the U.S. air cargo industry (ref. 5):

a) The increase in surface traffic over the next two decades will likely result in a degradation of service, making air shipment a more attractive option.

b) Air cargo needs will be two to three times 1978 levels, contributing to saturation of the system decade later.

c) Expansion of existing airports will be difficult due to the lack of available land.

With a large potential increase in air cargo demand expected before the end of the century, regional air cargo forecasts are particularly important. Essentially, the aggregation of these regional air cargo forecasts will provide a more reliable forecasting result of the future U.S. air cargo industry. Each individual economic region of the U.S. maintains its own constraints. For the New England region, the expansion of BIF is the only major land use development at Logan within this century. The chances of other types of land expansion at Logan are very remote. Only the BIF land use project could provide a land resource for major air cargo development. Hence, the forecast of air cargo for Logan Airport necessarily considers the constraint factors of BIF land use development plan and vice versa.

2.2 HISTORIC TRENDS OF AIR CARGO AT LOGAN AIRPORT

Before the historic trends of air cargo at Logan are examined, the economic and demographic situation of Boston Standard Metropolitan Statistical Area (SMSA) needs to be addressed. This SMSA is only a part of the market service area served by Logan International Airport.

The size of the base results in historic growth rates for economic and demographic indicators, which have been slightly lower than the national average for equivalent factors (see Table 2.2.1). Population is the Boston SMSA increased from 3.06 million in 1950 to only 3.72 million by 1970, for an average annual growth rate of 0.97 percent. This compares to the national population growth rate of 1.5 percent per year for the same twenty-year period. Per Capita Income, however, grew at a 2.92 percent annual rate in the Boston SMSA compared to an average annual growth rate of 2.65 percent for the U.S. as a whole. Communication, Transportation, and Public Utilities as a group grew at a faster rate than the national average, almost doubling in value between 1950 and 1970. The average annual growth rate for this sector of the economy was 3.4 percent per year compared to 3.3 percent per year for the total U.S. Likewise, services grew at an annual average of 6.3 percent per year, compared to 5.6 percent for the U.S. as a whole. Also, air cargo grew at a faster rate of 3.13 than the national average of 2.90.

All of the other economic indicators grew at rates slightly less than the total U.S. Table 2.2.1 shows the growth in the Boston SMSA from 1950 to 1970 for selected economic and demographic indicators, compared to those of the total U.S. for the same twenty years.

For the cargo sector, Figures 2.2.1 and 2.2.2 show the trends of domestic cargo by certificated domestic and commuter carriers respectively. In specific, the total export tonnage at Logan tends historically to be greater than import tonnage from other U.S. cities. From 1972 through 1979, domestic air cargo grew from 85 thousand tons to 100 thousand tons enplaned annually. With the exception of the 1974-1975 recession period, growth has been slow but steady in domestic service.

In the international air cargo sector, growth has been generally much greater but characterized by more violent fluctuations in year to year rates of growth. During the period, the growth rate of international enplaned cargo averages just over 7.6 percent per year.

Table 2.2.1 HISTORY OF SELECTED ECONOMIC INDICATORS AT BOSTON: 1950-1970

	1950	1970	Growth Factor	Average Annual Growth Rate %	U.S. Average Annual Growth Rate %
Population	3,062,393	3,715,118	1.2131	0.97	1.50
Per Capita Income*	2,279	4,050	1.7771	2.92	2.65
	Thousands of 1967 Dollars				
Contract Construction	353,547	774,622	2.1910	4.00	4.12
Manufacturing	1,726,768	3,065,705	1.7754	2.91	3.76
Transportation, Communication and Public Utilities	407,176	793,491	1.9488	3.39	3.25
Wholesale and Retail Trade	1,216,737	2,131,980	1.7522	2.84	3.28
Finance, Insurance and Real Estate	336,175	849,953	2.5283	4.75	4.99
Services	749,595	2,524,148	3.3673	6.26	5.57
Government	709,054	1,759,086	2.4809	4.65	6.29
Air Cargo	711	1,838	1.5850	3.13	2.90

* 1967 Dollars

Source: OBERS "Projections of Regional Economic Activity in the U.S.", Series "E" Population.

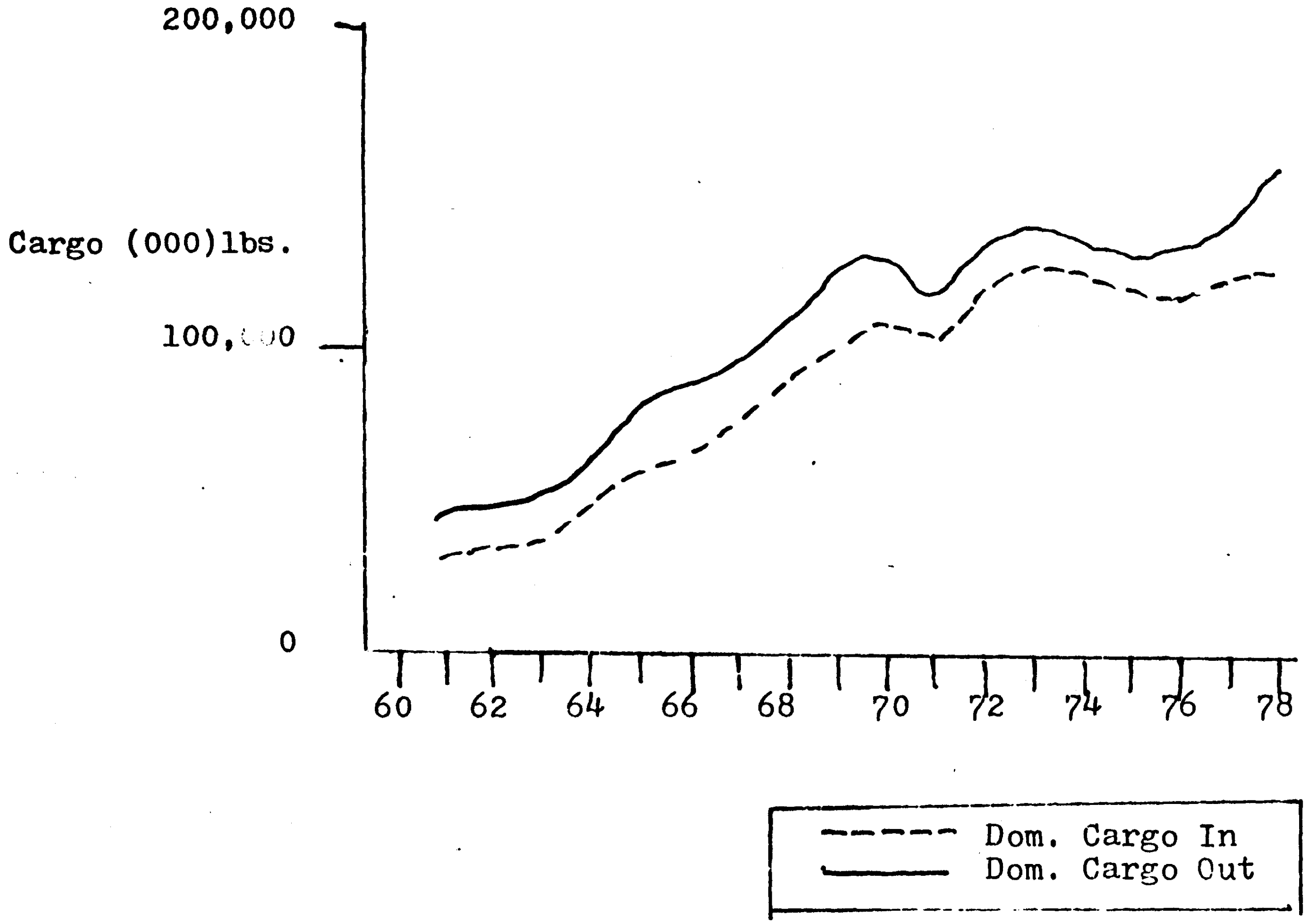


Figure 2.2.1: LOGAN HISTORIC TRENDS DOMESTIC CARGO

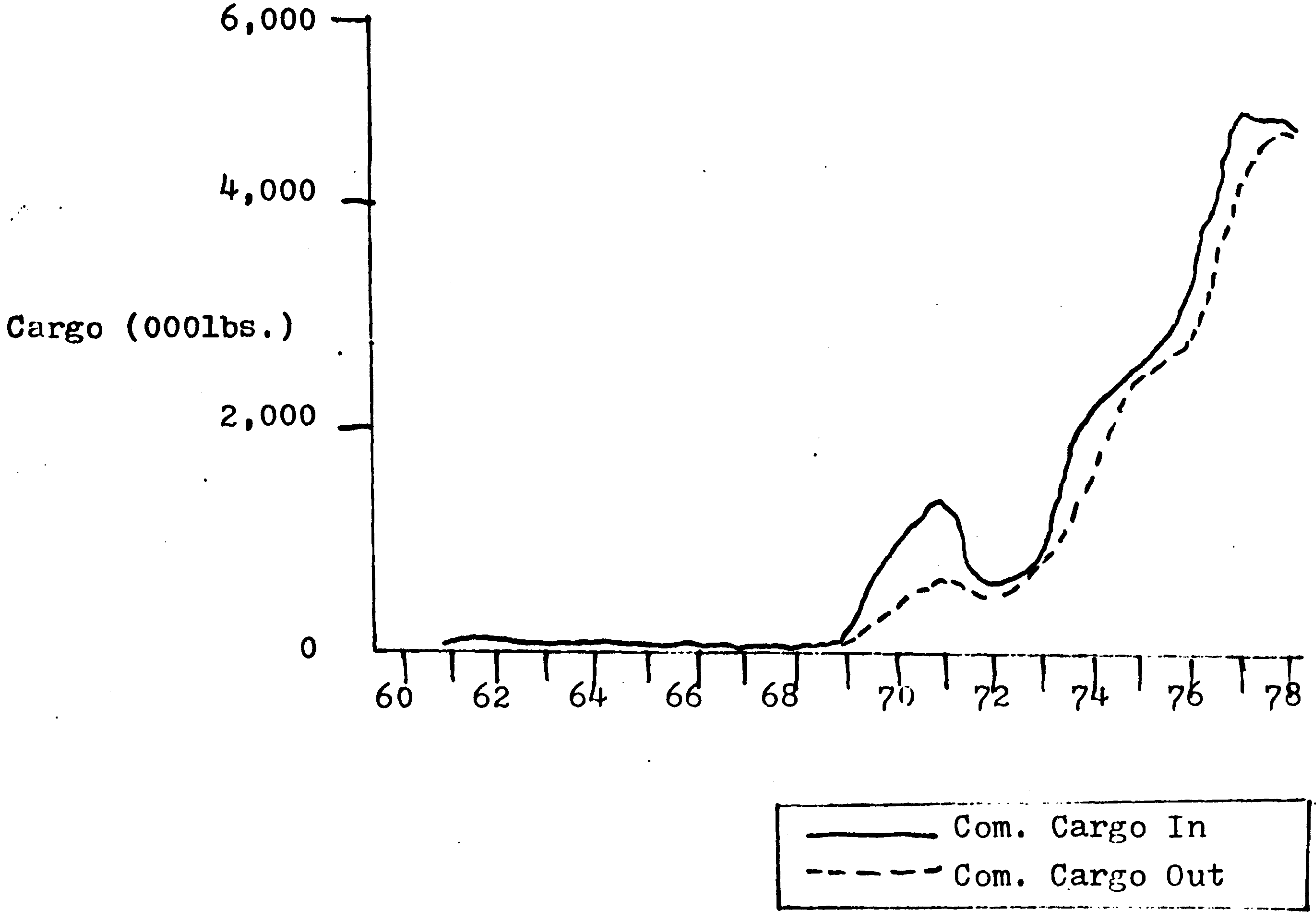


Figure 2.2.2: LOGAN AIRPORT HISTORIC TRENDS COMMUTER CARGO

Figure 2.2.3 shows the international cargo movements. These quantities include cargo enplaned into and deplaned from both U.S. flag and foreign flag carriers such as U.S.-Canadian "transborder" and overseas origins/ destinations routes.

Table 2.2.2 shows the growth of domestic and international cargo in Boston during the most recent seven-year period.

Generally speaking, market analysts can see no close correlation between enplaned and deplaned international tonnages, basically because international tonnages are in fact the products of international trade. By comparative advantages, the value of imported commodities may be the same, less, or more than the exported commodities' value. The characteristics of these commodities imported or exported are based on the demand of the region, since no city pairs in the world will exchange exactly the same commodities and impose more transport cost for their goods. Figure 2.2.3 shows that Logan international air freight growth trend is similar to many other markets of the world. Since 1974, imported international goods dropped significantly, the result being that tonnage deplaned in 1978 was still smaller than the corresponding import figure after a small drop

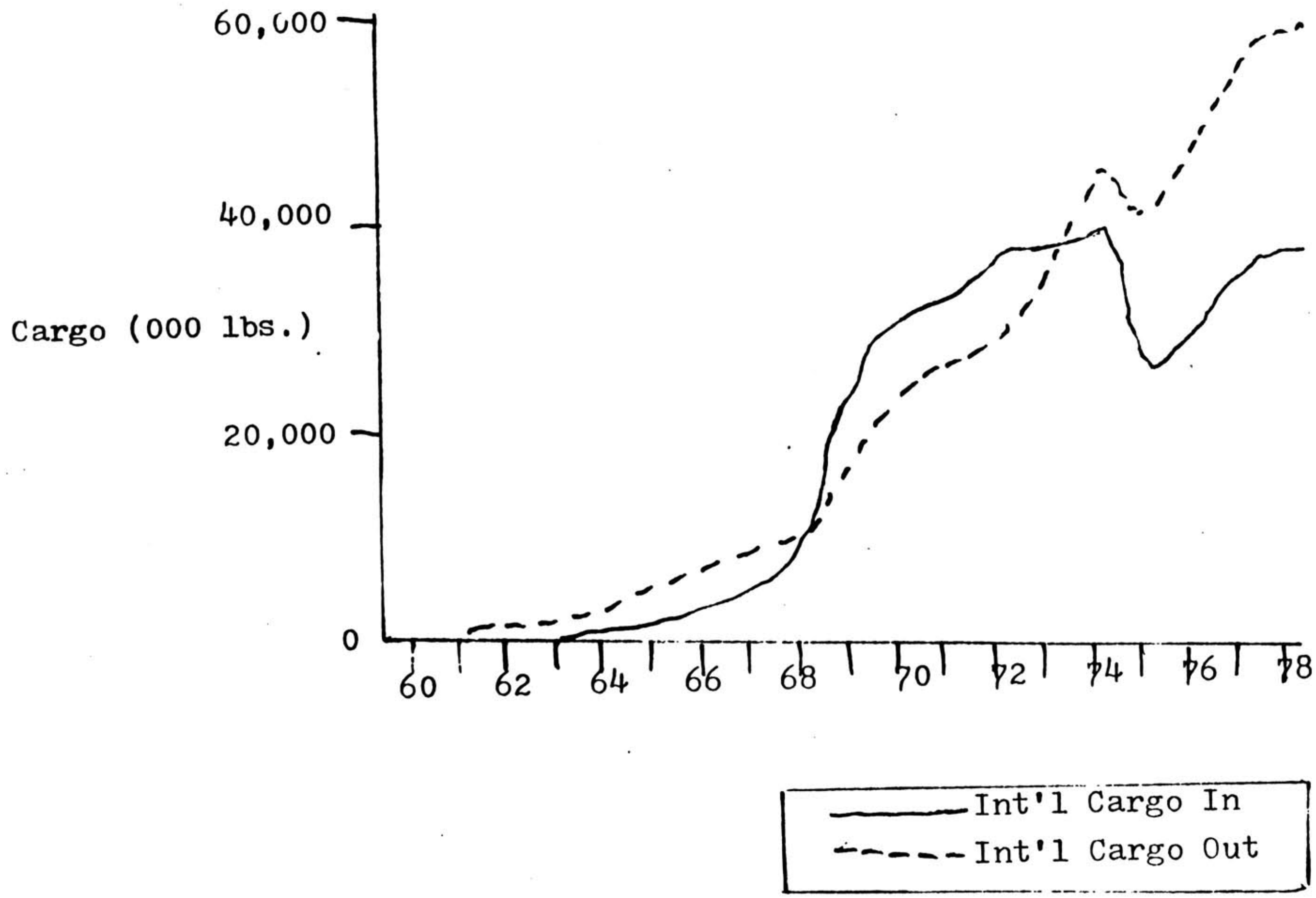


Figure 2.2.3: LOGAN AIRPORT HISTORIC TRENDS INTERNATIONAL CARGO

Table 2.2.2 CARGO TONS ENPLANED: DOMESTIC AND INTERNATIONAL AT LOGAN AIRPORT

Year	Domestic	% change	Foreign Flag Int'l.	% change	U.S. Flag Int'l.	% change	Total Int'l.	Total Cargo
1972	85,049.8		8,704.0		8,565.5		17,269.5	102,319.3
1973	89,464.1	5.2	11,711.1	34.5	7,406.4	(13.5)	19,117.5	108,581.6
1974	85,802.8	(4.1)	12,383.1	5.1	9,729.8	31.4	22,111.9	107,914.7
1975	84,636.0	(1.4)	6,659.1	(46.2)	10,770.3	10.7	17,429.4	102,065.4
1976	87,026.5	2.8	9,989.9	50.0	10,906.4	1.3	20,896.3	107,922.8
1977	90,544.9	4.0	12,231.6	22.4	12,503.6	14.6	24,735.2	115,280.1
1978	96,448.4	6.5	14,328.0	17.1	11,440.0	(8.5)	25,768.0	122,216.4
1979	100,133.9	3.8	14,462.4	0.9	14,434.4	26.2	28,896.8	129,030.7
Total Growth (1972-79)	17.7%		66.2%		68.5%		67.3%	26.1%

Source: "Green Sheets" received from the Massport Aviation Department in 1975, and by 1978 was 50 percent higher than imports. If a separate analysis of each trade direction is studied in more detail, the discrepancy of this international cargo traffic will be better understood. Thus, the back-haul and forward freight traffic and revenue will be easier to forecast, particularly in the international air freight and exchange rate movements.

For the commuter handlings as shown in Figure 2.2.2, the rapidly increasing tonnage handlings by the commuter service in the 1970s as compared to the previous decade, indicate some economic trends of the industrial growth especially at the smaller cities. That is to say, more high-valued commodities are carried by air to and from the smaller cities of the New England area in the 1970s. Whether the economic growth of the smaller New England cities will continue throughout this century is unpredictable. The graph shows no clear growth trend, and suggests that incoming and outgoing tonnages in this category tend to be fairly evenly balanced.

Figures 2.2.4 and 2.2.5 show the historic trends of mail tonnage. International mail by its market nature is relatively small compared to domestic mail tonnages, though Figure 2.2.4 shows that it experienced relatively large rates of growth during the 1970s. Figure 2.2.5 also shows that domestic mail experienced a relatively large increase

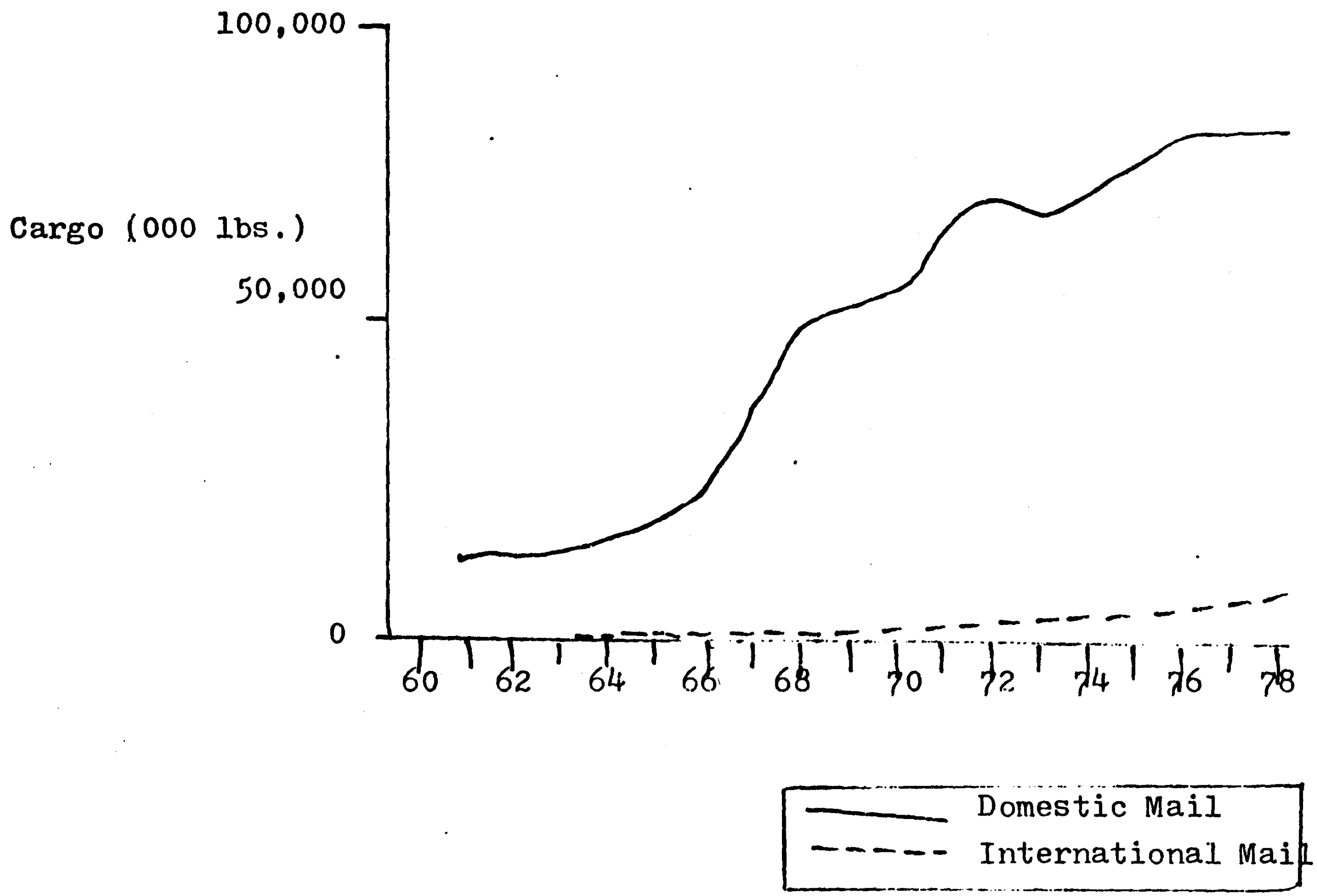


Figure 2.2.4: LOGAN AIRPORT HISTORIC TRENDS MAIL

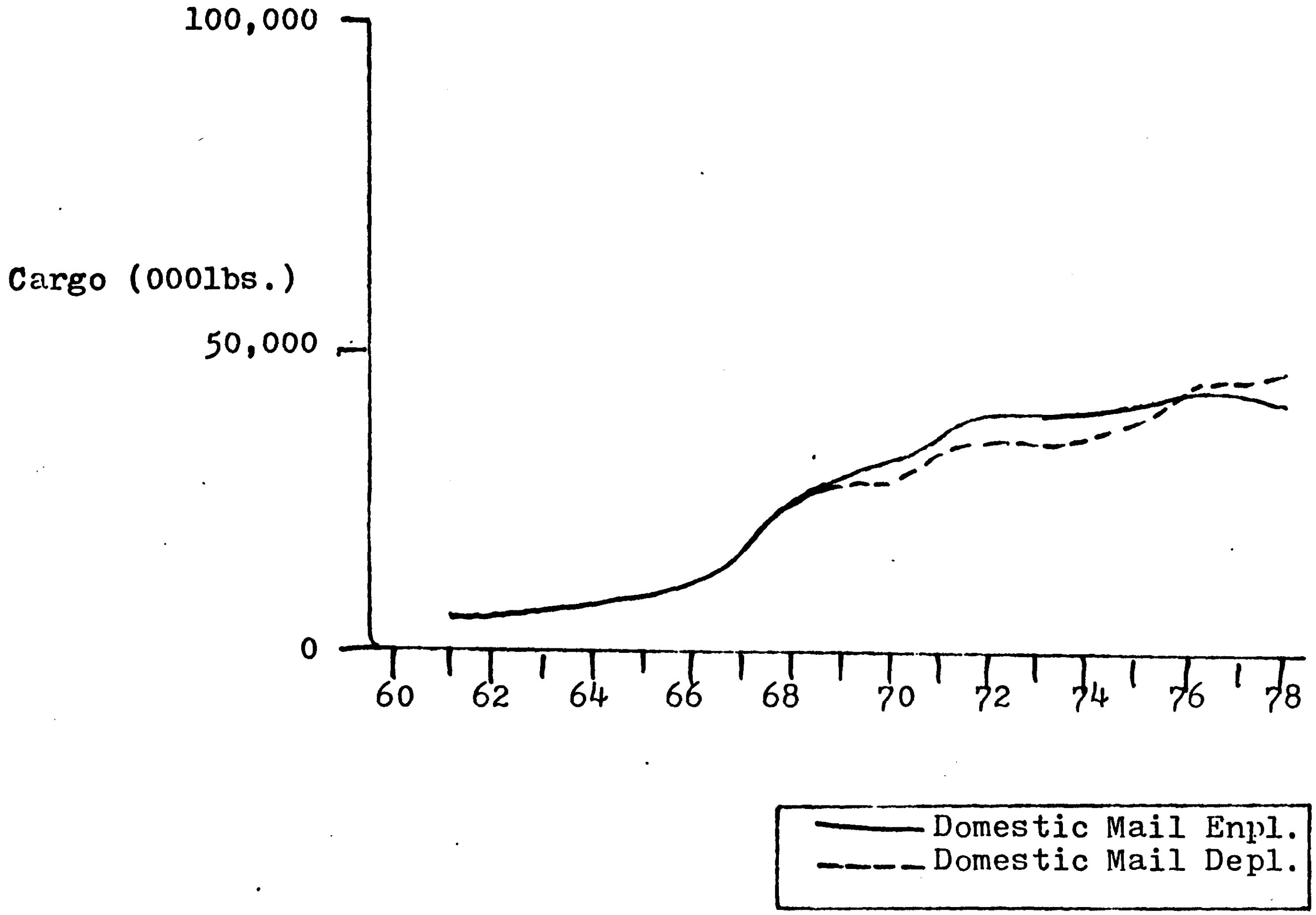


Figure 2.2.5: LOGAN AIRPORT HISTORIC TRENDS DOMESTIC MAIL

during the late 1960s. The tonnages of domestic mail have tended to level off since 1972, and particularly since 1976. As Figure 2.2.5 represents, the enplaned and deplaned tonnages of domestic mail by carriers tended to be about equal throughout the historic period.

In summary, Table 2.2.3 indicated the total tonnage and rates of change of relevant totals and subcategories. In percentage growth, the recession of the early 1970s slowed down the extraordinary growth of the 1960s and affected all categories drastically. The late 70s saw a healthy recovery in growth rates, especially in the international mail category. Table 2.2.4 compares the composition of Logan air cargo by service types. Notice that the international tonnage relatively increased its share. Mail, both domestic and international, also increased its share somewhat relative to domestic tonnage of general air freight.

Table 2.2.3 CARGO ACTIVITY BY SERVICE TYPE AT LOGAN AIRPORT: 1960-1978
(000) Total Tonnage and Percentage Change

Type of Cargo	1960	%	1965	%	1970	%	1975	%	1978
Freight and Express									
Domestic	30.5	17.5	67.9	11.5	117	1.1	124	4.5	142
International	1.2	31.6	4.6	44.1	28.6	2.8	32.8	13.3	47.7
Mail									
Domestic	5.3	10.1	9.8	23.5	28.2	6.1	37.9	2.8	41.2
International	.06	26.3	.2	33.9	.86	18.4	2.0	23.9	3.8
Total	36.8	17.6	82.6	16.2	175	2.4	197	5.9	234

Source: "Green Sheets" received from Massport Aviation Department.

Table 2.2.4 COMPOSITION OF CARGO LOADS AT LOGAN AIRPORT BY TYPE OF SERVICE FOR SELECTED YEARS 1960-1978 (percent)

Type of Cargo	1960	1965	1970	1975	1978
Freight and Express					
Domestic	82.2	82.3	67.0	63.0	60.4
International	3.2	5.6	16.4	17.7	20.4
Mail					
Domestic	14.5	11.9	16.1	19.3	17.6
International	0.2	0.2	0.5	1.0	1.6
Total Cargo	100.0	100.0	100.0	100.0	100.0

Source: "Green Sheets" received from Massport Aviation Department.

3.0 A SUPPLY-DETERMINED AIR CARGO FORECAST

The supply function in scheduled air cargo transport is defined over a network of markets. For different types of scheduled service, the routing of vehicles along paths in the network may be different. There is a very large number of possible vehicle routings in a typical network; therefore, suppliers at Logan may be serving Boston jointly with a different subset of adjacent markets, such as New York airports, and consequently, their behavior and competitive position may be very different from each other.

The decision variables for the supply function are the frequence of service and route pattern decisions. As air freight is routed along paths in the network, freight service is supplied to many markets. In addition, these freight paths must be combined to form cycles so that supply decisions are interlinked through the network structure, and strongly related to the shipper's time patterns of demand.

3.1 THE SUPPLY FUNCTION OF AIR CARGO SERVICE--(a multi-stage process)

As we think of how air cargo service operates, two stages can be classified. First, there are input variables such as labor, fuel, and other facilities, which in total provide an intermediate service function, such as in tonnage capability. For an air freighter, this service function describes the performance of the freighter service division in providing a least cost service capability for the above-mentioned input variables.

The later stage of the supply process is scheduling, or frequency of service. The air cargo schedules describe the work of the freighters, taking the service capability and market information data on demands and prices for certain commodities at certain time periods to produce a final service output to be offered in the many markets of the network. In order to obtain maximum profit, this scheduling has to be set optimally, utilizing inputs of tonnage capability efficiently.

The outputs of the supply process of air cargo service offered at Logan are generally not equivalent to those in New York or Los Angeles. Since the quantity and quality of service offered by the air freighters differs from market to market, in most cases, the services are offered based on the total optimal benefits of the supplier in each network system. Furthermore, the volume of tonnage or the available ton-miles, which shippers buy from the freighters, is not the product of the services, but rather the measurement of the volume of air cargo activities.

The measurement of supply function is basically dependent upon the number of flights offered daily along the route network by a certain air carrier type. Besides frequency of service, two other factors, such as type of vehicles (which determines payload capacity) and choice of routings may greatly affect the determination of marginal or incremental costs of adding or subtracting flights on a schedule.

The Air Cargo Guide provides a very up-to-date source of information about origin-destination cargo service at Logan. Table 3.1.1 shows the scheduled all-cargo and combi flights offered at Logan in the month of August, 1979.

Essentially, the supply quantity at the Logan network level, besides the frequency of service, is determined by payload capacity. Table 3.1.2 lists the payload capacity assumptions of each aircraft type. These aircraft types include all-cargo and combi certificated as well as commuter freight carriers. For commuter freight service, Lockheed Electra and Falcon are assumed to be the most common ones that will be used in the year 2000, whereas Federal Express has turned to bigger jet freighters (this air freighter has fifteen 727's on service at present and twenty more on order from Eastern Airlines). For the certificated air carriers, 747F and DC-10-30-AF aircraft are

Table 3.1.1: Scheduled Monthly Air Freight Service at Logan (August 1979)

All-cargo	City	Vehicle	Inbound Flights/month
International:			
	Frankfurt	74F	12
	London	70F	4
	Lyon	74F	4
	Madrid	D8F	4
	Paris	74F	12
Domestic:	Chicago	D8F	36
		70F	20
	Los Angeles	D8F	44
		70F	20
	Memphis	72F	20
	San Frans.	D8F	4
Commuter:	Atlanta		20
	Baltimore		40
	New Hampshire		60
	Philadelphia		60
	Rhode Island		20
	Vermont		20
	Maine		80
Combi			
International:			
	Amersterdam	747	8
	Brussels	DC8	4
	Dublin	747	12
	Frankfurt	D10	28
		747	12
	Glasgow	747	28
	Bermuda	L10	28
	London	747	56
	Milan	D10	8
	Paris	L1o	28
		747	12
	Rome	D10	16
	Shannon	747	12
Domestic:	Chicago	D10	28
		L10	28
		D8S	4
	Detroit	D10	28
	Hartford	L10	56

Table 3.1.1 (continued)

Combi	City	Vehicle	Inbound Flights/month
Domestic:	Las Vegas	L10	28
	Los Angeles	L10	56
		D10	28
	Milawakee	D10	28
	Twin City	D10	56
	New York	L10	84
		74F	8
		70F	24
	Orlando	L10	28
	Phoenix	D10	28
	San Frans.	D10	56
		L10	56
	San Juan	L10	28
	Seattle	D10	28
	Washington D.C.	D10	28
Commuter	Binghamton NY		48
	Utica NY		20
	New York City		40

Source: Air Cargo Guide, August, 1979.

Table 3.1.2 PAYLOAD CAPACITY OF ALL-CARGO AIRCRAFT AND ASSUMED PAYLOAD CAPACITY OF COMBI AIRCRAFT

Service Type	Aircraft Type	Payload (tons)
All-Cargo	747F	129
	DC10-30-AF	84
	L1011-C	60
	DC8-63AF	54
	707-320-C	46
	727-100C	22
	Lockheed Electra	10
	Falcon	2
Combi	747	39
	DC10	26
	L1011	18
	757	10
	767	14
	DC8	10
	707	9
	727	4
	average commuter	0.5

Source: Jane's All the World's Aircraft, 1979-80 used for medium-to-short haul service. Appendix A illustrates the characteristics and the fleet mix composition of the all-cargo carriers having scheduled service at Logan in detail in order to explain the market and fleet nature more thoroughly.

Table 3.1.3 displays the current scheduled all-cargo flights' payload capacity at Logan with the information given at Tables 3.1.1 and 3.1.2. This payload capacity estimation does not include domestic and international combi service, since different air carriers have different policies of acquiring combi aircrafts, and such policies may lead to different payload capability.

It is generally believed that for the international combi service, the average payload capacity of the wide-bodies is 30 percent of their all-cargo type's, and for the domestic combi service, the average payload capacity of the 2,3-engined widebodies or narrow bodies is 10 percent of its all-cargo type's.

The payload capacity for all-cargo and combi service depends on other factors, such as individual aircraft configuration, containerization, trip length, airline fuel supply, management of labor, etc. Mail cargo is excluded in the estimation. There has been a negative growth in commuter load factors both in Boston and

Table 3.1.3 PAYLOAD CAPACITY FOR ALL-CARGO OPERATIONS AT LOGAN
(August, 1979)

Service Type	City	Available Tons per Ave.Day-Peak Month	
International	Frankfurt	50.0	
	London	6.0	
	Lyon	16.8	
	Madrid	6.8	
	Paris	50.0	
	Sub-total		129.6
Domestic	Chicago	92.6	
	Los Angeles	106.6	
	Memphis	14.0	
	San Francisco	7.0	
	Sub-total		219.5
Commuter		23.7	
Grand Total		372.8	

Source: Constructed from Tables 3.1.1 and 3.1.2.

nationally. This is due mainly to the U.S. Postal Services' fiscal problems and is intensified by flight consolidation and competition from trucking firms and large airlines. The majority of domestic flights at Logan now are serviced by the narrow bodies. Many of these flights, however, do not carry cargo except passengers' baggage. That is the reason why the domestic combi payload capacity is only one-tenth of its all-cargo service.

For all-cargo international freighters, a load factor of 50 percent is assigned throughout the forecasting period. For all-cargo domestic freighters, it is 40 percent in load factor. The "cube-out" phenomenon in essence holds the load factor of all-cargo service always below 60 percent, since many times the commodities carried need extra spatial utilization and thus are far below the weight per cubic foot limit.

Another way to verify the above-mentioned load factor assumptions is by using the FAA Aviation Forecast of Boston-Hub (ref. 6). In this forecast, the all-cargo freighter average load factor of high cargo markets (i.e. mainly overseas markets) is 0.47 at 1978, and for the low cargo market (mainly served by combi domestic flights), its load factor is 0.20.

One possible way to determine the payload capacity for the year 2000 is to assign fleet forecast based upon demand level of the known demand factors. Before doing this fleet forecast, we can calculate the actual tonnage carried by all-cargo and combi carriers at Logan in the year 1979 in order to verify the accuracy of using the air freight supply function and its fleet mix as a forecasting method.

We apply the assigned 50 percent all-cargo international and 40 percent all-cargo domestic load factors to the available tonnage (average day-peak month payload capacity as shown in Table 3.1.3), which gives (129.6 x 0.50) or 64.8 tons for the international freight and express sector, and (219.5 x 0.40) or 87.8 tons for the domestic freight and express sector. The total freight and express carried by all-cargo carriers is, therefore, 152.6 tons per average day of August, or 4,578 tons in August, 1979. Since total tonnage in August is 10.5 percent of the total annual tonnage, the annual tonnage carried by all-cargo freighters is (4,578/0.105), or 43,600 tons.

Now, we may estimate the total tonnage of combi service by the 0.30 international and 0.10 domestic load factor calculation. But we need to summarize the flights of the year 1979 at Logan. Moreover, we can use the FAA's judgment of combi and all-cargo split ratio of 60:40 at the Boston-

Hub market. The tonnage carried by combi carriers would be 1.5 times the tonnage carried by all-cargo, (43,600 x 1.5) or 65,400 tons in the year 1979. The total freight and express tonnage carried by combi and all-cargo aircrafts is estimated to be (43,600 + 65,400) or 109,000 tons. The actual 1979 total freight and express tonnage is 102,382 tons. There is 6.4 percent more in the total tonnage estimated by the fleet-payload capacity method. Indeed, the 60:40 split ratio of Boston-Hub may be the factor causing this extra tonnage, since the Boston-Hub market involves other New England supplementary airports' estimations.

The methodology of forecast can be extremely helpful to the traditional econometric forecast methodology which is attempted in the next chapter in detail. In any event, the fleet forecast method analyzed in chapter 3.4 demonstrates the effectiveness of this forecast techniques.

3.2 ISSUES ON TECHNOLOGICAL IMPROVEMENT AND ITS EFFECT ON SUPPLY OF SERVICE

One noticeable feature of the air cargo industry is that the supply of air cargo service, which is determined by the needs of the shippers, may in fact put more constraints on the demand of air freight service. There are many speculations about the technical advancement of the aircraft industry in the coming two decades. Specialized air freighters, such as spanloader of Boeing and McDonald Douglas

Aircraft companies, have been suggested. These models have been advocated as the air freighters of the coming century. Specialized regional cargo airports are also suggested by shippers as well as air-cargo related businessmen.

Besides all these possible improvements, the most prominent and near-term change will be all-mode cargo load devices. This is a major container standardization for intermodal transport. The all-mode cargo load devices meet the fundamental need for changes, if any, during the next two decades. This development would promote the economic utility and feasibility of specialized freighters Specialized cargo airports would then be considered as a necessary facility in the air cargo industry.

3.2.1 CONTAINERIZATION AND WIDE-BODIED JET

It is estimated that over 90 percent of the air cargo flown across the Atlantic Ocean today is carried on wide-bodied aircraft in containers or units. The introduction of unit load devices in the form of pallets, containers, and igloos has greatly contributed to the expansion of air freight resources, and, just as important, made speedier and more efficient handling possible.

Much has been said about air container services, and their benefits to the shipper community in terms of rates, speed, security, and other customer/airline advantages. Some types of containers have always been used by the airlines in order to expedite on-and off-loading; shippers need not play a part. But large shippers and consignees will profit by using suitable containers to handle real door-to-door traffic. There are three basic categories of containers offered to the shippers or consignee: shipper-owned, airline-owned or used, and special purpose containers for perishables and live animal transport, which can either be airline-owned or leased.

Container Types:

The most widely used airline-owned container types range in size from the LD3 up to the 10-foot container (10'*8'*8'). Appendix B describes the different types of container (ref. 7).

Each unit load device, regardless of whether shipper or carrier-owned, must be approved and registered with the Container Board of the International Air Transport Association. The IATA container program began only in the early '60s. This was the first time shippers were able to register a standard size carton in order to receive a container discount. This led to a lot of different kinds of containers, so that in 1966 it was necessary to begin standardization. In that year, 17 standard sizes were introduced, which by 1971 had been reduced to 11. These shipper-owned containers each qualify for a specific discount.

In 1969, the IATA's Freight All Kinds program introduced containers owned by IATA airlines to the market with the objective of expanding door-to-door container traffic for the benefit of high-volume shippers and of airlines. This was the first significant step toward creating a door-to-door traffic concept by the airline industry.

With the introduction of the wide-body freighter in 1972, a true intermodal 10-foot container was offered to shippers and consignees for the first time. Today, the industry offers a wide range of different containers, from small lower deck ones to 20-foot units. The design and introduction of these containers represents a sizeable investment by the various carriers, indicating their commitment to intermodal transportation.

Moreover, the airlines have generally been trying to sell a product that is designed more for their own than their customers' convenience. The intermodal containers, in many cases, are not compatible with consignees' handling

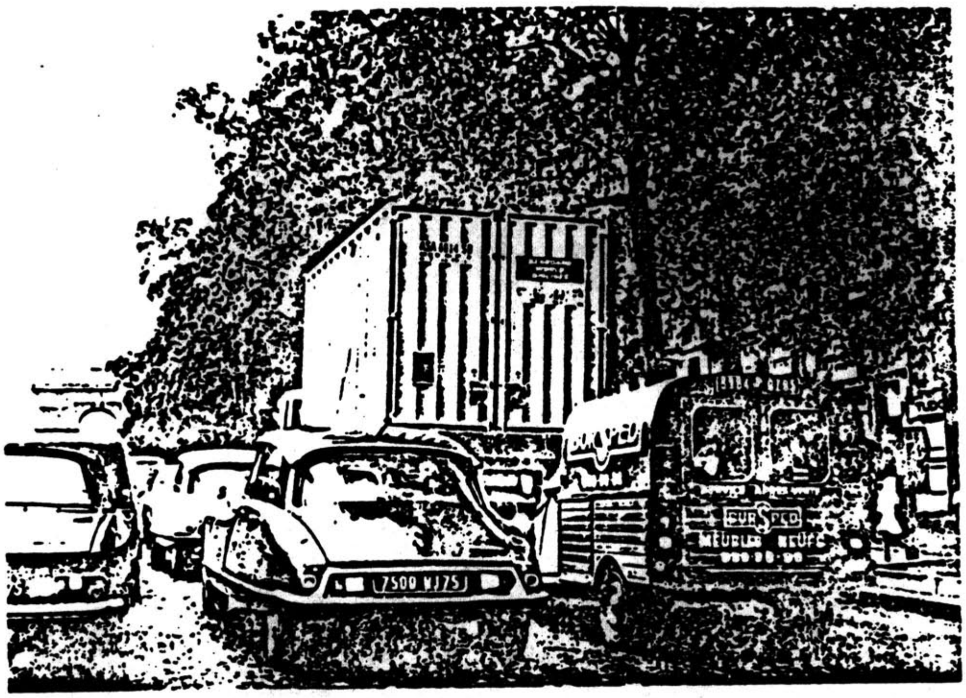


Figure 3.2 a) The Intermodal Container

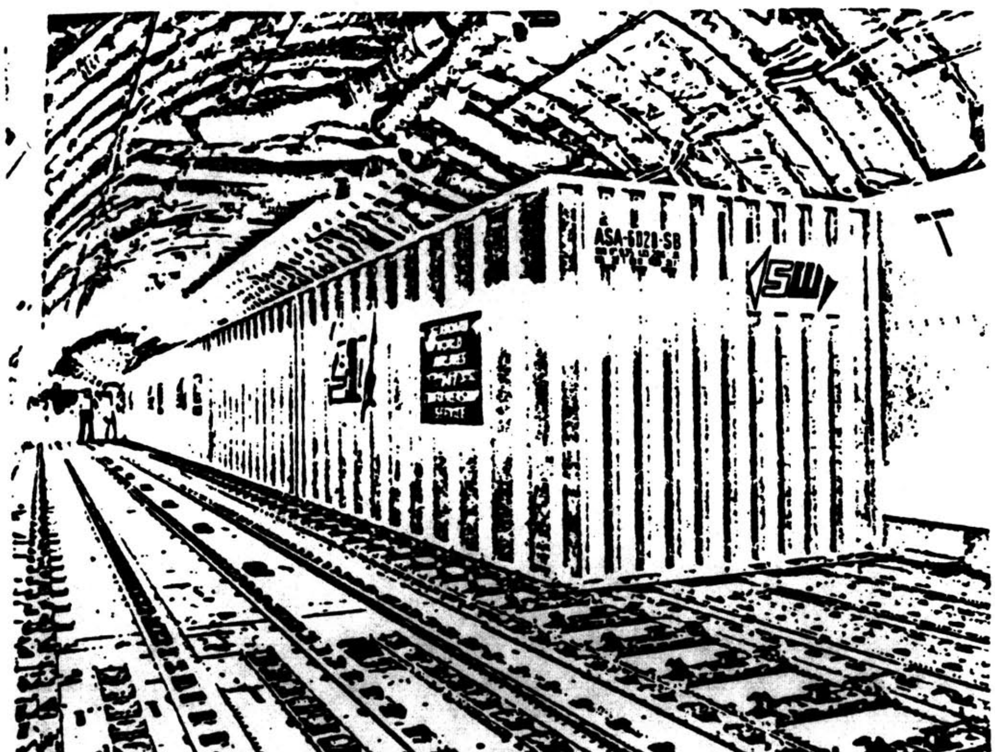


Figure 3.2 b) Side-by-Side Loading Capability of Intermodal Containers in the B-747F

Source: Seaboard World Airlines; reprinted from Nawal K. Taneja, U.S. Airfreight Industry (Lexington Books, D.C.Heath & Co.,MA,1979),p.192.

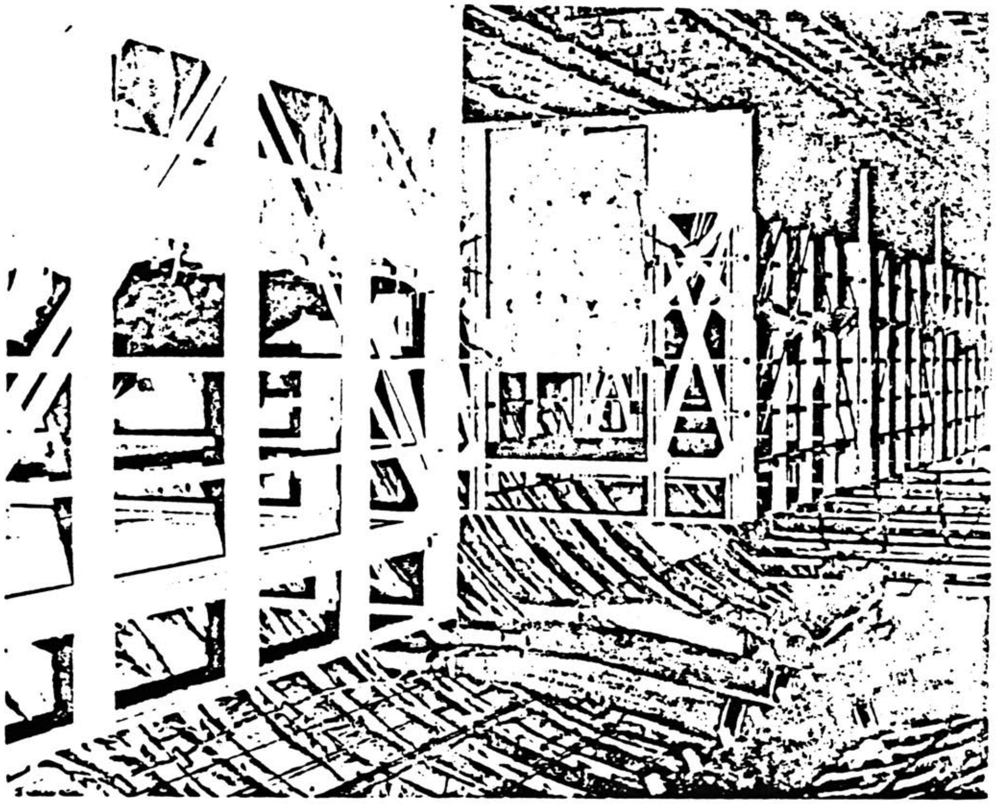


Figure 3.2 c) Aluminum-Frame Cattle Containers

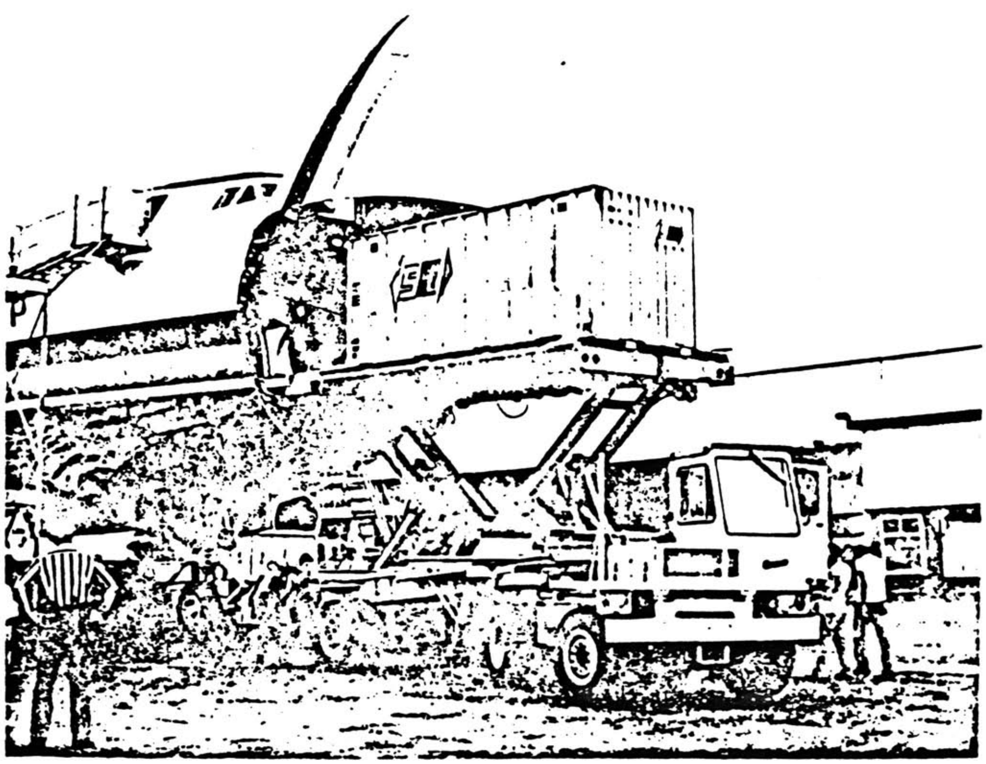


Figure 3.2 d) Nose Door Loading of Intermodal Containers in the B-747F

Source: see p.57.

equipment. Shaped to fit aircraft contours, they lose cubic space that shippers would like to fill; and unless an airline permits its containers to leave the airport, shipments require additional stowing and unstowing with the attendant hazards. Time saved in the air is too often lost on the ground.

There are many limitations with regard to intermodal container shipments. Besides dimensional constraints in load units, various kind of goods, such as chemical explosives, can only be shipped in containers in restricted amounts. The U.S. government, for example, has limited the maximum weight for such "restricted articles" to 25 kilos per container.

The investments in containers for airlines have been enormous. Some container types are valued at almost $9,000 apiece. This fact indicated how costs can easily soar in case of slowed activity when load units go unused.

The logistics of container use for air shipment are notably more involved than for sea freight. A container ship sailing between Rotterdam and Boston will need approximately three times as many units as are actually being transported: one on the ship, one at the receiving end, and one at the shipping end. For an aircraft covering the same route, nine or ten times as many containres are needed for the overall rotation as can actually be carried. Reasons for this are the greater speed of movement between producer and receiver and the smaller sorts of containers with which the airlines work. To overcome the worsening of the situation, it has become necessary for airlines to establish an international organization in order to assure standardization and interchangeability of containers among all companies concerned.

Another limitation upon the intermodal idea evolved not from the air cargo industry's commitment to the promotion of the concept of total distribution cost, but because of many air freight salesmen's inability to induce the customers to provide the business details that the salesmen needed in order to make useful proposals. A successful example can be cited for these salesmen to know how to market shipments properly: merchandise from the Orient arrives on the West Coast via steamship and then is either reloaded into air containers or left in its original marine containers for the journey inland.

Nowadays, the Boston area has emerged with many new air freight customers coming from high-technology companies with high-value products and low capital. These companies quickly grasp the value of the speed and other benefits of containerization, and they are the reason that air cargo growth has been so good in New England over the last decade. With the improvement of intermodal handlings and service in the near future, the supply of air cargo will be able to meet the foreseeable growth in demand, as will be illustrated in chapter 5.

3.2.2. SPECIALIZED AIR FREIGHTER

For the next generation of large cargo aircraft it is proposed to distribute the payload in the wing structure. Because of the need to lower transport costs and to lower the advanced cargo aircraft design from the foreign competition, the proposed spanloaders of Boeing and Douglas indicate substantial reductions in fuel consumption, empty weight, and operating costs. This design is expected to involve indirect and direct unit operating costs of only 27 percent of those associated with the standard-body all-cargo aircraft used currently. (See Figure 3.2.1 for a spanloader.)

NASA and U.S. industry studies have, on the other hand, indicated that large gains in spanloader payload and fuel efficiency are possibly the revolutionary innovation which may invalidate all the air cargo projection studies. Airport runways, terminal design, and loading facilities have to change accordingly. Stimulation of the demand

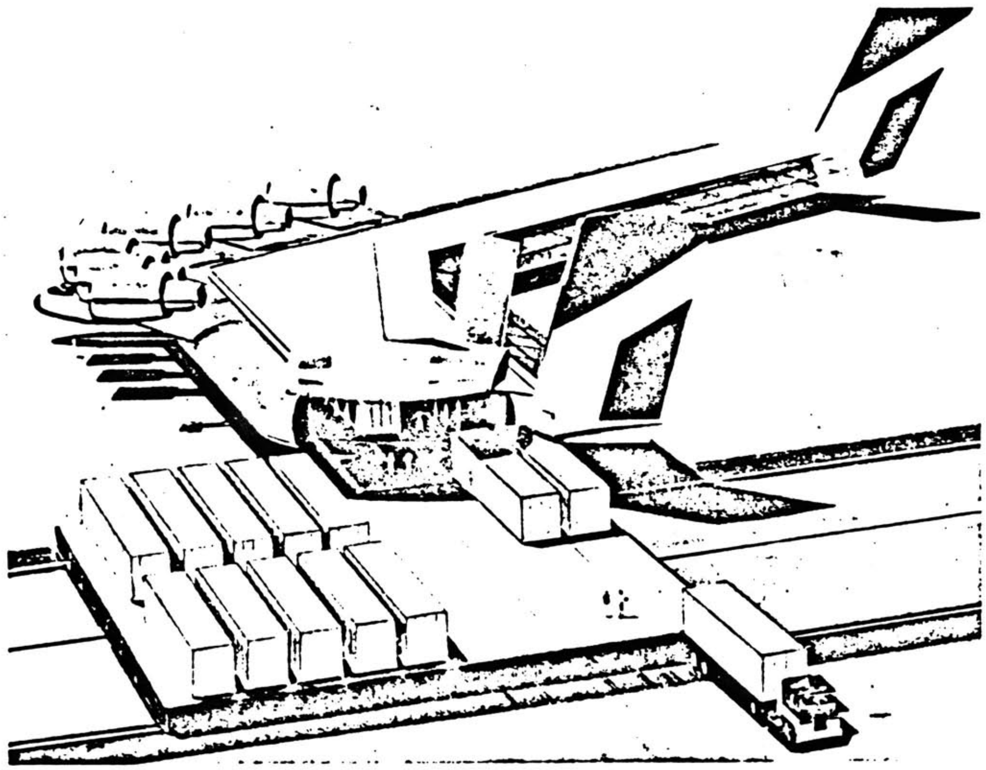


Figure 3.2.1: Conceptual Design of a Distributed Spanloader Freighter

Source: Boeing Commercial Airplane Company; reprinted from Nawal K. Taneja, U.S. Airfreight Industry (Lexington Books, D.C. Heath &Co., MA, 1979), p.194.

for air freight service via air commodity penetration and cooperative marketing by the salesmen will result from this spanloader concept as well as from the development of an integrated, intermodal system. If these technological innovations are brought to maturity and are implemented, the rate structure— an important element of the total cost of distribution— will be reformulated.

Figure 3.2.2 illustrates the economic potential of the spanloader design concept (ref. 8). The figure shows that the costs of the reference configuration have been optimized at the design with a gross payload of 21.5 tons, whereas payloads beyond that for the spanloader study configuration will greatly increase its economic advantage. As size increases, the thickness ratio and fuel consumption decrease for the spanloader aircraft. Incidentally, other studies resulted in suggestions that for a design payload less than 300 tons, conventional aircraft design is economically advantageous; beyond that payload value, the spanloader design is more attractive.

Nevertheless, all these promises in technological innovations of the air freighter design are not expected to come into commercial use until past the year 2000, and the above-mentioned should be a very long-term projection picture and need not be considered in this study.

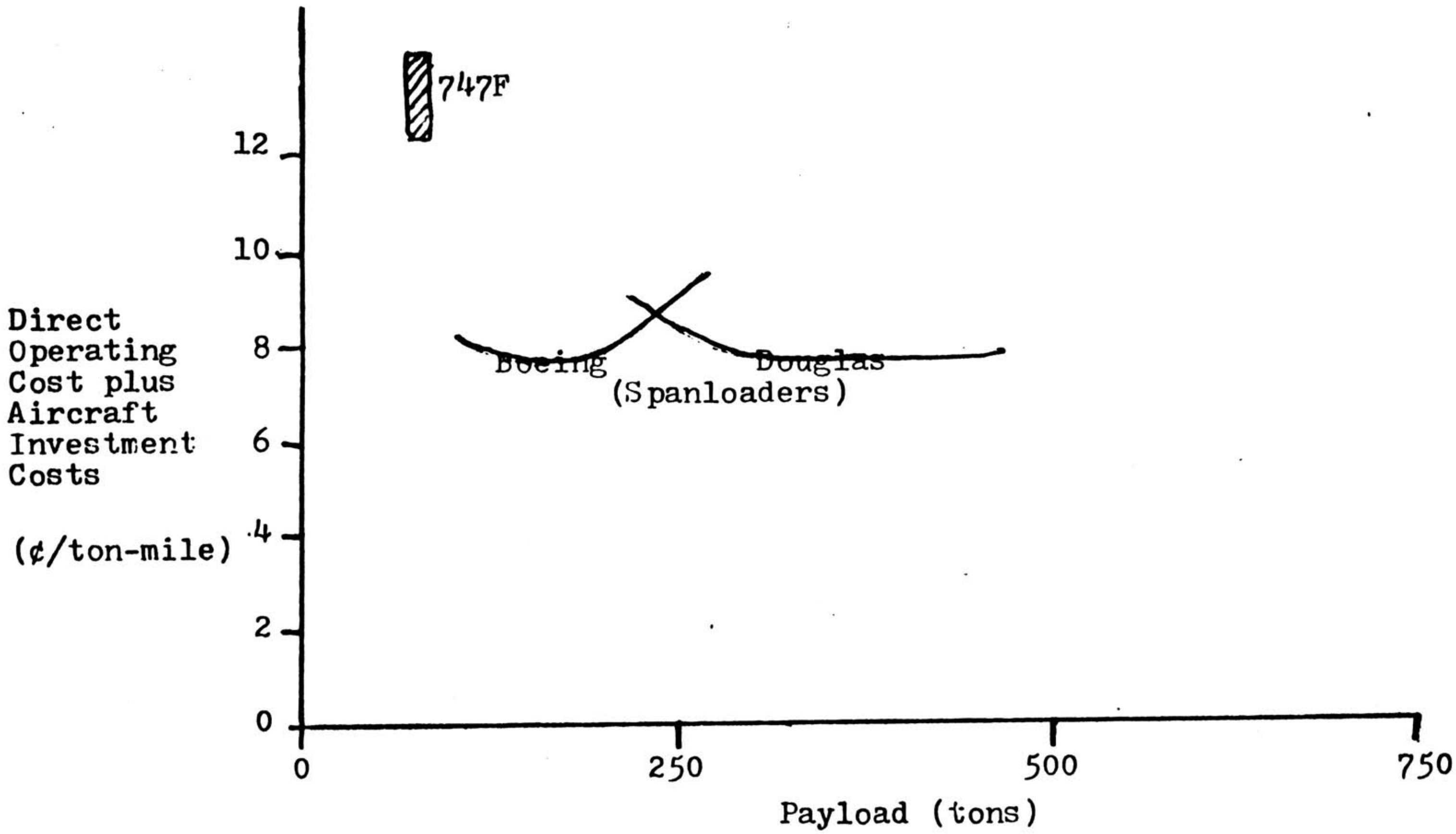


Figure 3.2.2: ECONOMIC POTENTIAL OF ADVANCED DESIGN CONCEPTS

Source: A.H. Whitehead,Jr., The Promise of Air Cargo- System Aspects and Vehicle Design, NASA Memo TMX-71981, Langley Research Center, VA July 19, 1976.

3.2.3 SPECIALIZED REGIONAL CARGO TERMINAL

As air cargo volume grows continuously, more, larger airfreighters need to be acquired. Ground-access congestion, plus the passenger traffic congestion, may eventually lead to an out-of-airport cargo terminal or even a specialized regional cargo airport for the all-cargo shipments. It is likely that when cargo terminals at Logan reach a saturation level, the idea of an out-of-airport cargo terminal may get closer examination and may be used for freight service. Certainly, this concept would be required after the new BIF cargo terminal proved to be insufficient in handling all the shipments. Depending on the final BIF cargo terminal set-up and the demand growth rate, the saturation period of air cargo service at Logan may range from thirty to fifty years from now.

Moreover, many big airlines in the busiest airports of the world have already built their out-of-airport cargo terminals. For instance, Japan Air Lines (JAL) has its Baraki City Cargo Terminal out of the vicinity of Narita Airport in Japan. Massport may well advise its current air freight tenants and other potential entrants to consider this idea once the Logan cargo facilities cannot accommodate all the needs of the airfreighters. Figure 3.2.3 shows import cargo flow of the out-of-airport cargo terminal

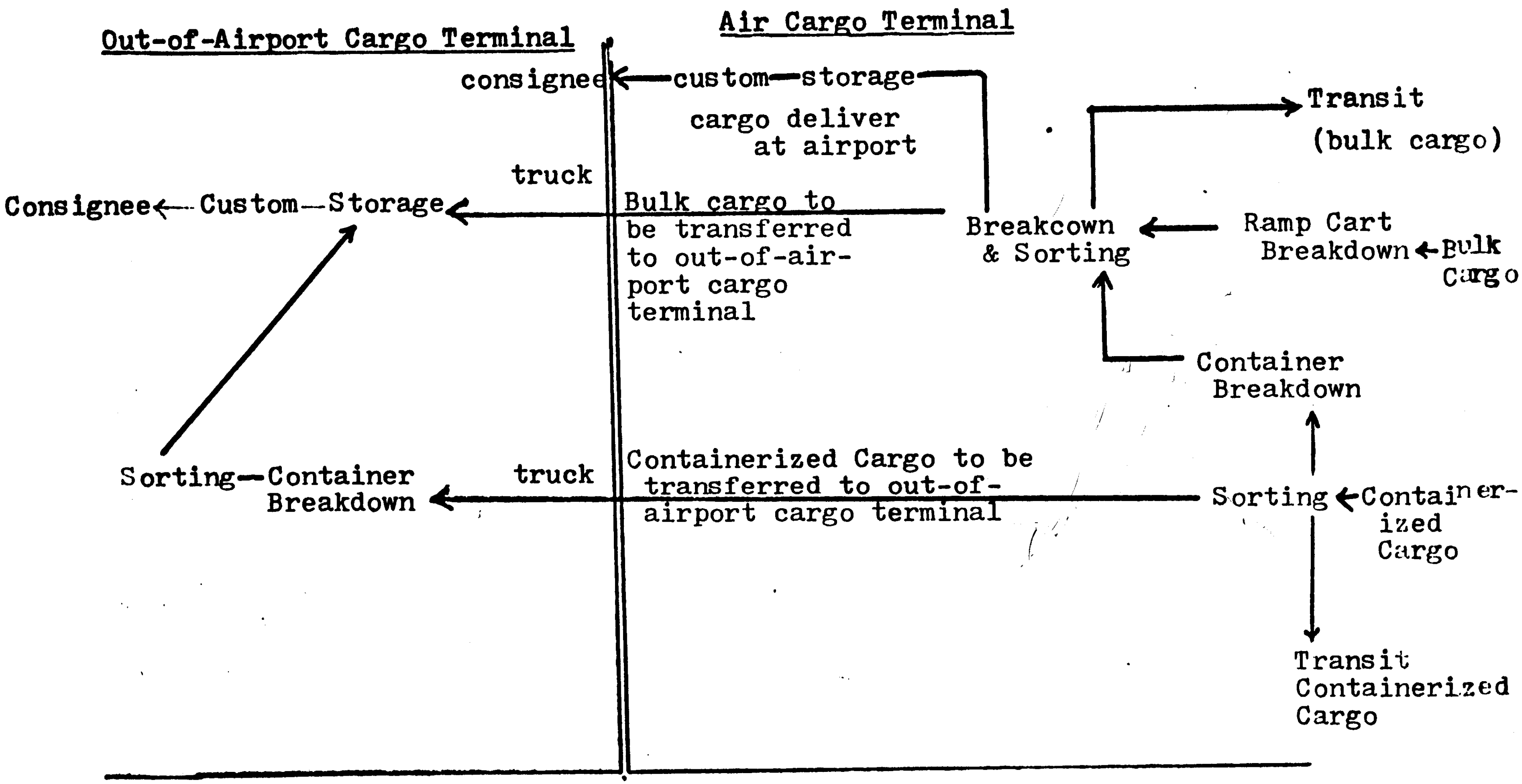


Figure 3.2.3: IMPORT CARGO FLOW AT AIRPORT AND OUT-OF-AIRPORT CARGO TERMINAL

concept. For the air cargo service at Narita Airport in Japan, only about 20 percent of JAL's domestic cargo is cleared and delivered to consignees at the airport. Except for the terminal cargo, most of the international import cargo is cleared and delivered to consignees at the Baraki City Cargo Terminal.

It is essential to understand that the provision of better labor utilization through specialized regional service, handling, and/or sharing of manpower at one terminal by all freighters will lead to better tonnage and frequency of service. The total operation costs, which are affected by congestion delays and inefficient scheduling, may be lowered via the establishment of the out-of-airport cargo terminal.

Lastly, the idea of a specially-designed regional cargo airport in addition to the present Logan and the future BIF terminal facilities might be justified if the specialized freighters, such as spanloaders, were extensively used in future air cargo business. Indeed, it would be plausible to proceed with a specially-designed regional cargo terminal at least half a century from now.

3.3 DEREGULATION

In November 9, 1977, the Cargo Deregulation Law, an amendment of the Federal Aviation Act of 1958 by P.L. 95-163, was passed and enacted by the Congress. It has opened a wholesale deregulation environment in the U.S. air transport industry. Deregulation has enabled carriers of all certificated types to restructure route networks with relative ease. Before this, the Civil Aeronautics Board (CAB) tended to turn down large numbers of applicants on various technical grounds. It may be too early to conclude that this deregulation development will lead to a genuine liberalization of the industry.

In this deregulated competitive environment, air carriers have to reformulate many aspects of their policies. Since deregulation, costs have risen in marginal and in real terms sufficiently to make short hauls and low load factor routes unprofitable in many instances. In passenger carriers, trunk carriers have eliminated frequencies in more short-haul routes (1 to 400 miles) than they have added. Frequencies in long-haul markets have increased among these certificated carriers.

In a similar behavioral pattern, the air cargo industry attempts to use its resources in a more productive manner. Route networks have been extended to market areas that will increase its capacity and revenue. More specifically, some of the more significant changes in the nation's air cargo industry include:

1) Freight rates were increased by more than one-fifth in the fourteen months after deregulation (ref.9).
2) Flying Tiger , the nation's first ranked airfreight company, has expanded its route-network with an eighty percent increase in 1978 scheduled service over that of 1977. Because of market competition, other major air cargo competitors,such as Pan American Airways and Seaboard Airlines, also added more scheduled service (ref. 10).
3) Federal Express, the leading domestic supplemental air freighter, which has moved up from the commuter category and has been granted authority to operate larger aircrafts, tends to control traffic flow by further developing its hub-and-spoke system. Its acquisition of a fleet of B-727s will guarantee larger capacity service to many shippers and receivers of the country. Another acquisition of two DC-10 widebodies from Western Airlines will increase

Federal Express's stage length to many overseas markets. (see Appendix A)

4) Specialized airlines such as airfreight commuters, which can economically serve short-haul markets, have filled the vacancy left by the withdrawal of trunk and local freight carriers in those markets.

5) Many carriers refuse to carry certain types of cargo. Before, some hazardous and handled-with-special-care commodities could not be rejected for air service. Now, the saying "air freighters are haulers of anything" is no longer true.

6) Certain commodities, such as livestock, have been charged up to two-fold increases since the air cargo liners were allowed to add surcharges and raise minimum charges voluntarily (ref. 11).

7) For better load factor and profit, carriers were permitted and encouraged to offer discounts with commodities in container shipments, off-peak hours, special contracts, and special markets (ref. 12).

3.3.1 DEREGULATION AND ITS EFFECT ON RATES AND MARKET STRUCTURE

The success of charging higher fees on many special shipments lies in the fact that losses sustained by sea transport may rise as high as 50 percent whereas the sustained losses by this speedy mode of transportation are 0.15 percent on average (ref. 13). In general, these special commodities require a team of handling experts and special equipments for loading and housing. In 1974, only one-tenth of the cattle and horses shipped out of U.S. travelled by air. Three years later, over 90 percent of the shipment was done by air (ref. 14).

Industry experts and observers agree that there is no noticeable entry of new carriers into the market under deregulation. In January, 1978, the top three carriers-- namely, American, United and Flying Tiger-- handled 49 percent of all revenue ton-miles. In May, 1978, after 418 certificates were issued to large air cargo carriers, these top three carriers handled 9 percent more of the total market than they had in January. This slight increase of market concentration and the lack of new entry into air cargo market over a five month period may be explained by the following barriers to entry:

1) Increasing overhead costs of aircraft, equipment, and handling lead to a very difficult finance situation for the potential newcomers.
2) High direct operating costs such as those for fuel and labor may also discourage the potential newcomers. There could be a great pressure if new entrants were unable to get hold of their fuel supply.
3) No short term breakthrough of technological advancement has been promised by aircraft manufacturers, and no such technical improvement and changes are anticipated by airport operators.
4) It is suspected that some form of reregulatory policy will be formulated sooner or later by the U.S. government, causing new carriers to be skeptical about entering the market.

Also, the short haul air forwarders were found to be about fifteen percent of the total certificated cargo carriers, since "grandfather clause" cargo certificates were issued in November, 1977. These were about two-thirds of the total cargo certificates granted to the commuter cargo carriers.

One may look at the effect of deregulation for the potential entrants by studying the profit margins of the existing carriers. Table 3.3.1 shows the net income of

Table 3.3.1 OPERATING RESULTS FOR FIVE LARGEST FREIGHTER OPERATORS, 1967-1975

Twelve Months Ended	Operating Profit or (Loss) ($000)*					
	American	Eastern	TWA	United	Flying Tiger	Total
12/31/67	1354	(504)	(4,237)	1,333	(1,808)	(3,862)
12/31/68	339	(2517)	(3484)	782	(3,424)	(8,304)
12/31/69	(5036)	(3053)	(5719)	(6,274)	(2,836)	(22,918)
12/31/70	(6595)	(3828)	(7747)	(99,812)	(1,680)	(39,662)
12/31/71	(7723)	(5014)	(6295)	(11,248)	(1.107)	(31,387)
12/31/72	(7185)	(5123)	(473)	(6,267)	2,569	(16,479)
12/31/73	(163)	(6545)	1148	(2,799)	8,113	(246)
12/31/74	(2293)	(3648)	423	(11,714)	(12,376)	(29,608)
12/31/75	(5446)	(3318)	(7759)	(11,599)	(14,070)	(42,193)

*Systemwide results including international and nonscheduled operations, freight operations only.

Source: Reproduced from D. Daryl Wyckoff and David H. Maister, The Domestic Airline Industry (Lexington, Mass.: D.C.Heath and Company, 1977), p.xiv.

major freight carriers over the years 1967-1975. Total freighter operations for these carriers showed negative income every year. Revenue generated from passenger traffic and other business ventures such as hotel owned by these carriers help out much of the losses these carriers suffered in freighter operations.

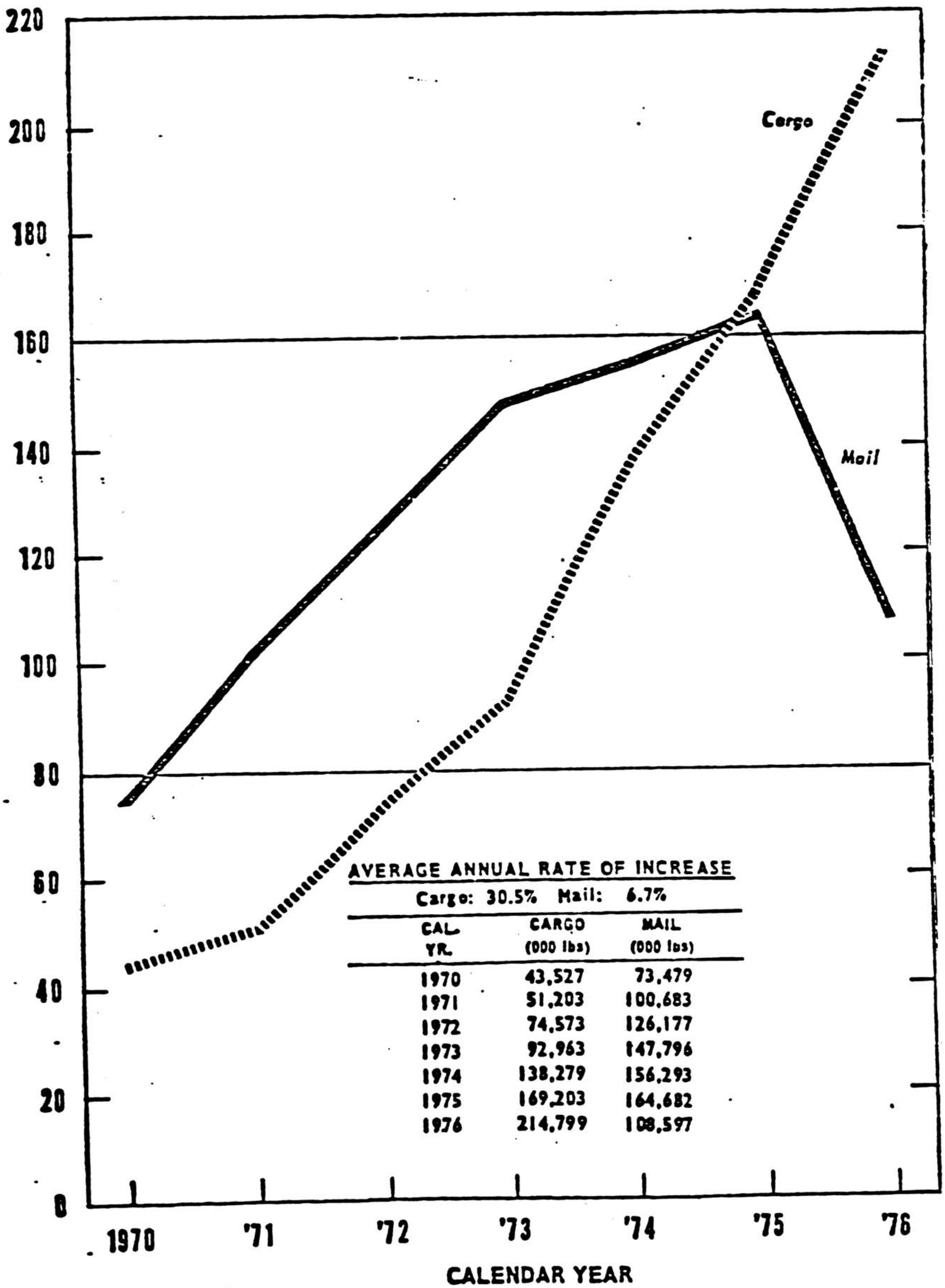
If the potential entrants looked solely at the recent record of the financial health of the industry, the possibility of large losses in the future would greatly diminish their interest in joining the market. While many barriers to entry have been analyzed, it is appropriate to say that once the initial effects of deregulation are carried out, the rationalization of rates, schedules, routes, equipment, and promising income may increase the firms' chances of entry, either those firms totally new to the air freight industry or those emerging from the related firms such as forwarders, or land-or-sea side transport corporations.

3.3.2 DEREGULATION AND ITS EFFECT ON COMMUTER SERVICE

The discussion of commuter freight at Logan may be focused on two major issues. In 1972, the commuter air freight weight restriction of 12,500 lbs. per aircraft was lifted in the CAB's commuter legislation. Since 1970, the average annual tonnage increase of the industry has been 30 percent (see Figure 3.3.2).

Figure 3.3.2:

NATIONAL STATISTICS FOR COMMUTER AIR CARGO AND MAIL



AVERAGE ANNUAL RATE OF INCREASE

Cargo: 30.5% Mail: 6.7%

CAL. YR.	CARGO (000 lbs)	MAIL (000 lbs)
1970	43,527	73,479
1971	51,203	100,683
1972	74,573	126,177
1973	92,963	147,796
1974	138,279	156,293
1975	169,203	164,682
1976	214,799	108,597

Source: 1976 CAB Commuter Airline Statistics

The commuter air freight business is relatively more specialized than other freighters because of the limited average capacity payload of 1,500 lb. Even in the deregulation era, typical aircraft capacity is about 1,000 lb. because the bulk of the commuter air freight fleet operating at Logan was made before the weight restriction was lifted. The commuter air freighters still need time to overcome financial and political barriers before they can utilize larger aircraft. The overhead capital and operational costs of these freighters are relatively the same in proportion to their financial statement for the small and the larger commuter aircraft. However, for greater fuel and cargo capacity, it is expected that these freighters may try to acquire more large aircraft. By 2000, the average payload capacity may reach 8,000 lb.

The noticeable growth rate increase has been in the area of priority package service with Federal Express Corporation leading the way. Commuter air freight service from cities to hub is sometimes three days faster than scheduled surface transportation. With the assistance of air freight forwarders, this service often proves to be very efficient. Shippers are willing to pay a premium for it.

The priority package service, offered uniquely by Federal Express among the Logan freight commuters, is a successful operation. It also involves pickup and delivery service in the origin and destination cities with the arrangements of freight forwarders, trucking firms, taxi, or other ground transportation firms. Because of the expense and coordination effort involved, it seems unlikely that there will be a great proliferation of these operations. The prognosis is clouded even further since deregulation came into effect.

Another successful type of operation is the specialized service to a single customer. For instance, both Summit and Pinehurst Airlines have contracts exclusively with one freight forwarder— Emery Air Freight. A low overhead and high yield cargo collected by the freight forwarder makes profits possible. Because a specialized forwarder acts as the single customer, these freighters can carry a wide variety of cargo, such as medical items, commercial needs, industrial supplies, and communication materials. With the expected revenue, these freighters need to care only about operation expenses such as salary, fuel, and aircraft maintenance. This type of operation has proved the most successful for the most commuter operators at Logan.

Presently, besides the previous three freight commuters mentioned earlier, Georgia Air Freight, Midwest, and Precision make up the rest of the freight commuter team at Logan. Table 3.3.2 summarizes the team, its composition, equipment, and national ranking by tonnage.

As a result of airline deregulation and the CAB rulings, many carriers have begun to change their fleet composition. Federal Express will be using 727s and 737s jet aircraft, replacing their Falcon 20 Jets. Summit Airlines has purchased two Convair 580 aircrafts and petitioned for permission to begin service with this equipment at Logan. Since their operations are acheduled for late night hours, it is necessary to insure a permit for late night flying. Also, Pinehurst has tried to secure larger aircraft; it has been permitted to supplement its DC-3 operations within Boston since 1979.

Table 3.3.2 summarizes the Logan freight commuter with its equipment and national ranking by each airlines. Essentially, deregulation and the CAB's recent rulings have restructured the whole commuter air freight activity pattern and behavior. Increase in aircraft size and late night traffic have taken place. The impact of deregulation upon the political, financial, and legal issues is not so obvious. As time passes, these issues will become more significant and further work needs to be done on the impact of deregulation.

Table 3.3.2 FREIGHT COMMUTER BY AIRLINE AT LOGAN

Commuter Carrier	Equipment (payload in lb.)	National Ranking
Federal Express	Falcon (2,200) B-727 (44,000) DC10 (168,000)	1
Summit	DC3 (3,400) Skyvan (1,400)	2
Pinehurst	DC3 (3,400)	4
Precision	Beech-18(2,250) Piper ChewKeel (1,100)	13
Georgia Air Freight	Beech-Volper(2,250)	21
Midwest	Cessna-Citation (1.400)	NA

Source: Official Airline Guide, 1979.

3.4 FLEET FORECAST METHOD

A fleet mix-based forecast, a projection of the peak hour to average day-peak month (ADPM), peak month, and annual total freight and express tonnage movement, using factors gained from past experience at Logan and other judgmental factors from the industry analysts, is considered to be a common approach to preparing forecasts for freight and express forecasts at Logan. The air cargo fleet movements may be affected by factors such as availability and competition of other transport modes, rate structure, and fuel costs, as well as economic growth in the region. An estimate of air cargo fleet mix, using historical data and trend analysis of fleet replacement, is necessary for freight and express forecasts at Logan.

Since the fleet mix-based forecast also considers the effect of supply-side constraints, in intermediate to long-term applications, this method has the potential of showing less uncertainty than the demand forecast approach. The computation process, based upon the fleet-mix approach, resulting in the annual year 2000 total freight and express tonnage, consisted of the following general steps:

1) Based upon a memo of "Year 2000 Logan Traffic

Table 3.4.1 TOTAL PEAK MONTH OPERATION FORECASTS OF ALL AIRCRAFT TYPES AT LOGAN

Fleet mix	1980	1985	Peak Month 1990	1995	2000
Certificated					
Standard-body					
2-engine	4,590	5,460	6,810	6,660	7,830
3-engine	10,680	8,940	6,030	2,700	1,020
4-engine	2,010	750	270	90	90
Sub-total	17,280	15,150	13,110	9,450	8,940
Wide-body					
2-engine	NA	1,830	4,350	7,200	10,050
3-engine	1,890	2,010	2,700	3,300	3,630
4-engine	300	600	1,080	1,650	2,130
Sub-total	2,190	4,440	8,130	12,150	15,810
Commuter type	13,590	11,040	9,660	8,790	9,180

Source: Memo prepared for Massport Planning Department by the writer, dated 4/1/80.

Forecasts" prepared by the writer for Massport (see Appendix C). Table 3.4.1 shows peak month traffic for all service and aircraft types for five year increments between 1980 and 2000.

2) Table 3.4.2 illustrates the annual percentage growth rates of combi and all-cargo operations form the peak month traffic of Table 3.4.1.

3) Peak month traffic of Table 3.4.1 is divided by 30 days to yield average day-peak month traffic (ADPM) by service type and by aircraft type (see Table 3.4.3).

4) Payload capacity of each aircraft type (as shown in Table 3.1.2) was applied to the respective ADPM operations forecast to get total tonnage volume in freight and express service. Specific load factors were assigned to the different service types to five total ADPM freight and express tonnage volume between the years 1980 and 2000 (Table 3.4.4).

5) Table 3.4.5 summarized the projected ADPM freight and express tonnage of all-cargo and combi service separately.

6) Peak month tonnage volume was estimated by expanding ADPM to peak month with a factor of 30.

7) Annual totals were obtained by expanding peak month with a seasonality factor. A seasonality factor of 0.104 was estimated from the past two years' (1978-79) data. Since about one-fifth of the combi scheduled service consisted of short-haul hub-and-spoke flights with no freight except passenger baggage, only 80 percent was accounted for as annual combi tonnage. A 144 percent increase of freight and express tonnage for the design year (243,600 tons in 1980 to 595,500 tons in 2000) was recorded with mail tonnage (regression approach for mail forecast was done in the following section) of 62,900 tons to give 667,400 tons in the year 2000 (see Table 3.4.6).

Table 3.4.2 PERCENTAGE OF ANNUAL OPERATION GROWTH RATE AT LOGAN: 1980-2000

Domestic	1980-85	1985-90	1990-95	1995-2000
Combi				
Standard-body				
2-engine	3.8	4.9	-0.4	3.5
3-engine	-3.9	-6.5	-11.0	-12.2
4-engine	-13.0	-8.3	-5.7	0.0
Wide-body				
2-engine	120.0	27.5	13.1	7.9
3-engine	2.7	6.2	1.0	-1.4
All-cargo				
Standard-body				
4-engine	-8.0	-6.7	-10.0	NA
Wide-body				
4-engine	NA	20.0	15.0	7.3
International				
Combi				
Standard-body				
4-engine	-12.6	-20.0	NA	NA
Wide-body				
3-engine	5.7	3.6	18.8	2.0
4-engine	22.0	15.8	10.0	5.0
All-cargo				
Standard-body				
4-engine	-10.0	-20.0	NA	NA
Wide-body				
4-engine	NA	20.0	20.0	15.0
Commuter				
Combi	17.2	10.4	13.0	2.5
All-cargo	3.5	0.0	-1.5	-3.3

Source: Table 3.4.1

Table 3.4.3 ADPM OPERATION BREAKDOWN AT LOGAN: 1980-2000

	1980	1985	1990	1995	2000
Domestic					
Combi					
Standard-body					
2-engine	153	182	227	222	261
3-engine	356	298	201	90	35
4-engine	40	12	7	5	5
Wide-body					
2-engine	NA	61	145	240	335
3-engine	50	58	76	82	88
All-cargo					
Standard-body					
4-engine	5	3	2	1	1
Wide-body	NA	NA	4	7	11
International					
Combi					
Standard-body					
4-engine	27	10	0	0	0
Wide-body					
3-engine	7	9	11	21	23
4-engine	9	19	34	51	64
All-cargo					
Standard-body					
4-engine	2	1	0	0	0
Wide-body					
4-engine	1	1	2	4	7
Commuter					
Combi	57	67	74	84	86
All-cargo	11	13	13	12	10

Source: Table 3.4.2 and Table 3.4.1

Table 3.4.4 TOTAL ADPM COMBI AND ALL-CARGO PAYLOAD CAPACITY AND TONNAGE OF EACH AIRCRAFT AND SERVICE TYPES AT LOGAN : 1980-2000 (tons)(load factor holds constant)

	Payload Capacity					Tonnage Projected				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Domestic										
Combi (L.F..10)										
Standard-body										
2-engine	612	728	908	888	1044	61	73	91	89	104
3-engine	3204	2682	1809	810	315	320	278	181	81	31
4-engine	360	108	63	45	45	36	11	6	5	4
Wide-body										
2-engine	-	610	1450	2400	3350	-	61	145	240	335
3-engine	510	580	700	820	880	51	58	76	82	88
All-cargo (L.F..40)										
Standard-body 4-engine	250	150	100	50	50	100	60	40	20	20
Wide-body 4-engine	-	-	516	930	1420	-	-	206	360	560
International										
Combi (L.F..30)										
Standard-body 4-engine	243	90	-	-	-	24	9	-	-	-
Wide-body										
3-engine	140	180	220	420	460	14	18	22	42	46
4-engine	345	735	1310	1950	2470	34	74	131	195	247
All-cargo (L.F..50)										
Standard-body 4-engine	90	45	-	-	-	45	22	-	-	-
Wide-body 4-engine	130	130	260	520	910	65	65	130	260	455
Commuter										
Combi (L.F..10)	114	203	322	530	582	12	20	32	53	58
All-cargo (L.F..50)	110	130	130	120	100	55	65	65	60	50

Source: Tables 3.4.1, 3.4.2 & 3.4.3.

Table 3.4.5 PROJECTED ADPM TONNAGE OF ALL-CARGO (FREIGHT AND EXPRESS) AND COMBI SERVICES AT LOGAN: 1980-2000 (tons)

	Freight and Express-All-cargo					Combi				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Domestic	100	60	246	380	580	468	471	499	497	562
International	110	87	130	260	455	72	101	153	237	293
Commuter	55	65	65	60	50	12	20	32	53	58
TOTAL	265	212	441	700	1085	552	592	684	787	913

Source: Constructed from the data of Table 3.4.4

Table 3.4.6: Projected Annual Tonnage at Logan: 1980-2000

(Tons)

	1980	1985	1990	1995	2000
All-cargo	78,990	63,200	131,500	208,600	323,400
Combi	164,600	176,500	203,900	234,600	272,100
Sub-total	243,600	239,700	335,400	443,200	595,500
Mail*	45,000	47,650	51,900	55,200	62,900
Total	288,600	287,350	387,300	498,400	667,400

(* see Table 3.5.4 for total tonnage of mail)

Source: constructed from Table 3.4.5.

3.5 AIR MAIL FORECAST

3.5.1 BACKGROUND

The United States has about six percent of the world's population and occupies about seven percent of the world's land mass, but its scheduled airlines provide the U.S. Postal Service with more than 60 percent of the world— by all of the world's airlines, for all of the world's postal systems.

In fact, a decision by Congress 50 years ago that air mail be carried by commercial air carriers helped many of today's airlines get their start. Now the nation's airlines move eight out of every 10 intercity first class letters. Airlines provide mail transportation to the U.S. Postal Service at one of the best bargain rates in transportation history, receiving less of a share of the price of a stamp than they did nearly two decades ago. Out of the current 15-cent first class postage stamp, the airlines receive one-half of a cent each time a letter goes by air. Back in 1958, the airlines received seven-tenths of a cent out of each six-cent air mail stamp of that day.

Largely because of the scope and reliability of the scheduled air system, the Postal Service, in October, 1975, was able to put into effect a significant advance in first class mail service. The Postal Service consolidated the processing of air mail and first class mail to give first class letters a level of service equal to or exceeding that formerly given air mail.

The U.S. Postal Service has started using air transportation for the movement of parcel post packages which had previously been moved mainly in surface parcel post. Further development of air parcel post packages over long distances, such as using trucks in the destination city for final delivery, means more air mail tonnage in the future.

3.5.2 AIR MAIL FORECAST METHOD

Since mail tonnage grew steadily at a 2 per cent rate in the last decade at Logan, and constituted 15 percent of the total tonnage, it is considered as having less impact in the tonnage projection exercise. Also, because of the special nature of this industry, future air mail demand at Logan is projected by using a demand function of regression approach with estimated elasticities of income earned by New England residents as an independent variable and the domestic and international mail as dependent variables in each estimated equation. Commuter mail volume should not be projected because this service is assigned by the U.S. Post Office to the small commuter carriers mainly on a short-term basis.

Table 3.5.1 shows the historic trends of domestic, international, and commuter mail tonnage. There was no enplaned mail tonnage in commuter service recorded for the years between 1976 and 1979. Table 3.5.2 summarizes the total earnings of New England residents from the year 1960 to 1978.

Table 3.5.3 shows the air mail demand forecasting equations using a generalized least square algorithm based upon data base in Table 3.5.1 and Table 3.5.2. The figures in the parenthesis under the coefficients are t-statistics. New England income, an economic activity measure, is used as an explanatory variable as is domestic mail lagged one year. The first domestic mail equation is primarily a simple time trend extrapolation. The income elasticity is small and not statistically significant, only 0.005. Since the mail tonnages are affected by discrete policy decisions of the U.S. Post Office, these mail forecasts may be only marginally useful. International mail was projected as a function of income and of international mail lagged one year. The income elasticity of 1.681 is statistically significant. Since international mail is strongly related

Table 3.5.1 TOTAL MAIL TONNAGE BY MARKET TYPES AT LOGAN: 1961-1978 (tons)

Year	Domestic	International	Commuter	Total (000)
1961	6200	104	0.2	6.304
1962	6500	149	0.4	6.649
1963	7200	162	0.3	7.362
1964	7900	193	0.3	8.093
1965	9800	192	1.1	9.993
1966	12000	266	0.1	12.266
1967	18100	257	0.3	18.357
1968	25400	368	0.4	25.768
1969	27300	613	7.4	27.913
1970	28100	857	126.0	28.957
1971	33500	1286	189.4	34.975
1972	36100	1491	172.3	37.763
1973	34100	1911	130.9	36.232
1974	36100	1967	109.8	38.176
1975	37900	2012	22.0	39.934
1976	41000	2948	0.0	43.948
1977	41110	3157	0.0	44.267
1978	41200	3780	0.0	44.980

Source: Massport "Green Sheet" Aviation Department

Table 3.5.2 TOTAL NEW ENGLAND EARNINGS: 1960-1978

($ million)

Year	Total earnings
1960	22.7
1961	23.4
1962	24.4
1963	25.0
1964	26.3
1965	27.8
1966	28.7
1967	31.1
1968	32.5
1969	33.9
1970	34.4
1971	34.4
1972	36.0
1973	37.5
1974	36.0
1975	34.8
1976	41.1
1977	42.6
1978	44.1

Source: US Department of Commerce, Bureau of Economic Analysis, Regional Economic Analysis Division, "Earnings by Industry" Table 1, 1978

Table 3.5.3: Mail Demand Equations

1) Domestic:

$$\mathrm{LOG(DMAIL)}t = \underset{(2.60)}{2.026} + \underset{(0.1)}{0.005}\,\mathrm{LOG(YNE)}t + \underset{(7.46)}{0.821}\,\mathrm{LOG(DMAIL)}t\text{-}1$$

R2 = 0.95
DW = 1.6

2) International:

$$\mathrm{LOG(IMAIL)}t = \underset{(0.38)}{1.45} + \underset{(2.04)}{1.681}\,\mathrm{LOG(YNE)}t + \underset{(0.78)}{0.152}\,\mathrm{LOG(IMAIL)}t\text{-}1$$

R2 = 0.98
DW = 1.9

where: YNE = total earnings in New England (millions of 1967 dollars) (see Table 3.5.2)

DMAIL = domestic mail total (see Table 3.5.1)

IMAIL = international mail total (see Table 3.5.1)
TMAIL = Total mail (see Table 3.5.1)(000 tons)

3) Total: (linear regression)*

TMAIL = -48.45 + 2.263 YNE R^2 = 0.96

standard deviation TMAIL=6.02
standard deviation YNE = 14.2

variance TMAIL = 36.2
variance YNE = 2.01

*Equation 3 shows the effect of earnings without time lag in a linear relation for the total mail at Logan.

to the trends of international trade and the regional economy of both ends, the explosive business activities of the New England area in the last decade created an enormous increase of international mail, a three-fold increase of international mail for 1971-1978.

3.5.3 THE MAIL FORECASTS AND THE TOTAL SUPPLY-SIDE PROJECTION

Based upon equation 3 of Table 3.5.3, the total mail forecasts are linearly correlated with total New England industry earnings of 2.26 slope, with R^2 of 0.96 showing a high positive correlation. As the economy is expected to slowdown between the 80s and the early 90s, recovery of the economy may be in the late 90s. Therefore, the mail growth rates are held to be implicitly 1.51 percent in the 80s, 1.30 percent in the early 90s, and a 40 percent total increase of mail tonnage by the year 2000, from 45,000 tons in 1980 to 62,900 tons in the year 2000. This mail tonnage is added together with total freight and express forecasts in Table 3.4.6 to give the total annual supply-determined tonnage projections at Logan. Because of its regression approach, this mail forecast is also added to a demand-determined forecast of the later chapter for a total annual demand cargo projection for the year 2000.

Table 3.5.4 AIR MAIL PROJECTIONS AT LOGAN: 1980-2000 (tons)

Type of Service	1980	1985	1990	1995	2000
Domestic Mail	41200	43000	45400	46400	47400
International Mail	3800	4650	6500	8800	15500
TOTAL	45000	47650	51900	55200	62900

The calculation of total fleet forecast tonnage is intended to bring forth the effect of supply-side constraints into the forecasting process. Indeed, the estimations of total aircraft operations, combi and cargo split estimation, payload capacity estimation, and the load factor estimation are very critical to the projection total and need to be estimated by the best knowledge and information we have at present. After we examined many aspects of technology, route pattern, freight operation behavior and the region's economy, we could extrapolate the current operation level and obtain a reliable forecast of the next two decades' freight activities based on these supply-side factors.

However, for the forecasting period of twenty years or more, many determinant factors of supply-related fleet forecasts cannot be judgmentally applied at all times. Obviously, technology is expected to change. Load factors may shift accordingly, as well as route and rate structure. Therefore, in order to obtain another scenario for the long-term forecast at Logan, the demand-determined approach needs to be estimated in this study.

In the case of passenger forecasts, industry analysts consider the fleet mix-based forecasts as the current state-of-the-art; but since an airfreight forecast is less involved in human comfort in travel mode selection, and is dependent more on cost and rate structure of the industry, it may be more appropriate to use a demand forecast approach or a fleet forecast approach for airfreight forecasting.

3.6 THE PROPORTION OF TONNAGE IN ALL-CARGO FREIGHTER SERVICE

In actual operations, the shipments moved by all-cargo carriers require different service treatment, such as containerization, time schedules, rate structure, and labor service. Historical data of cargo splits for Logan (domestic and international) for the year 1975 were recorded with the projected annual tonnage in percentage terms. Table 3.6.1 shows the future trend of the proportion of tonnage in all-cargo, combi, and mail sectors. The FAA air cargo forecast with one chapter mentioned for the Boston-Hub area (a draft memorandum of March, 1980) is compared with the projected tonnage by the supply-determined forecast of Table 3.4.6. The rate of change in the proportion of air cargo tonnage projected by FAA from 1975 to 1990 is in concurrence with the projections in this study. A general decline of combi tonnage was projected over the years between 1990 and 2000 in this study, since the forecast here assumes more replacement of wide-body all-freighters for Logan than the FAA's assumption. Therefore, all-cargo tonnage would begin to increase proportionately after 1985.

Table 3.6.1 PERCENTAGE OF ANNUAL TONNAGE AT LOGAN: 1975-2000

	(1)		(2)	
	All-cargo	Combi	All-cargo	Combi
1975	41.9	58.1	40.8	59.2
1980	34.2	65.8	36.0	64.0
1985	30.3	69.7	28.9	71.1
1990	40.7	59.3	32.6	67.4
1995	47.4	52.6	NA	NA
2000	53.8	46.2	NA	NA

Source: (1) Constructed from Table 3.4.6

(2) "TSC Large Hub Forecasts," Tables 3 & 4, adjusted to reflect 1975-78 level, and reported by FAA Aviation Forecasts, draft memo, March, 1980, p.58.

The last thing we should mention in the supply constraints is the seasonality factor. There are domestic freight peaks in May-June and August-November. International freight peaks in March-June and again from October-December. For the all-cargo freighter, its peaking pattern is in June and August-November. Table 3.6.2 shows the portion of annual tonnage handled in a given month. If each month had an equal share of the tonnage, its percentage would be 8.3. In peak month total cargo operations, however, the figure is 10.4 percent. The figures in the table represent averages from the years 1970, 1975, 1977 and 1978. In the fleet forecasts, the current cargo seasonality for all-freighter is assumed to be 10.4 percent.

Table 3.6.2 Average Monthly Tonnage as a Percent of Average Annual Tonnage-- by Types of Service a/

(percent)

	Domestic Freight & Express	Internat'l Freight & Express	Mail	Total Cargo
Jan.	7.0	7.3	8.1	7.5
Febr.	6.8	7.2	7.4	7.8
Mar.	8.4	8.8	8.8	8.1
Apr.	8.3	8.4	8.5	6.3
May	8.9	8.5	8.3	8.0
June	9.0	8.6	8.0	9.0
July	7.9	8.2	7.6	7.3
Aug.	8.9	7.8	7.8	9.3
Sept.	8.9	8.2	7.9	9.6
Oct.	9.2	9.5	8.2	10.4
Nov.	8.6	9.9	8.4	10.4
Dec.	8.3	8.5	11.2	6.3

a/ averages are for the years 1970, 1975, 1977 and 1978

Source: "Green Sheets", Massport Aviation Department.

4.0 A DEMAND-DETERMINED AIR CARGO FORECAST

The demand-determined air cargo forecast has been prepared on a different basis than the fleet forecast. This methodology was not designed to estimate payload capacity from assigned forecasts, but concerned trends involving the adoption of certain basic assumptions on factors influencing the air cargo demand. These factors included the rates of economic growth in the New England region; air freight costs, particularly fuel costs, and their implications for freight fares; and income and price elasticities of demand for air cargo.

In the supply-determined fleet forecast, all the assumptions adopted involved some degree of uncertainty. For instance, conversion of a monthly figure to an annual one depends on the current seasonality factor, future airlines' policy affecting the assumed load factors of the present, and so forth. As a consequence of the fleet forecast approach, a combination of assumptions incorporated.

In the case of air cargo demand forecast, a three-part model is applied as follows:

1) A set of single-equation air cargo demand functions with economic growth, freight rate, and fuel costs as explanatory variables, estimated respectively for several subcategories of cargo service;
2) a proportional projection of combi and all-cargo freighters demand, based on the fleet mix forecasts of passengers and cargo operations; and
3) a judgmental analysis of demand due to the other variables such as technology and facility improvement, which will be expected to have definite impacts on the projected demand of air cargo.

The first two parts are described in the following sections, while the third has been examined in the previous chapter of this study.

4.1 THE DEMAND FUNCTIONS

There are many more considerations for shippers using air cargo than for those using other transport modes, the major consideration being the quality of service. Factors influencing the quality of air cargo service may include the following: speed, scheduled frequency, safety, reliability, convenience of delivery, and capacity offered. In general, air freight rates, price and quality of service provided by competing modes, the level of economic activity, fuel costs, and regional specialization in activity conducive to air freight are the endogeneous variables of the demand for air freight movements.

Because air cargo forecasting is one of the most volatile sectors of commercial aviation, the problems in forecasting methodology have not been addressed by the industry analysts; that methodology, if followed, would be very sophisticated. Therefore, it is not a good strategy to acquire a fully specified "mode competition" model that would require a probably unavailable large data base for the New England region. Besides, no aviation analyst at this point can conclude that detailed and elegant models in air cargo forecasts actually perform better than simpler models. Also, due to the lack of a set of air cargo level-of-service variables for the Boston region, air cargo safety, speed, and convenience in delivery service are assumed to be constant in the forecasting period. Nevertheless, advanced technologies and route expansion are foreseeable to improve the quality and frequency of service. The fleet forecast results indeed show a 144 percent increase in the quantity of service between the years 1980 and 2000.

The following air cargo demand forecasting functions were developed to see the effects of price, regional income levels, and an additional variable-- fuel costs-- on the projection of air cargo activities. These functions were estimated on annual Logan available data over the last decade using the multiple sample regression with a double-log transformation. The sample partial regression coefficients is computed by applying the principle of least squares to the logarithmic values of variables. By this technique, assumptions of constant elasticity between the dependent and independent variables will be indicated. The figures in parenthesis under the coefficients are t-statistics.

The endogeneous variable is total freight per year in thousands of pounds. The exogeneous variables are total New England income, average national freight revenue per ton, and fuel costs all in real terms. Data sources and complete statistical outputs are listed in Appendix D.

Domestic Freight and Express

1) $$LOG(DFE) = \underset{}{2.447} + \underset{(4.72)}{1.267}\ LOG(YNE) - \underset{(-6.65)}{1.313}\ LOG(DFR) + \underset{(0.33)}{0.035}\ LOG(DFU) \qquad R^2 = 0.993$$

International Freight and Express

$$2)\ LOG(IFE) = -1.345 + 2.568\ LOG(YNE) - 2.661\ LOG(IFR) + 0.021\ LOG(IFU)$$

$$\qquad\qquad\qquad\qquad\quad (1.65) \qquad\qquad (-2.63) \qquad\qquad (0.04)$$

$R^2 = 0.979$

where:

DFE = domestic freight and express (000 lbs.);

YNE = total earnings in New England (millions of 1967 dollars);

DFR = domestic average real freight revenue per ton-mile (¢/ton-mile);

DFU = domestic average real fuel cost per ton-mile (¢/ton-mile);

IFE = international freight and express (000 lbs.);

IFR = international average real freight revenue per ton-mile (¢/ton-mile);

IFU = international average real fuel cost per ton-mile (¢/ton-mile).

The demand for domestic freight and express is very likely affected by New England regional income levels with an elasticity of +1.267 and by price with an elasticity of -1.313. Fuel price has an insignificant effect with an elasticity of 0.035 only because the increase in fuel price has been leveled off by increase in other commodities. Furthermore, speed, safety and reliability and convenience of service might be given more consideration by the shippers as compared to other ground and sea transport modes. Hence, we can see that fuel price is somewhat inelastic as to the total tonnage; this is even more so in the international sector. The equation for total domestic freight and express tends to explain close to 99 percent of the variability in domestic air cargo tonnages during the period 1965-78, and small autocorrelation can be found.

Equation 2 for the international freight and express tonnages is similar to Equation 1. Price elasticity of -2.661 and income elasticity of 2.568 are more significant than domestic ones, i.e. because speed may be affected by custom service, by frequency of service, by tariffs, air cargo facilities, and so forth. International shippers are more easily discouraged from sending their commodities by air than the domestic shippers.

However, the income elasticity of 2.568 shows a positive side of the business. Table 4.2 shows the income and price elasticities of the several cargo categories estimated, along with comparable elasticities from several other selected studies. These studies indicate that the international air freight and express business is volatile. With the promising effect of increase in large payload capacity per flight and in containerization peculiar to the international air traffic, it is the writer's opinion that the demand of international air freight and express will continuously exceed other market sectors in growth rate percentage.

Table 4.2 COMPARISON OF PRICE AND INCOME ELASTICITIES IN SELECTED STUDIES

	Elasticities	
	Price	Income
(From Equations 1 & 2)		
Domestic Freight & Express	-1.31	1.27
International Freight & Express	-2.66	2.57
Other Studies:		
Boeing[1]	-1.04	1.13
Boeing[2]	-2.05	2.73

Source: [1]Hong Kong-US air-tons. G. Sletmo, "Air Freight Forwarding and Pricing," Logistics and Transport-Review 2, 1974, p.9.

[2]West Bound (Europe-US), Sletmo, p.8.

4.2 DEMAND FORECAST METHOD

This section contains the demand forecast of air cargo at Logan through the year 2000. The forecast assumes that no drastic changes occur in the supply factors. Explanations of the three exogeneous variables are important and are given in the following two sections.

4.2.1 ECONOMIC GROWTH AND EARNINGS OF THE NEW ENGLAND REGION:

During the forecast time frame, the New England's income may continue to grow. There are two projections that describe the region's growth rate of real income. Table 4.2.1 shows the projections of the Bureau of Economic Analysis (BEA) (Department of Commerce) and of the National Planning Association (NPA). The BEA growth forecasts are higher than the NPA forecasts.

Inflation-adjusted total earnings in the region grew at an average annual rate of 4.2 percent during the 1960s. From 1970-1978 the growth rate slowed to an annual rate of 3.2 percent. As the region recovered from the 73-74 recession, real personal income in New England for 1975-1978 grew at an annual rate of 4.36 percent (based upon BEA's analysis). The reason for acceptance of the higher BEA forecasts is that the costs of over-

Table 4.2.1 Average Annual Growth Rates of Real Income in New England (percent)

Periods	Bureau of Economic Analysis[1]	National Planning Association[2]
1975-1978	4.36	NA
1978-1980	3.95	3.83
1980-1985	3.44	2.78
1985-1990	3.02	2.70
1990-1995	3.11	NA
1995-2000	2.70	NA

[1]Department of Commerce, Bureau of Economic Analysis prepared for OPE in 1977

[2]National Planning Association-Regional Economic Projection Series 1977, p.77.

estimating required capacity are lower than the costs of underestimating future required capacity.

4.2.2 REAL RATES OF THE AIR CARGO TONNAGE AT NEW ENGLAND

Since the BEA projection was made before the fuel price increase of 1979, its projected real rates change would not be used. During the forecasting period, we assume that real rates will decline by an annual average of 1.6 percent from 1980 to 1990, and thereafter will decline at 0.7 percent per annum. This equals an average annual decline of 0.85 percent from 1980 to 2000. This is consistent with the Department of Transportation's (DOT) projection of an annual decrease of 0.9 percent in the average revenue per ton-mile (ref. 15).

Another study showed that the combined effects of projected increased load factors, increased containerization improved terminal technology, economies of scale, and the introduction of new specialized systems would lower the total operating costs of air cargo carriers by about 35 percent from 1980 to 2000 (ref. 16).

The assumed 0.85 percent in average real rate annual decline from 1978 to 2000 is based on the following considerations:

1) From 1960 to 1978, real rates for domestic and international traffic at Logan have declined 2,8 percent and 4.4 percent respectively.

2) Given an annual average inflation rate of about 10 percent, a decline in real rates of 0.85 percent translates to an annual nominal increase of 9.15 percent from 1980 to 2000.

3) As the fuel crisis continues, the economic outlook of the region tends to be pessimistic. The reduction of total operating costs will be less than the proposed 35 percent. Thus, we use 25 percent instead. This figure is reasonable and consistent with historical experience.

4.3 THE CARGO PROJECTIONS

The cargo projections presented in Table 4.3.1 forecast a 115 percent increase (cargo and mail) by the year 2000, from 260 thousand tons in 1980 to 558 thousand tons in the year 2000. Table 4.3.2 presents the average annual growth rates by types of service implicit in Table 4.3.1.

The projection shows a gradual reduction in air cargo tonnage growth rates toward the end of this century. It also indicates that international cargo activity will grow more rapidly than the domestic sector.

Table 4.3.1 Air Cargo Projections at Logan: 1980-2000 (tons)

Type of Service	1978	1985	1990	1995	2000
Domestic (Freight and Express)	153,100	185,200	224,000	273,280	333,400
Commuter	6,800	9,180	12,300	16,240	21,930
International	55,200	68,450	86,950	110,400	140,210
Sub-total	214,900	262,830	323,250	399,920	495,540
Mail*	45,000	47,650	51,900	55,200	62,900
Total	260,100	310,480	375,150	455,120	558,440

(*see Table 3.5.4. for total tonnage of mail)

Table 4.3.2 PROJECTED AVERAGE GROWTH RATES OF AIR CARGO BY SERVICE TYPE AT LOGAN (percent)

Type of Service	Actual 1975-78	1980-85	1985-90	1990-95	1995-2000
			Years		
Freight and Express					
Commuter	6.9	7.0	6.8	6.4	6.1
International	6.3	4.8	5.2	5.5	6.0
Domestic	5.0	4.2	4.3	4.4	4.6
TOTAL	6.5	6.0	5.8	5.7	5.3

Since the Logan market is already relatively mature due to extremely rapid growth in the 1960s, the figures in the above table suggest that the explosive growth rates of the 1960s are not likely to be seen at Logan over the next two decades, though tonnages will not stagnate, as was the case in the recession of the mid-1970s

Also, ATA forecasts European traffic to grow more slowly than other international traffic segments; a slowdown in international air cargo growth rates at Logan reflects Logan's international traffic is primarily with Europe (ref. 17).

Because domestic freight and express constitute 75 percent of all freight and express at Logan airport, the forecast implies that Logan's share in the national air cargo market should remain roughly constant over the forecast period. However, individual segments, by service types, are projected to grow at different rates; the composition of air cargo will change over the period. Table 4.3.3 illustrates this change.

Applying these seasonality factors (Table 3.6.2) to the projected tonnage from Table 4.3.1, we obtain the forecasts of Table 4.3.4, expressed in monthly figures.

Table 4.3.3: Distribution of Air Cargo Tonnages by Service Type, 1978 and 2000 (percent)

Type of Service	Years 1978 (actual)	2000
Freight and Express		
Domestic		
Certificated	58.3	59.7
Commuters	2.2	3.9
Total	60.4	63.6
International		
Total	20,4	25.1
Total	80.8	88.7
Mail	19.2	11.3
Grand Total	100.0	100.0

Table 4.3.4: Forecast of Total Cargo Tonnage by Month. 1978,1990 and 2000 (tons)

	1978	1990	2000
January	12,877	28,136	41,883
February	10,415	29,262	43,558
March	17,233	30,387	45,234
April	14,392	23,634	35,182
May	15,150	30,012	44,675
June	15,339	33,764	50,260
July	14,518	27,386	40,766
August	18,937	34,889	51,935
September	17,990	36,014	53,610
October	17,611	39,016	58,078
November	17,043	39,016	58,078
December	17,611	23,259	34,623
Actual Total	189,369	375,150	558,440

Source: Constructed from Tables 3.6.2 and 4.3.1

5.0 BIF LAND USE PLANNING

The BIF Land Use Master Plan Study was prepared by Wallace, Floyd, Ellenzweign, Moore, Inc./Griffith Associate (WFEM/GA), a Massport consultant firm. Three land use concept plans were produced, which allocated land uses based on the anticipated growth at Logan up to the year 2000. A final concept plan was decided by Massport in the summer of 1979. In this final concept plan, the passenger and cargo volumes generated by the traffic forecast in Appendix C will be the most important determinant of the land requirements for the facilities needed to service such volumes. Despite the passenger forecast as shown in the Appendix C, the cargo forecast study here implicitly provides an understanding of both air cargo demand and supply at Logan through the year 2000. Since this study forecast makes explicit assumptions about the regional economy, fuel prices, and deregulation, it is important to note that the BIF Land Use Master Plan Study of WFEM/GA does not examine whether the projected air cargo growth illustrated here can be accommodated.

It should be noted that this cargo forecast has not been evaluated or interpreted by Massport or its consultants, and projections based on the study should be considered as an alternative scenario of air cargo activities to the BIF land use planning.

5.1 BIF LAND USE PLAN REVIEW: CARGO SECTOR

In general, non-airfield airport land uses are of several types:passenger terminal and cargo terminal, plus a variety of other land uses that support these primary functions. Cargo terminals also include landside and airside loading areas and often aircraft parking aprons. The BIF land uses are defined in several categories: cargo, airline support, passenger, airport maintenance, or parking.

Cargo terminals at Logan are supplemented by facilities for air freight forwarders, and a contract trucker (Dave's Motor Transportation) which reduces truck movements on the airport by receiving most incoming freight from the cargo terminals and disbursing it to a large number of outlying truck routes. The U.S. Post Office at the airport acts very much like a freight forwarder.

5.1.1 USES CONSIDERED FOR BIF

Air cargo, maintenance hangars, food preparation facilities, and airport maintenance buildings are all suitable uses for BIF if environmental impacts are found to be acceptably low. The priority lists of potential land uses can be ranked in the following order: passenger terminal, air freighter terminal, air cargo with airside access, general aviation, maintenance hangar, food preparation, airport maintenance, car rental, and freight forwarder.

BIF is created by landfill at a cost of $12.24 million. A roughly rectangular piece of land located at the south-western corner of the airport is bounded by the shoreline on the west and south, by the taxiway on the north, and by the overruns of runways 4L/22R and 9/27 on the east. The area totals about 4,000 thousand square feet. It is distant from terminals, but adjacent to the terminal apron. Regional truck access is fair, but auto access is poor. There are still some negative environmental impact such as air quality, noise, and visual impacts. Figure 5.1.1 shows the existing facilities of the Logan Airport and BIF location.

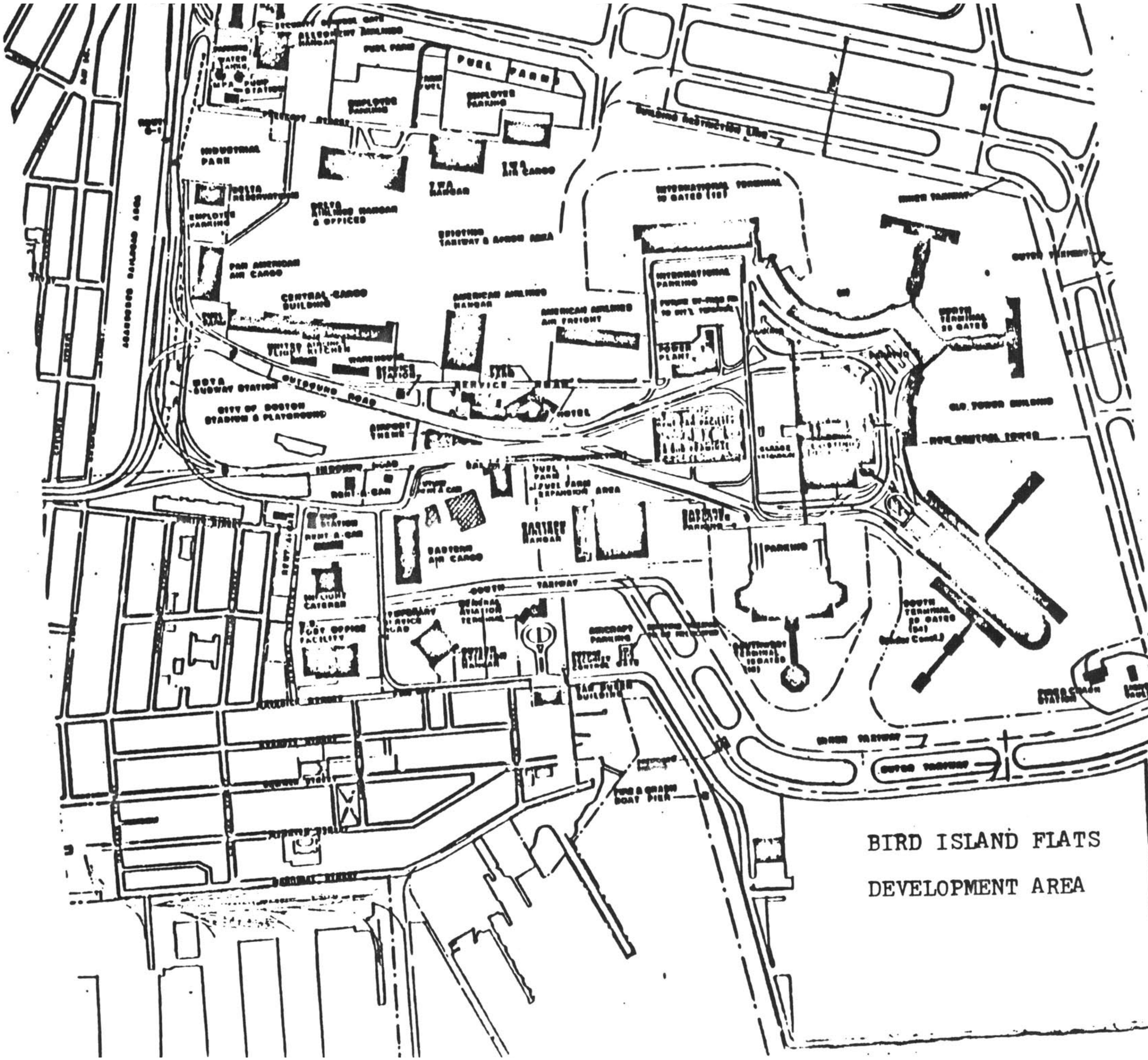


Fig.5.1.1

Logan Airport Facilities 1979

Table 5.1.1 indicates the building area of the airport at present and the additional area of the adopted land use plan. From the Table, we can see the distribution of cargo area increases 83 percent in total: 114 percent without apron and 60 percent with apron. This cargo land increase is in fact the largest increase in percentage, as well as in total square footage, among all categories. This reflects the urgent need of cargo land area at the present Logan situation.

In the adopted plan the cargo facilities are split between each area with each airline's cargo and support facilities ideally located as close as possible to its passenger terminal gates; this reduces the vehicular traffic on the terminal apron, most of which originates at one of the support or cargo facilities. This saves both energy and time.

For the layout land area, Table 5.1.2 shows the utilization of about two-thirds (2,600,000 sq.ft.) of the total BIF area (4,000,000 sq.ft.). The cargo usage occupies about 30 percent of the total BIF area and is about 47 percent of the total leaseable BIF area, as suggested in the adopted master plan.

Table 5.1.1: Land Use Concept Plans: Building Area of the Logan Area (1000 sq.ft.)

	Present	Adopted Plan	Additional area under adopted Plan
Passenger Service			
Terminal	1,285	1,385	100
Parking	2,848	2,848	0
Hotel	390	900	510
Car rental	40	40	0
Cargo			
Total	528	958	438
with apron	317	506	189
w/o apron	211	451	240
Post Office	74	88	14
General Aviation	69	100	31
Airline Support			
Fuel farm	1,350	1,350	0
Hangar (maint.)	424	623	199
Food prep.	115	173	58
Reserv. center	104	139	35
Airport maint.	93	93	0
Total	7,774	9,414	1,640

Source: WFEM/GA Year One Study Report, Table 1, p.46, June,1979.

Table 5.1.2: Land Use Plan: BIF Layout (1000 sq.ft.)

Cargo Split N-S

Potential Land Uses (sq.ft. land area)

Airport maintenance	135
Cargo	1,223
Hangar	760
Food preparation	110
Ancillary uses	525
Total leaseable area	2,618
Freighter Positions	6
Roads (linear feet)	8
Common apron/taxiway	150
30' noise barrier (linear feet)	1.7
Non-potential land uses area	1,382

Source: WFEM/GA Year One Study Report, Table 5, p.62.

5.2 GROWTH REQUIREMENTS

5.2.1 SUPPLY AND DEMAND FORECASTS

Even the best forecasts can only minimize the limits of our uncertainty about the future; forecasts have been used to arrive at target levels of activity needing to be accommodated in the physical program. We may view the supply and demand forecasts as separate scenarios.

These scenarios were chosen for use with the planning studies, a supply forecast which results in an average annual growth of 7.4 percent in certificated freight and express, and a demand growth based on regional economic growth, fuel prices, and declining rates charged, resulted in an average annual certificated freight and express increase of 6.5 percent. For the mail cargo, an estimation of 2 percent average annual growth rate is used throughout the study. The effect of 20 years of average annual growth rates is substantial in each approach as Table 5.2.1 shows.

All of the forecasts assume that the increasing proportion of cargo carried by all-cargo carriers reflects an expected increase usage of all-cargo widebodies, which

Table 5.2.1 Effect of 20 years of Air Cargo increase at Logan
(,000 tons)

Freight and Express	1980[a/]	2000	Ave.annual % change	Total % change
Supply Forecast	233	571	7.2%	145%
Demand Forecast	215*	496	6.5%	130%
Mail	45	63	2.0%	40%
Total Air Cargo				
Supply Forecast	278	634	6.4%	128%
Demand Forecast	260	559	5.7%	115%

(* see 1978 data)

a/ base years are estimated differently with supply forecast using 1979 data, demand forecast using 1978 data.

shows the potential entry by new all-cargo carriers and the expanded operations of the existing all-cargo carriers, such as Flying Tigers.

5.2.2 STANDARDS FOR CARGO HANDLINGS

There is a statistical analysis performed by WFEM/GA on air cargo carriers presently operating at Logan. Figure 5.2.2 shows a linear regression analysis of the space occupied by each air cargo carrier as a function of total tonnage that it handled in 1978. For common practice, an air cargo carrier uses from one-half to one square foot of building space per annual ton of cargo handled. For mechanized cargo handling, such as computerized loading and unloading, containerization, etc., one-half square foot per ton per year is considered as the high utilization rate. In the figure, the space utilization rate ranges from 0.7 to 1.3 square foot per ton per year.

Small commuter carriers and most of the combi carriers shipping unconsolidated cargo would use more than one square foot per annual ton. For much international cargo, a three-day waiting period for customs clearance may lead to a slower turnover rate and a greater space utilization rate. Because of this reason, most airlines have attempted to acquire and lease more space than they actual need.

Legend:
FT=Flying Tiger
DL=Delta
AA=American
EA=Eastern
UA=United
LF=Lufthansa
AF=Air France
BA=Bri.Airways
NC=North Central
(all others
are local-
service or
commuter
airlines)

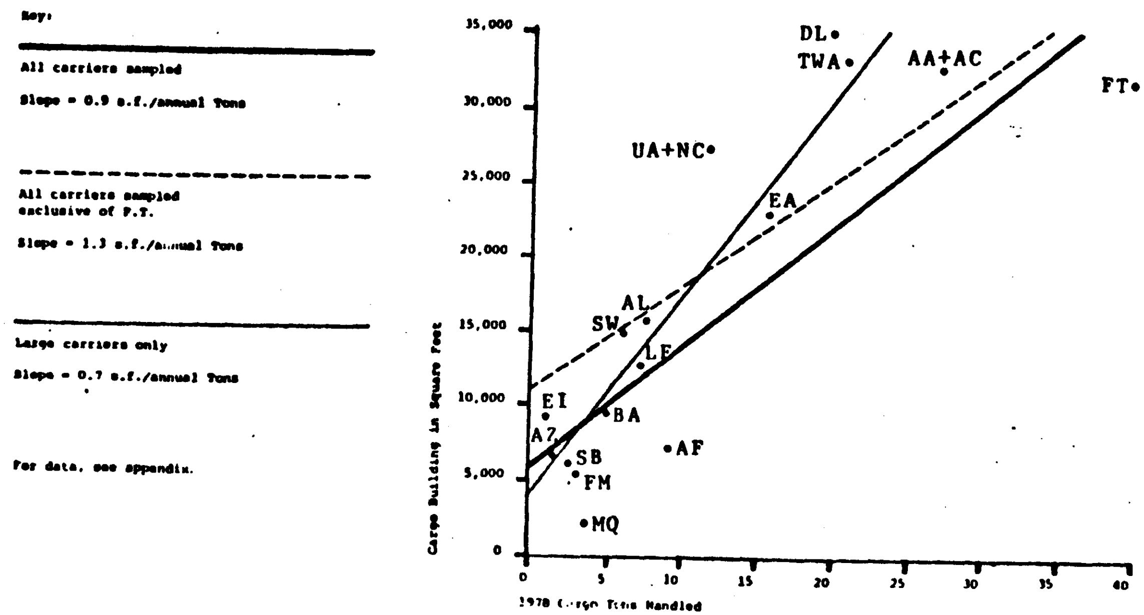


Figure 5.2.2: **Relationship of Cargo Handling Space to 1978 Cargo (Carriers at Logan International Airport)**

Source: WFEM/GA Year One Report to Massport, July, 1979, p.39

We can see also in the figure that those who fall below the line, such as Flying Tigers and the small all-freighter carriers, are relatively tight for space. Air France (AF), for example, needs to sub-lease terminal and gate facilities from Delta Air Lines. On the other hand, the large combi carriers appear to have adequate cargo handling space.

5.3 APRON CARGO HANDLING

As containers begin to be more commonly used than the palletized and igloo units, a mechanized nose dock system may be acquired in order to carry out the transfer of the freight from the terminal to the aircraft in a very short aircraft turnaround time. This apron cargo handling system must be capable of rapid loading and unloading times while achieving high payload densities.

The nose dock system is operated at many huge cargo terminals, such as Lufthansa Cargo at Kennedy Airport in New York. It consists of two rows of container stacks with a transfer vehicle running between them. Containers are moved on roller mats onto the transfer vehicle, which moves to the aircraft loading bridge. These are transferred across the powered roller floor loading bridge to the deck of the aircraft.

For smaller cargo handlings, loose cargo can be transferred across the apron by dollies and loaded either by cargo lift or by small cargo conveyor. Hence, out-of-gauge and non-palletized cargo can be handled in this way.

The choice of apron handling devices depends mainly on the air vehicle to be loaded. Combi and narrow-bodied all-cargo carriers can take igloos, pallets, and low containers. They must be loosely loaded in the belly holds because of low cargo capacity, and they are normally side loaded, using cargo lifts and transporters or dollies, while wide-bodied all-cargo carriers can be loaded by nose docks and can take 8 x 8 ft. containers in modular lengths up to 40 ft.

5.4 SPACE REQUIREMENT CALCULATION FOR BIF CARGO TERMINALS

For the BIF cargo terminals, the master planner must prepare estimates of cargo terminal size, using peak and annual flow rates for the design year, and the annual cargo throughput (ref. 18). The calculation shown here is sufficient for master planning and design under typical operating conditions at Logan.

It should be noted that the space requirement for BIF cargo handling is only considered for the handling of all-cargo operations. For combi operations, it is assumed that trailing dollies and containers to the aircraft at passenger terminals will be the handling system throughout the forecasting period. The following calculations stated an unique proposed situation, i.e. air cargo handled under one roof or a single system of handling air cargo by all airlines shared together.
In real life, different airlines with their own terminal and handling facilities may come into a situation where the relationship of cargo handling space to cargo is in the range of 0.9 to 1.3 square feet per annual tons (see Figure 5.2.2). Since the calculation below is just intended to show how the space is assumed by certain airlines, the square foot per annual tons relationship will not be reflected at all throughout the calculation process.

Step 1: Normal and deferred freight allowance plus circulation space for one handling system case:

From Table 3.4.6 (using a high tonnage scenario), annual tons of cargo at year 2000 by all freighters

= 667,400 tons

Daily tons

= 667,400/264 (working days)

= 2,528 tons

Space required for normal and deferred freight

= 2,528 * 85

= 214,880 sq.ft. (ref. 19)

: (Under one handling system situation, cargo area per tons handled annually):

= 214,880/667,400

= 0.322 sq.ft./ton/yr.

Step 2: Peak space allowance for one handling system case:

From Table 3.4.3, number of all-cargo aircraft movement at ADPM of year 2000

= 1 standard-body, 18 wide-bodies, 10 ten-ton commuter all-freighters

Historic trends indicate that 24 percent of the total ADPM aircraft movement occured at peak hours; therefore, peak hour all-cargo aircraft mix at year 2000

= 4 wide-bodies, 2 ten-ton commuters

Total cargo weight at ADPM

= 4* 129 tons + 2 * 10 tons

= 536 tons (21.2% of total daily tonnage capacity)

Allowing 80% load factor, average cargo load per aircraft cargo gate

= (536 * 0.80)/6

= 71.5 tons

(Since all-cargo gates peak hour in year 2000 is 6 gates, as proposed in the master plan (WFEM/GA))
cargo handling during peak hour

= 71.5 * 6

= 429 tons (17% of total daily tonnage capacity)

Space required for peak hour at 30 sq.ft. per ton

= 429 * 30

= 12,870 sq.ft.

Step 3: Processing space allowance for one handling system case:

= Total processing space is the sum of the two first steps

= 214,880 + 12,870

= 227,750 sq.ft.

Administrative space (7% of processing space)

= 15,950 sq.ft.

Total space

= 227,750 + 15,950

= 243,700 sq.ft.

Number of truck docks

= hourly tons/5 tons per hour per dock

= (4280/24)/5

= 30 truck docks

Summary of the BIF Cargo Land Use Development:

With the approved 1,223,000 square feet in the BIF layout plan (Table 5.1.2), the estimated terminal required area of 243,700 square feet occupies one-fifth of the total cargo area.* It is estimated that about 50,000 square feet are used for apron handling (Table 5.1.1), which leaves 929,300 square feet for other purposes of cargo-related activities.

The development potential of this 929,300 square feet have been analyzed in terms of the access requirements of the various cargo-related land use activities. For the purpose of this analysis, three broad cargo-related land use categories have been defined: Airside activities-- activities requiring direct apron access, e.g., general aviation; Activities with airside access-- activities requiring indirect airside access, e.g. catering; and Landside activities-- activities which do not require any form of airside access, e.g. cargo forwarders.

Table 5.4 shows the range of cargo-related activities that can be accommodated in this extra space.

The proposed land use plan alternatives for the non-utilized BIF cargo area can indeed accommodate a wide range

*In this case, 243,700 sq.ft. is the minimum required terminal area for one system handling situation. The development of the total cargo area, in fact, should be more than this amount of land.

Table 5.4 Proposed Cargo-related Uses for BIF total Cargo Area

Airside Activities	250,000 s.f.	-- Aircarft maintenance w/o Hangar
		-- General Aviation
		--Passenger Aircraft Parking Positions (w/o landside access)
		-- Public Use Apron
Activities with Airside Access	470,000 s.f.	--Catering
		--Crash/Fire Rescue Station
Activities	200,000 s.f.	-- Cargo Forwarding
		-- Car Parking
		-- Car Rental Storage
		-- Office Space
		-- Berm

of land use activities. But the land use mixes possible within a given BIF cargo area may vary more in the environmental impact they generate. For instance, the orientation of air freighter buildings can help to reduce ground noise impacts, but the use of all the available cargo area (929,300 sq.ft.) for freighters may differ less in total noise impact than the proposed cargo-related uses in the concept plan.

The proposed cargo-related land use mixes have been chosen to illustrate the functional requirements and their environmental impacts; uses not accommodated on cargo area must be accommodated on other BIF land. Furthermore, cargo facilities should not, without necessity, be too widely dispersed nor separate a single airline's combi from its all-cargo or its cargo from its maintenance facilities.

The BIF's use as a cargo area depends on the availability of physical facilities, the airlines' policy, and particularly Massport's decision. Whether Massport considers leasing the BIF cargo area in this low utilization terminal handling pattern will be a decision of the Board. The study here should make no further comment.

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Appendix A: US AND FOREIGN INTERNATIONAL, DOMESTIC AND COMMUTER ALL-CARGO CARRIERS SERVING LOGAN, 1979

<u>All-cargo carriers</u>:

International sector:

Air France
ownerhsip - state
network - worldwide except for routes awarded to UTA
fleet - 4 Concordes, 21 747s (3 more on order), 12 A300Bs (11 more on order, 22 on option), 17 707s, 20 727s, 2 737s, 23 Caravelles, 15 F 27s, 4 Transall
Air France onws Meriden hotels group and partial interest in Air Madagascar, Air Comores, Middle East Airlines, Tunis Air, Royal Air Maroc, Cameroon Airlines, Air Djibouti, Air Guadeloupe, Air Inter, Air Charter International, several other small carriers.

British Airways (formed 1974 from merger BEA/BOAC)
ownership - state (40-49% to be sold to private interests)
network - 28 domestic points including shuttles London-Edinburgh, L-Glasgow, L-Belfast; extensive European service; worldwide except those routes awarded to British Caledonian; helicopter service; inclusive tours
fleet - 5 Concordes (1 more on order), 26 747s,(3 more on order), 9 L-1011s (15 more on order), 20 707s, 15 VC-10s, 19 757s on order, 56 Tridents, 25 BAC-111s, 28 737s on order, 5 Merchantmen, 18 Viscounts, 2 HS 748s, 28 helicopters (4 more on order)
also operates hotels and other ventures, incl. British Airtours (Gatwick)
owns subsidiary airlines in British Isles and part interest in Air Mauritius, Air Pacific, Cathay Pacific, Cyprus Airways, Turkish Airways, Gibraltar Airways, New Hegrides Airways

Iberia
ownership - state
network - domestic; worldwide except the Far East
fleet - 3 747s (1 more on order, 5 on option), 6 DC-10s (3 more on order, 2 on option), 4 A300Bs on order, 6 DC-8s, 32 727s, 34 DC-9s, 9 F 27s.

Appendix A (cont'd)

Sabena
ownership - 65% state; remainder held by state trusts and state-influenced private sources
network - worldwide except Australia
fleet- 2 747s, 3 DC-10s (1 more on order), 5 707s, 14 737s
Sabena owns Sobelair

Domestic sector:

American Airlines
Headquarter - new York
network - transcontinental, Hawaii to east coast, Toronto, Montreal, Mexico City, Acapulco, Carribbean/
fleet - 10 747s, 30 767s on order , 27 DC-10s (7 more on order), 72 707s, 136 727s (19 more on order), 5 CV-440s.

Flying Tiger Line, Inc.
Headquarter - Los Angeles
Operations-schedules, charter, and military contract all-cargo domestic and worldwide service, international concentraction on transpacific routes; aircraft leasing
fleets - 6 747s, (4 more on order), 15 DC8-63F, 5 DC-8-61
Tigers holds 24.4% of Seaboard World stock and has agreed to merge that airline

Federal Express Corporation
Headquarter - Memphis, Tenn.
Operations are domestic cargo service
Fleet includes 15 727s (20 more on order from Eastern Airlines, 3 more to be leased from Eastern), 2 737s (3 more on order), 32 Falcon 20Fs

Summit Airlines
Headquarter - Philadelphia
network - scheduled domestic service delivers overnight on east coast and west to Cleveland, Dayton Detroit. Interline agreement with most foreign and US domestic trunkliners.

Precision Airlines
Information not available because of its new entry to Logan.

APPENDIX B -Container types

LD3 (IATA type 8)-- 141 cu.ft. internal volume-- 3125 lbs. maximum

LD7 (IATA type 5)--346 cu.ft. internal volume-- 9,808 lbs. maximum

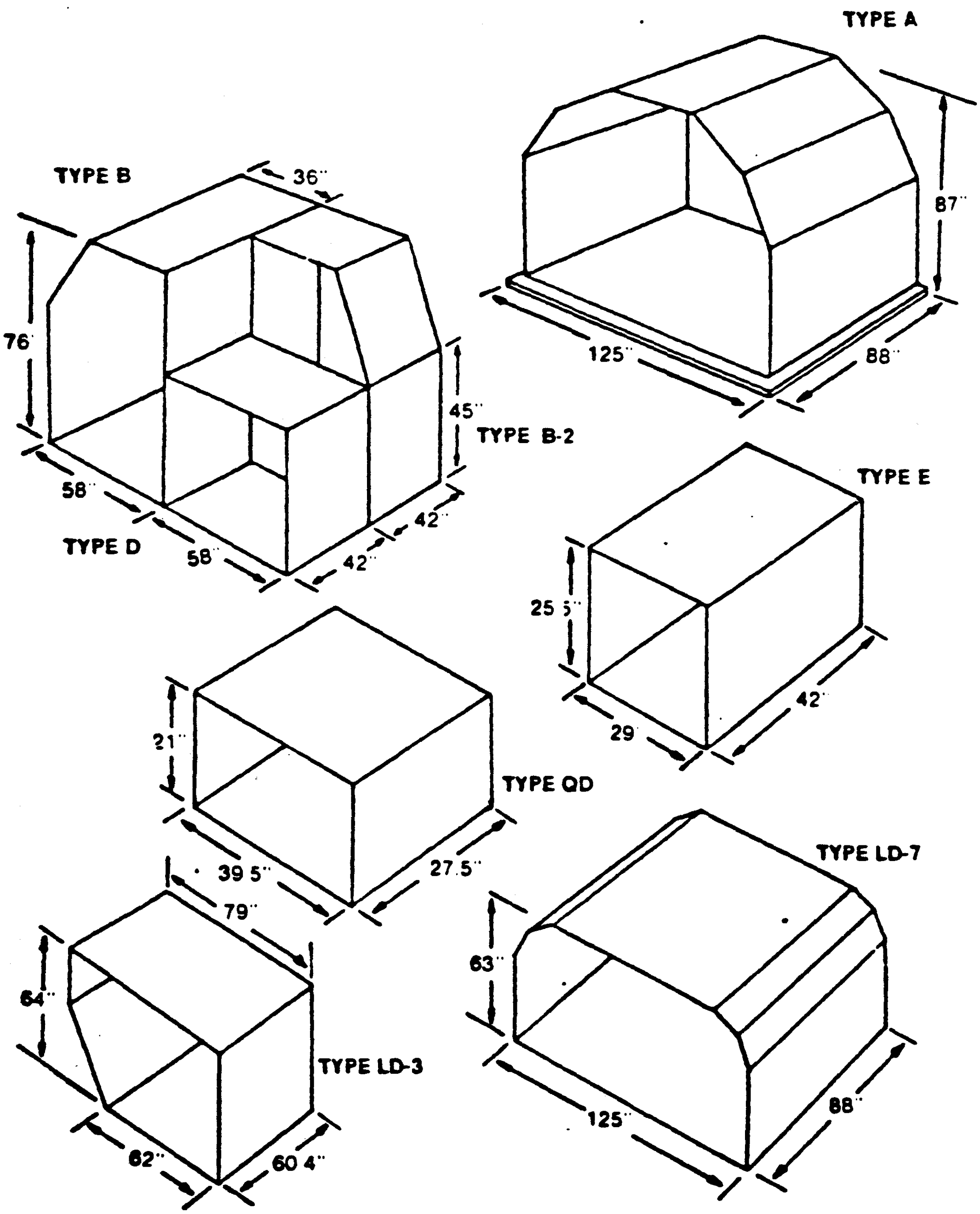
LD11 (IATA type 6)-- 275 cu.ft. internal volume-- 5,800 lbs. maximum

125-inch Igloo (IATA type 3)-- 420 cu.ft. internal volume-- 12,345 lbs. maximum

108-inch Igloo (IATA type 4)--339 cu.ft. internal volume-- 12,345 les. maximum

10-foot Container (IATA type 2)-- 600 cu.ft. internal volume-- 15,000 lb. maximum

Appendix B (cont'd)

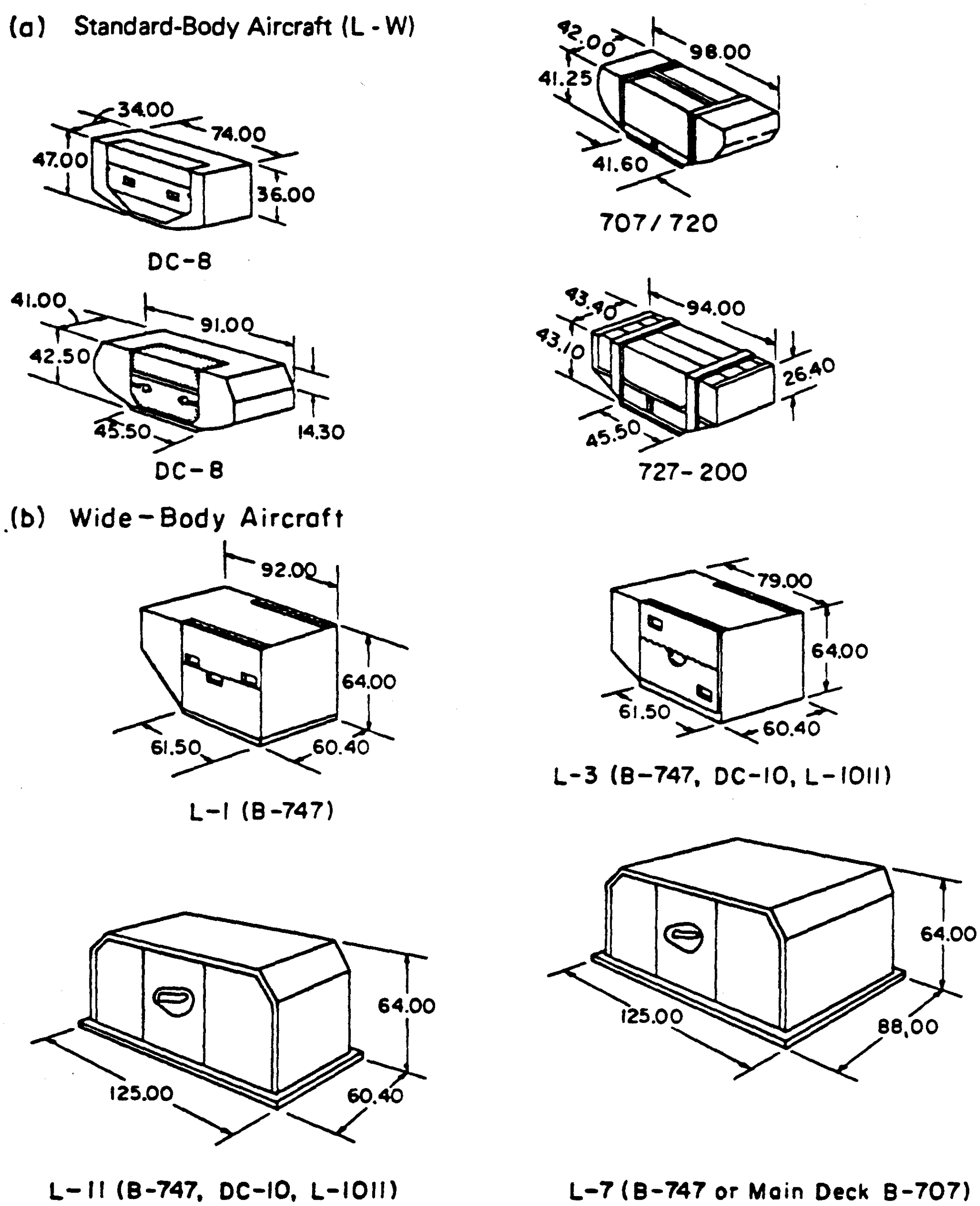


Typical Containers Used By U.S. Scheduled Air Carriers

Source: Boeing Commercial Airplane Company, "Airborne/Intermodal Pallets and Containers," Report Number D6-58502R7 (August 1978).

Common Types of Main-Deck Containers for Standard-Body Jets.

Appendix B (continued)



Source: Boeing Commercial Airplane Company, "Airborne/Intermodal Pallets and Containers," Report Number D6-58502R7.

Typical Lower-Deck Containers.

Appendix C: Memo to Massport

TO: Joe Brevard

FROM: Alan Eng

RE: Year 2000 Logan Traffic Forecasts

DATE: April 16, 1980

INTRODUCTION

This memorandum presents and discusses Massport Planning Department's estimates of operations and passenger demand for the peak hour/average day/peak month (PHADPM) at Logan Airport in the Year 2000. The operations estimate is mainly based upon the review of the Charles River Associates (CRA) forecasts done by Flight Transportation Associates (FTA). This memo shows, in Table 1, operations and passengers in terms of average day/peak month (ADPM) and PHADPM by service type (certificated, commuter, GA).

In the year 2000, 1278 ADPM operations and 130,500 ADPM passengers are estimated, with 103 PHADPM operations and 11,700 PHADPM passengers.

It should be kept in mind that these are estimates, based in part upon subjectively determined basic passenger growth assumptions provided to MPA by FTA. They also reflect numerous assumptions made by the writer in accordance with what are felt to be reasonable expectations about the future of the industry in general and Logan in particular. The estimates are therefore felt to be representative of one reasonable, defensible future for Logan aviation activity and not as the final word on the matter. As such, they are considered quite adequate and appropriate for the land use and ground transportation uses to which they are being put.

In general, we are confident of the general levels prescribed in Table 1. However, because of the relatively crude basis upon which they were derived, care should be exercised in attempting to extract conclusions from intermediate steps in the calculation process. To expedite the process, simplifying assumptions were made at different stages. It is important, in using these forecasts, to be aware of the limitations which are associated with these assumptions.

PURPOSE

Estimates of ADPM and PHADPM traffic demand for Logan in the year 2000 are an essential element in Massport's Year II planning projects. These estimates will serve as major design targets for Year II airport terminal planning and its related ground traffic forecasts. They have been done for total traffic, split between certificated (international and domestic), commuter and general aviation (GA) operations, and for passenger volume in each of these categories.

Estimating aviation demand twenty years ahead certainly involves considerable uncertainty. The estimates presented here are no better than the assumptions and methodology on which the targets of this memo are based. Over the last few months, there have been considerable reassessment of the future of passenger demand, and more particularly of aircraft operations. This has been largely due to the rapidly increasing cost of fuel, although other factors are also present. Different industry forecast procedures have resulted in different projections. These are described below and provided for purposes of comparison in some of the exhibits included in this memorandum.

APPROACH

The Massport forecasts relied heavily upon a careful review of fleet-mix-based activity estimates for the year 2000, produced by Flight Transportation Associates (FTA). In addition to estimating fleet mix, FTA also produced estimates of operations and passengers for "average day of year" and "peak day of year" for five year increments between 1980 and 2000. These two groups of forecasts were considered by FTA to establish a reasonable range, roughly defining limits between underdesigning and overdesigning of facilities.

Out of concern for designating an appropriate "design hour", the Massport Planning Department decided to reexamine the basic FTA forecasts in an attempt to come up with a forecast based upon Peak Hour - Average Day - Peak Month (PHADPM). This is the general design hour approach used by the Air Transport Association (ATA), and it was felt that it could be the most appropriate for our purposes. The computation process resulting in the estimates in Table 1 consisted of the following general steps:-

1. FTA's operations forecast was adopted for the most part and considered as average day/January operations since their forecasts were based upon one day traffic data of January 1, 1980.

2. Conversion of FTA's average day/January data to average day/ peak month ADPM (August) of 2000 by a seasonality factor.

3. Peak month (PM) traffic is divided by 31 days to yield average day (ADPM).

4. PHADPM estimate is obtained by multiplying the ADPM estimate with a factor reflecting the daily peaking characteristics.

5. Seating capacity of each aircraft type (as forecast by FTA) was applied to the respective operations forecast to get total seat volume.

6. Seat volume of PHADPM operations was converted to a total passenger volume by use of an assumed peak hour load factor (.75).

7. PHADPM passengers are expanded to obtain ADPM passengers with another conversion factor based upon present peaking relationship for passengers.

8. Peak month passengers were estimated by expanding ADPM to PM with a factor of 31.

9. Annual totals were similarly obtained by expanding Peak Month with a passenger seasonality factor.

10. All GA operations are held constant and GA passengers are considered negligible in the forecasting period.

Table 1 gives the year 2000 forecasts in terms of ADPM and PHADPM operations and passengers. Table 2 shows FTA's forecast of scheduled daily departures based upon the fleet mix approach. Table 3 presents PHADPM, ADPM and Peak Month operations and passengers by aircraft types (since seating capacity of year 2000 aircraft types is expected to be different than the current level). Table 4 gives the assumed fleet mix distribution based upon seating capacity levels. Percentage increases in PHADPM and ADPM between 1978 and 2000 is summarized in Table 5. To prepare the basic design hour of peak day and average day, FTA provided Massport with some preliminary design targets (Table 6) and with key assumptions (Table 7). Table 8 compares the ATA and MPA fleet forecast in PHADPM in the year 2000. Lastly, Table 9 also compares the total annual passenger volume of FAA, ATA and MPA forecasts.

Before we apply the 419 daily base year departures (from FTA's base year estimate, Table 2) to estimate year 2000 activity, a change in the number of 4-engine standard body operations is required. Because of the expected steady increase in stage length of domestic operations at Logan throughout the forecasting period, these 4-engine standard bodies are likely to be reassigned to serve the Boston markets. Economic and financial conditions may make it difficult for airlines to replace these standard bodies with wide body aircrafts. Therefore, FTA's 4-engine standard body estimate of two operations per day in the year 2000 is increased to five operations.

Because FTA's fleet forecast uses January traffic as base line, a seasonality conversion is necessary in order to obtain peak month traffic. We, therefore, compare the operations of the average day of January in the last two years(1978-79) to the ADPM (August) of the last two years, which resulted in a seasonal conversion factor (for average the day) of 1.32 between January and August. Since the total daily operations in January 2000 is 858 (plus 3 extra 4-engine standard body operations) or 861 (excluding GA), ADPM operations will be (861 x 1.32)or 1137 operations. Again, GA is excluded.

To obtain PHADPM operations, we apply the percent of operations that take place during the peak hour of day to the ADPM calculation. The "peaking factor" used for this step was .075.[1] The resulting PHADPM figure is 88 operations. Since GA is assumed to be constant at 50,000 per year, 142 per day, or 15 in the peak hour, the total operations in the PHADPM is (88 + 15) or 103 operations (see Results, Table 1).

Finally, when we expand the ADPM operations (1137 without GA) into the peak month, we get 1137 x 31 = 35,247 operations. Peak month operations over the last two years (1978-79) are about 10.2% of the annual

1) Assumed by Flight Transportation Associates

operations of the last two years. So for the year 2000 annual total, we get 35,247 + .102 = 345,560 operations. We add 50,000 GA operations to get an annual total of 395,560 operations for year 2000. This compares well with FTA's rough estimate of total annual operations of 365,000 (average day of year = 1000 operations).

PASSENGERS

Before we estimate passenger levels it is necessary to estimate seat availability of each aircraft type. Table 4 shows FTA's projected seating capacity of each aircraft in year 2000. Consequently, seat availability is measured by multiplying operations levels of each aircraft type for year 2000 by the expected seating capacity from Table 4. Seat availability for ADPM and PHADPM can be obtained in this manner. Taking it further, passenger volume of PHADPM is obtained by multiplying seat availability of PHADPM with the assumed peak load factor of .75 (see Table 3). The ADPM passenger calculation is obtained by assuming that the passenger volume of PHADPM is about 9% of the total ADPM passenger volume. (Previous estimates of the percentage of PHADPM total ADPM for both 1978 and 1979 are 8% and 10.2% respectively. Therefore, 9% was assumed for the conversion of PHADPM to ADPM passengers).

Peak month passenger volume is calculated by multiplying ADPM passenger volume by 31 days. This yields about 4,023,900 for peak month passengers. To calculate annual passengers, a seasonal factor is necessary. If we take the 1978 and 1979 annual passengers and estimate the percentages in the peak months of these respective years, we obtain an estimate of 10.4 percent for this factor. So, the annual passenger total is estimated by dividing peak month passengers of 4,023,900 by .104, resulting in approximately 38,691,000 annual passengers. When we follow the same procedure and estimate passengers of commuter and certificated markets separately, we will get 2,432,000 commuter passengers and 36,259,000 certificated passengers. In percentage terms, commuter passengers is about 6.3% of the total passengers in the year 2000 (CRA's commuter passengers is 6.0% of the total). The provision in the year 2000 of the larger commuter aircraft types as shown on Table 2 explains the increase in percentage of commuter passengers. The projected passenger figures are all rounded as indicated in Tables 1, 3, 5 and 9.

In the FTA January 16 memo, there is a statement (page 28) that "Since demand has increased roughly 50% during the last decade, it was assumed for the purpose of the fleet forecast, that a similar increase in demand would develop during the coming decade and a further 50% between 1990 and 2000.) If this were the sole consideration for the passenger forecasts, the annual passenger volume in 2000 would be 34.4 million (1.25 times more than the 1979 passenger volume of 15.3 million). This is somewhat lower than the approximately 39 million estimated by the approach described in this memo. This discrepancy is due to the differences in the calculation of the peak hour which are discussed in the next section.

Fleet mix - based forecast, a projection of the peak hour passenger movement using factors gained from past experience at Logan and extrapolating annual passenger volumes for the coming two decades, is felt to be a reasonable approach to preparing projections for passengers and operations. An estimate of aircraft mix, using historical data and trend analysis of fleet replacement is necessary for aviation forecasts at Logan. The passenger movements may be affected by factors such as availability and competition of other transport modes, fare and rate structure, as well as economic growth in the region. In long term applications, fleet mix - based forecast have the potential of showing less uncertainty than the regression approach, because it also considers the effect of supply-side constraints. This is the reason why FTA, ATA and many other airline analysts adopt this fleet mix - based forecast method in many of their operation and passenger forecast exercises.

OBSERVATIONS

Table 8 compares MPA and ATA forecasts of year 2000 PHADPM fleet mix operations and passenger volumes. Noteworthy in the ATA's forecast is that the pattern of development of commuter service would result in the increase of scheduled commuter aircraft movements in both less than 20-seats aircrafts and the larger aircrafts of the 30-60 passenger size; whereas the MPA forecasts reflects the assumptions that economic conditions will make under-20 seats commuter aircrafts unprofitable to operate and hence, totally eliminated by the year 2000. Besides this noticeable difference in less than 20-seats commuter aircraft operations, the projection of other aircraft type operations and the total passenger volume are quite in agreement with each other, particularly in total PHADPM seat availability.

Tables 6 and 7 give the design targets and key assumptions made by FTA in preparing the basic design hour (peak day and average day) targets mentioned above. Note that the PHADPM year 2000 passenger estimates prepared by Massport (11,700) actually exceeds the peak day estimate developed by FTA (10,500). This is mainly because of the different assumptions in peak hour load factor: FTA uses .67 and MPA uses .75 for the projections in year 2000 (applying a .67 load factor to the PHADPM seat availability yields 10,500 PHADPM passengers). Another reason is the slight increase in daily seats created by the increase in the number of 4-engine standard-body operations from two to five.

The load factor assumption of .75 for the PHADPM in year 2000 is considered to be a reasonable assumption. Because of steadily rising costs, airline managers could be expected to increase their effective use of equipment. At present, load factors of .65 or more are very common in peak-hour regular service. It is not at all unreasonable to use .75 for a load factor assumptions for the PHADPM in the year 2000. We realize .75 peak-hour load factor assumption is a relatively high one. However, it was used on this analysis to ensure that the peak-hour passenger estimates were conservative for planning purposes. For the non-peak traffic, a .67 load factor is applied to the MPA projections.

The recent FAA Boston-Hub forecasts from the years 1980 to 1991 are developed using a "top-down" procedure from the national level to hub-share model using economic and demographic projections (FAA Aviation

Forecasts - Boston, March, 1980 Draft). It is not a fleet mix-based forecast. Demand for air travel based upon total earnings, population growth and rate of air travel of the New England region and the U.S. as a whole is projected by regression models. Even though it shows no operation characteristics, the passenger movements are in very close agreement with the projections described in this memorandum. For comparison purposes, these FAA forecast results, ATA's projections and the MPA estimates of total annual passengers are given in Table 9 for five-year intervals. Finally a graphic comparison of this three sets of forecasts is given in Figure 1.

c.c. N. Faramelli
P. Sheinfeld
T. Baldwin
R. Marchi
A. Bratt
H. Conover

RESULTS - TABLE 1

Year 2000 Forecasts (Operations and Passengers)

	Operations		Passengers	
	Average Day/ Peak Month	Peak Hour/ Average Day/ Peak Month	Average Day/ Peak Month	Peak Hour/ Average Day Peak Month
Certificated	830	65	122,000	11,000
Commuter	306	23	8,200	740
GA	142	15	-	-
Total	1,278	103	130,200	11,740

TABLE 2

FORECASTED TOTAL SCHEDULED TRAFFIC AT LOGAN INTERNATIONAL AIRPORT (IN TERMS OF DAILY DEPARTURES)

	1980 (ACTUAL)	1985	1990	1995	2000
PROPELLER AIRCRAFT					
Less than 10 Seats	86.0	30.0	--	--	--
10-20 Seat	60.0	63.0	56.0	6.0	--
20-35 Seat	13.0	17.0	6.0	--	--
30-45 Seat	--	22.0	52.0	94.0	71.0
45-60 Seat	13.0	9.0	8.0	11.0	45.0
TOTAL (PROPELLER)	172.0	141.0	122.0	111.0	116.0
JET AIRCRAFT					
STANDARD BODY					
2 Engine	58.0	69.0	86.0	84.0	99.0
3 Engine	135.0	113.0	76.0	34.0	13.0
4 Engine	25.5	9.5	3.5	1.0	1.0
TOTAL (STANDARD BODY)	218.5	191.5	165.5	119.0	113.0
WIDE BODY					
2 Engine	--	23.0	55.0	91.0	127.0
3 Engine	24.0	25.5	34.0	41.5	46.0
4 Engine	4.0	7.5	13.5	21.0	27.0
TOTAL (WIDE BODY)	28.0	56.0	102.5	153.5	200.0
TOTAL (JET)	246.5	247.5	268.0	272.5	313.0
GRAND TOTAL	418.5	387.5	390.0	383.5	429.0

Source: FTA's January 15, 1980 memo to Massport

Table 3: Forecast, Operations and Passengers for Year 2000

Certificated	OPERATIONS AveDay/Jan	ADPM	PHADPM	PASSENGERS PHADPM Seat Available	PHADPM L.F..75	ADPM	Peak Month
Standard Body							
120 seats	198	261	20	2,400	1,800	20,000	620,000
153 seats	31	41	4	610	460	5,100	158,000
Wide Body							
247.5 seats	346	457	35	8,700	6,500	72,200	2,240,000
500 seats	54	71	6	3,000	2,200	25,000	755,000
Commuter							
37.5 seats	142	187	15	560	420	4,700	144,500
52.5 seats	90	119	8	420	310	3,500	108,500
General Aviation	142	142	15	-	-	-	-
Total	1,003	1,278	103	15,600	11,700	130,200	4,020,000

Appendix C (continued) TABLE 4

ASSUMPTIONS WITH RESPECT TO SEATING CAPACITY OF VARIOUS PASSENGER AIRCRAFT

Aircraft Type	1980	1985	1990	1995	2000
less than 10 seat prop	7.5	7.5	7.5	7.5	7.5
10-20 seat prop	15	15	15	15	15
20-35 seat prop	27.5	27.5	27.5	27.5	27.5
30-45 seat prop	37.5	37.5	37.5	37.5	37.5
45-60 seat prop	52.5	52.5	52.5	52.5	52.5
BAC-111	79	79	79	79	79
DC-9-50	139	139	139	139	139
DC-9-30	100	105	110	110	110
DC-9-10	90	90	90	90	90
737-200	115	120	125	130	130
727-100	100	110	110	110	110
727-200	135	145	155	155	155
707	135	140	140	140	140
DC-8-60	180	185	190	190	190
757	--	180	190	200	200
767	--	205	210	215	215
A300	260	265	270	275	275
A310	--	205	210	215	215
L1011	250	260	265	270	275
DC10	265	275	285	295	305
747	395	425	455	475	500

Source: FTA's February 1, 1980 memo to Massport

TABLE 5

Percentage Increase in Peak Hour/Average Day/Peak Month and Average Day/Peak Month of 1978 and 2000

	OPERATIONS						PASSENGERS					
	Pk. Hr./Av. Day/Pk. Mth.			Av. Day/Pk. Mth.			Pk. Hr./Av. Day/Pk. Mth.			Av. Day/Pk. Mth.		
	1978	2000	% Change	1978	2000	% Change	1978	2000	% Change	1978	2000	% Change
Certificated	39	65	66.7	525	830	58.1	3,220	11,000	240	43,000	122,000	184
Commuter	23	23	-	310	306	-1.2	250	740	192	3,380	8,200	143
General Aviation	20	15	-25	261	142	-45.6	-	-	-	-	-	-
TOTAL	82	103	25.6	1,096	1,278	16.6	3,470	11,740	237	46,380	130,200	180

Note: Year 1978 data from Massport monthly aviation statistics.

TABLE 6

Some Preliminary Design Targets for Logan International Airport

Item	1980	1985	1990	1995	2000
Aircraft Operations[1] on Average Day	980	920	920	900	1,000
Aircraft Operations[1] on Peak Day	1,470	1,380	1,380	1,350	1,500
Aircraft Operations[1] in Peak Hour of Average Day	80	74	72	68	75
Aircraft Operations[1] in Peak Hour of Peak Day	120	110	108	103	113
Passengers[2] in Peak Hour of Average Day	3,600	4,200	5,300	5,900	7,000
Passengers[2] in Peak Hour of Peak Day	5,400	6,300	8,000	8,800	10,500
No. of Gates[3] Required at Peak Hour of Peak Day	34	33	31	31	35
No. of Gates for Wide-Body Aircraft Required at Peak Hour of Peak Day	8	12	17	21	26

1. Includes general aviation operations (operation = landing or takeoff).
2. Includes enplaning, deplaning, and transfer passengers.
3. Does not include gates for commuter traffic; includes gates for wide-body aircraft.

Source: FTA's February 1, 1980 memo to Massport

TABLE 7

Some Key Assumptions Used in Preparing Table [illegible]

Item	1980	1985	1990	1995	2000
Ratio of no. of peak day operations to no. of average day operations	1.5	1.5	1.5	1.5	1.5
Percentage of daily operations that takes place during peak hour of day	8.2%	8%	7.8%	7.6%	7.5%
No. of g.a. operations for year	50,000	50,000	50,000	50,000	50,000
Load factor, commercial operations	63%	64%	65%	66%	67%
Average gate occupancy time for wide-body aircraft, peak hour	60 mins	55 mins	50 mins	45 mins	45 mins
Average gate occupancy time for standard-body aircraft, peak hour	40 mins	40 mins	35 mins	35 mins	35 mins

Source: FTA's February 1, 1980 memo to Massport

Aircraft Types	Peak Hour - Average Day - Peak Month (PHADPM)	
	ATA	MPA (Table 3)
Commuter		
15 seats	46	—
37.5 seats	19	15
52.5 seats	8	8
Certificated		
Standard Body		
2.3 engine	10	20
4 engine	17	4
Wide Body		
2.3 engine	43	35
4 engine	3	6
Total Movements	146	88
Total Seats	16,100	15,700
Total Passengers at 67% LF	10,800	10,500
at 75% LF	12,100	11,700

Source: ATA memo to Massport, 1/30/80

TABLE 9: Total Annual Passengers of MPA, FAA and ATA Forecasts

	1980	1985	1990	1995	2000
FAA	15,600	19,800	24,200	NA	NA
MPA	17,500	19,800	25,200	28,500	38,700
ATA	14,700	20,200	26,200	33,100	41,000

Source: FAA Aviation Forecast of Boston, 3/80
ATA drafted memo, 1/80

Appendix C (continued)

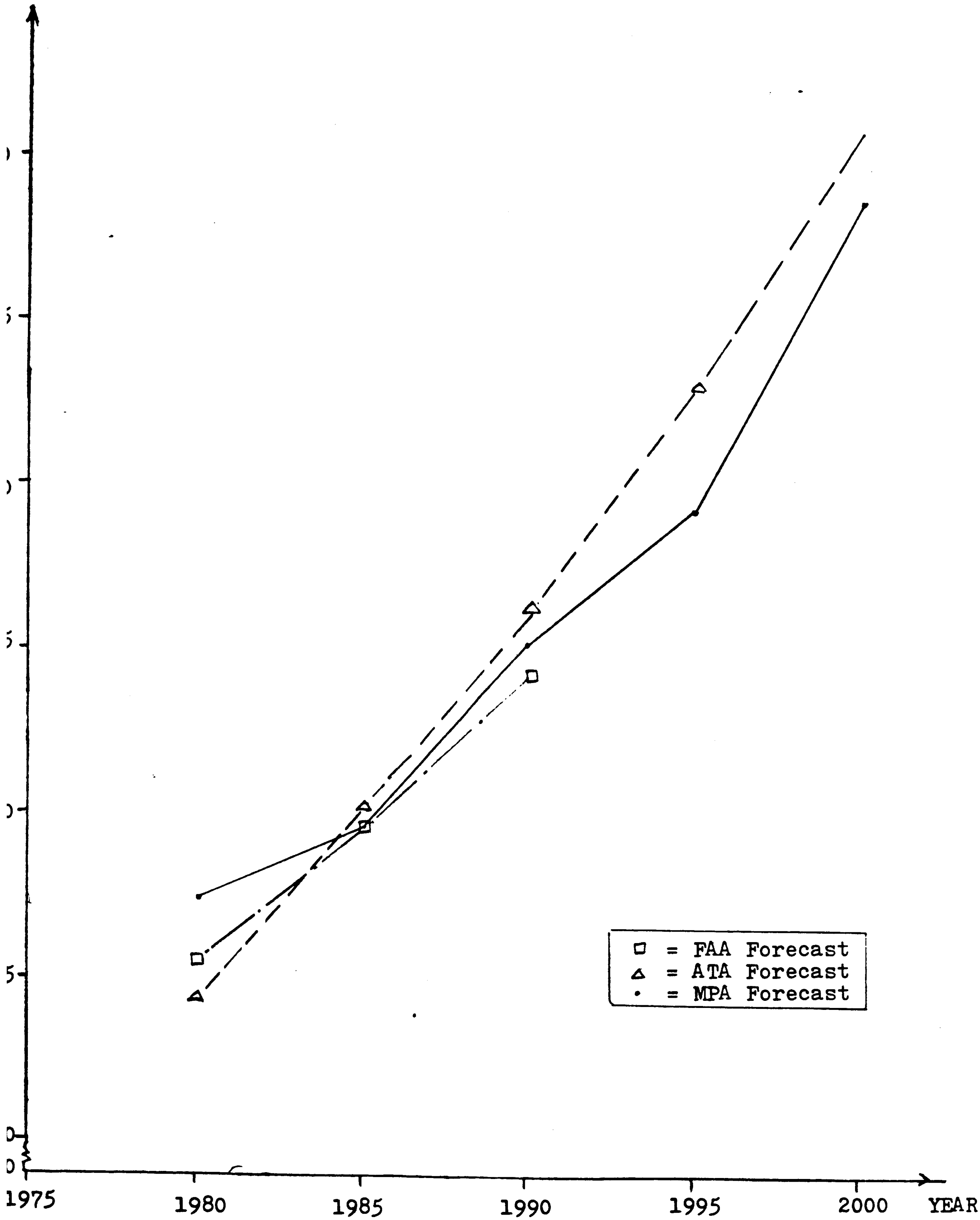


Figure 1: Total Annual Passenger Forecasts of MPA, FAA, ATA.

Appendix D: DATA FOR DEMAND FORECAST

Table (a): Real Average Fuel Cost by Service Type at Logan
(¢/ton-mile = Ave. Fuel Cost/consumer price index

(b): Average Fuel Cost by Service Type at Logan
(¢/ton-mile)

	(a)		(b)	
Year	Domestic	International	Domestic	International
1960	0.072	0.021	6.4	2.3
1961	NA	NA	NA	NA
1962	NA	NA	NA	NA
1963	NA	NA	NA	NA
1964	NA	NA	NA	NA
1965	0.065	0.025	6.2	2.0
1966	0.071	0.027	7.3	2.4
1967	0.094	0.033	9.9	3.1
1968	0.102	0.038	10.4	3.4
1969	0.098	0.033	10.8	3.7
1970	0.097	0.036	11.0	3.8
1971	0.096	0.032	11.7	3.9
1972	0.095	0.033	11.9	4.1
1973	0.106	0.034	12.7	4.2
1974	0.106	0.034	15.6	5.1
1975	0.157	0.052	19.1	6.3
1976	0.138	0.044	23.5	7.4

Source: "Green Sheets" received from Massport Aviation Department

Appendix D (continued)

Table (c): Fuel Consumption by Certificated Carriers at Logan

(million gallons)

Year	Domestic Freight & Express	Internatinal Freight & Express	Total
1960	50	14	64
1961	NA	NA	NA
1962	NA	NA	NA
1963	NA	NA	NA
1964	NA	NA	NA
1965	100	34	134
1966	114	44	158
1967	145	58	203
1968	172	66	238
1969	194	72	266
1970	206	60	266
1971	200	63	263
1972	198	66	264
1973	214	61	275
1974	193	53	246
1975	194	50	244
1976	203	48	251

Source: Bureau of Accounts and Statistics, CAB

Appendix D (continued)

Table (d): US CONSUMER PRICE INDEX

Year	All Items
1960	88.7
1961	89.6
1962	90.6
1963	91.7
1964	92.9
1965	94.5
1966	97.5
1967	100.0
1968	104.2
1969	109.8
1970	116.3
1971	121.3
1972	125.3
1973	133.1
1974	147.7
1975	121.3
1976	170,5
1977	181.5
1978	193.2

Source: US Department of Commerce, Bureau of the Census, Statistical Abstract of the US, 1978, p.490, Table #792.

Appendix D (continued)

Table (e): Freight and Express - Average Revenue by Service Type: (¢/ton-mile)

(f): Freight & Express - Real Average Freight Revenue by Service Type: (¢/ton-mile = Ave.Freight Rev. / Consumer Price Index)

	(e)		(f)	
Year	Domestic	International	Domestic	International
1960	64.0	29.92	.285	.337
1961	61.7	27.83	.269	.311
1962	60.0	25.40	.250	.276
1963	62.0	24.78	.249	,270
1964	60.7	23.60	.254	.254
1965	58.4	20.76	.218	.219
1966	57.8	19.92	.207	.205
1967	55.8	19.63	.198	.196
1968	56.2	18.83	.187	.180
1969	55.8	18.29	.182	.166
1970	56.0	18.36	.180	.158
1971	59.4	19.70	.176	.162
1972	58.9	19.69	.165	.157
1973	59.4	23.46	.168	.149
1974	65.0	25.78	.167	.158
1975	78.7	25.71	.175	.159
1976	98.6	25.80	.186	.151
1977	109.8	27.47		
1978	123.4			

Source: "Green Sheets". received from Massport Aviation Department

Appendix D (continued)

Table (g): Total Domsetic Freight at Logan (000lbs.)

(h): Total International Freight at Logan (000 lbs.)

	(g)			(h)		
Year	Unloaded	Loaded	Total	Unloaded	Loaded	Total
1960	NA	NA	NA	NA	NA	NA
1961	31,284	43,790	75,074	1,480	2,268	3,748
1962	34,921	48,044	82,965	1,047	2,852	3,899
1963	36,764	49,949	86,713	1,584	3.344	4,928
1964	46,178	61,350	107,528	1,846	4,123	5,969
1965	58,517	77,402	135,919	2,920	6,300	9,220
1966	63,451	84,908	148,359	4,484	8,283	12,767
1967	71,288	89,074	160,362	5,901	9,731	15,632
1968	86,510	104,855	191,365	11,172	10,500	21,672
1969	96,529	118,179	215,327	27,872	20,191	48,063
1970	107,605	127,356	234,421	32,753	24,530	57,283
1971	98,639	112,295	210,934	37,780	26,329	59,109
1972	115,542	128,368	243,910	38,138	27,872	66,000
1973	126,144	137,397	263,541	37,576	35,071	72,647
1974	121,277	134,286	255,563	39,910	44,602	84,512
1975	118,058	129,957	248,015	25,598	40,096	65,694
1976	115,052	133,018	248,070	29,981	47,708	77,689
1977	124,687	139,287	263,974	36,079	56,546	92,625
1978	126,402	156,823	283,225	36,307	59,205	95,512

Source: "Green Sheets" received from Massport Aviation Department

Appendix D (continued)

Table (i) Earning -- Total (million dollars)

Year	Total Massachusetts	Total New England	Total United States
1960	11.4	22.7	364.7
1961	11.8	23.4	372.6
1962	12.3	24.4	392.1
1963	12.5	25.0	406.1
1964	13.1	26.3	428.6
1965	13.8	27.8	457.0
1966	14.6	29.7	488.5
1967	15.2	31.1	507.3
1968	16.0	32.5	535.8
1969	16.7	33.9	561.2
1970	17.0	34.4	567.1
1971	17.1	34.4	578.4
1972	17.8	36.0	615.9
1973	18.4	37.5	655.2
1974	17.6	36.0	633.5
1975	17.0	34.8	620.3
1976	20.1	41.1	719.4
1977	20.8	42.6	747.9
1978	21.5	44.1	778.1

Source: US Department of Commerce, Bureau of Economic Analysis, Regional Economic Analysis Division, "Earnings by Industry", Table 1,2,and 11.

Appendix D: (continued)

DOMESTIC FREIGHT AND EXPRESS

MULTIPLE REGRESSION.....SAMPLE

SELECTION..... 1

01\1\00403010203

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	1.49533	0.08344	0.96837	1.26721	0.26862	4.71745
2	-0.69222	0.07742	-0.96202	-1.31292	0.19746	-6.64895
3	-1.03206	0.12893	0.79728	0.03540	0.10798	0.32788
DEPENDENT						
4	5.21444	0.20659				

INTERCEPT 2.44724

MUTILPLE CORRELATION 0.99325

STD. ERROR OF ESTIMATE 0.02640

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	3	0.71578	0.23859	342.23990
DEVIATION FROM REGRESSION	14	0.00976	0.00070	
TOTAL	17	0.72554		

Appendix D: (continued)

INTERNATIONAL FREIGHT AND EXPRESS

MULTIPLE REGRESSION.....SAMPLE

SELECTION..... 1

000403010203

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	1.49572	0.08315	0.96867	2.56795	1.55676	1.64955
2	-0.70828	0.11922	-0.97439	-2.66076	1.01010	-2.63417
3	-1.50617	0.11427	0.87153	0.02096	0.57173	0.03666
DEPENDENT						
4	4.34911	0.54023				

INTERCEPT -1.34482

MUTILPLE CORRELATION 0.97923

STD. ERROR OF ESTIMATE 0.12070

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	3	4.75743	1.58581	108.85731
DEVIATION FROM REGRESSION	14	0.20395	0.01457	
TOTAL	17	4.96138		