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METROPOLITAN WASHINGTON AIRPORT INVESTMENT REQUIREMENTS

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Technical Supplement to
The Metropolitan Washington Airport Policy Analysis

Prepared for

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16. Abstract The Federal Aviation Administration (FAA), as owner and operator of the Metropolitan Washington Airports, Washington National and Dulles International, is issuing a policy statement to guide development and operation of these facilities into the 1990's. The FAA's Metropolitan Washington Airport policy establishes a balance between a complex set of criteria which reflect transportation service, investment requirements, and environmental impacts. This report presents the results of an analysis of the impact of policy alternatives on capital investment requirements for the Metropolitan Washington Airports. A description of the range of policy options considered is contained in the introduction to the report. The FAA is recommending limiting air carrier aircraft operations at National Airport to 40 per hour, and furthermore, authorizing wide body aircraft at National, with the understanding that wide body service there would average four departures per hour by 1990. Estimated investments at National and Dulles required to support the recommended policy total approximately \$119 million in 1976 dollars. Given the uncertainties of investment forecasting, however, there are no significant differences in investment requirements between the policy alternatives evaluated.					
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INVESTMENT REQUIREMENTS

I. Introduction

This workpaper presents an analysis of investments required, in a system of airports serving air carrier airlines in the Washington D. C. Region, assuming varying policies for the operation of National Airport. The airports considered are National Airport (DCA), Dulles Airport (IAD) and the Baltimore-Washington Airport (BWI). The alternative policies examined are as follows:

<u>Case</u>	<u>Description</u>
2 (Baseline)	Hold DCA slots at 40 per hour and do <u>not</u> allow wide body aircraft.
6	Reduce DCA slots to 20 per hour and do <u>not</u> allow wide body aircraft. In this scenario, growth at National Airport is constrained by reducing airline quotas.
12	Hold DCA slots at 40 per hour and allow wide body aircraft. Here, growth is accommodated with new technology aircraft. ^{1/}
17	Reduce DCA slots to 30 per hour and allow wide body aircraft. Thus, scenario represents a combination of Case 6 and Case 12.

^{1/}A supporting analysis indicates that airlines, if allowed, would introduce wide body aircraft at DCA at an average frequency of four per hour. Refer to "Wide Body Aircraft Use at National Airport", DOT, FAA, 1976.

II. General Information

The range of alternatives investigated in this work paper presents a general indication of the impact of adopting different policies for aircraft use at National Airport - specifically the impact upon the future levels of investment required at the three airports. The necessity of analyzing all three, as a system, is most pronounced when one considers that a change in policy at National could create the need for an additional investment of millions of dollars at the other two airports.

In terms of the impact of each policy, the investment requirements are sensitive to two primary demands; (1) the demand for space at the airport by different numbers and types of aircraft during the peak periods, and (2) the demand for facilities to accommodate varying numbers of passengers from the access roadways to the holdrooms and loading bridges. The basic assumption of the analysis is that for a constant regional demand a constraint on use at National would result in a demand for increased facilities at the other two airports.

The investment requirements were determined independently of other studies, however, to the extent that it was applicable, information from all available studies was utilized in formulating this report. Specifically, the data sources include past reports on expansion capabilities at National, the various information items relating to the current expansion program at Baltimore-Washington and earlier development concepts for Dulles.

At the time of preparation of this report, a development program was under way at Baltimore-Washington International Airport. This program will provide terminal facilities designed to meet long range growth and for this study was considered adequate to meet the design level of 11.2 million passengers per year. It was also assumed that policy decisions for the operation of National would not act to reduce the scope of the terminal expansion project at BWI.

These cost estimates do not represent the total expenditures that will be required at each airport. Maintenance, new airfield facilities and other improvements will be identified through Master Plans of National and Dulles. These estimates are prepared only as an indication of relative sensitivity to varying levels and types of demands influenced by the operating policies of National Airport.

III. Summary of Findings

In summary, it is appropriate to note certain factors which influence the requirements in investment for the various modes. Those are:

1. The current development program at the Baltimore-Washington International Airport is a commitment of funding independent of National Airport Policy. The level of demand projected under this analysis does not, in any mode, exceed the design capacity of the proposed BWI facilities. Therefore, modes which cause a shift of passengers to BWI reflect no additional cost at that facility and result in a reduction of costs at National. Therefore, for a more sensitive comparison of available alternatives, the costs of BWI can be deleted as it is constant throughout the analysis.
2. The investment required in the terminal to accommodate additional passengers at National Airport is multiplied by the high cost of providing automobile parking facilities to serve those passengers. However, the per passenger costs at Dulles are significantly higher than for National.
3. The effect of introducing wide-body aircraft at National appears to be in the range of \$10 million if a comparison is made between Cases 2 and 17 which handle approximately the same number of passengers. Case 17, with wide-body aircraft, handles about five percent fewer passengers in 1990 but costs about \$8 million more. Case 13, on the other hand, has the same number of aircraft as Case 2, and handles seven percent more passengers and costs \$16 million more with wide-body aircraft.

To better consider the required investment to accommodate the demand, a series of indices were analyzed on a per passenger basis. This provides a gauge of a balance between investments and identifies the mode which provides the lowest investment requirement per passenger served. The results indicate that Case 2 offers the lowest investment per passenger, however, the variance between modes was not considered to be significant (12%).

The summary of costs and the per passenger investments are presented in the following Table 1 and 2.

SUMMARY OF COSTS
(All Costs Are In Millions of 1976 Constant Dollars)

COST ESTIMATES-NATIONAL				
CASE	Airside	Terminal	Groundside	Total
Current Demand	\$0.63	\$33.37	\$ 8.28	\$42.28
2	0.81	34.34	12.28	47.43
6	-	15.04	1.33	16.37
13	2.59	42.86	17.72	63.18
17	2.20	34.62	18.72	55.54

COST ESTIMATES-DULLES				
CASE	Airside	Terminal	Groundside	Total
2	\$10.30	\$38.90	\$ 6.8	\$ 56.00
6	23.50	69.50	12.7	105.70
13	12.40	38.60	5.1	56.10
17	12.40	37.40	7.5	57.30

COST ESTIMATES-BALTIMORE

Current development program meets estimated requirements for all modes; cost is \$64.50 million.

AIRPORT SYSTEM COSTS					
CASE	DCA	BWI	IAD	3 Airport Total	DCA&IAD Total
2	\$47.43	\$64.50	\$ 56.00	\$167.93	\$102.43
6	16.37	64.50	105.70	186.57	122.07
13	63.18	64.50	56.10	183.78	119.28
17	55.54	64.50	57.30	177.34	112.84

Table 2

CUMMULATIVE PER PASSENGER INVESTMENTS

Washington National

<u>CASE</u>	<u>Cummulative Epl. 1976-1990 1/</u>	<u>Total Cost</u>	<u>\$/Epl.</u>
2	109.13M	\$47.43M	0.43
6	79.88M	16.37M	0.20
13	116.63M	63.18M	0.54
17	106.13M	55.54M	0.52

Dulles

<u>CASE</u>	<u>Cummulative Epl. 1976-1990</u>	<u>Total Cost</u>	<u>\$/Epl.</u>
2	50.10M	56.00	1.12
6	76.35M	105.70	1.38
13	44.10M	56.10	1.27
17	52.35M	57.30	1.09

Washington National and Dulles

<u>CASE</u>	<u>\$/Epl.</u>
2	0.65
6	0.78
13	0.74
17	0.71

1/ Assumes a straight line growth from current level of enplanements to the 1990 forecast.

IV. Demand Profiles

The demand for aviation facilities and services at all airports will vary dependent upon the policy adopted at National Airport. The specific variations expected to affect the investment requirements are the aircraft demands (peak number at the terminal and the type) and the passenger demands (peak flow in each direction and annual levels).

Certain basic factors are assumed to be constant to all three airports and are thus used to analyze the demand. The first is the passenger directional flow balance. The standard assumption of 60% - 40%, which assumes that during the peak hour for enplaning passengers approximately 2/3 that number are deplaning. These assumptions were checked using CAB data for 1975 and found to be accurate with plus or minus a few percent. ^{1/} Table 3 shows the directional flow during the peak hour for enplanements at each of the three airports individually and combined and the enplanements as a percent of the total passenger activity during that hour. Also shown in the same Table are the aircraft arrivals and departures and the directional flow.

^{1/} Profiles of Scheduled Air Carrier Passenger Traffic, FAA, January 1976.

Table 3

PASSENGER DIRECTIONAL FLOW			
(CAB Data, May 1975)			
	Peak Hour Enplanements	Same Hour Deplanements	Enplanements as a % of Total
BWI	418	322	56%
DCA	1,506	1,251	55%
IAD	999	467	68%
Total ^{1/}	2,923	2,040	61%

AIRCRAFT DIRECTIONAL FLOW			
(OAG Schedules November 1, 1974)			
	Peak Hour Departures	Same Hour Arrivals	Departures as a % of Total
BWI	14	12	54%
DCA	26	21	55%
IAD	14	7	67%

Note: Peak hour for departures at the three airports did not coincide.

Also included in the determination of terminal requirements is the length of time the average aircraft occupies a gate. This also has been found to be correlated to the aircraft size. While load factors and airline scheduling also play an important part of this a check of schedules at various airports and other studies have provided a dwell time for each size aircraft. ^{2/}

- ^{1/} For sample period all three airports had simultaneous peak hours for enplanements at 5 - 6 PM.
- ^{2/} Sources: Washington National Airport Master Plan Report, 1968; IATA Terminal Design Standards; FAA Facility Requirements for Large Hubs; Official Airline Guide-July 15, 1976.

The following tabulation provides these dwell times:

TERMINAL DWELL TIME

<u>Aircraft Seating Capacity</u>	<u>Dwell Time</u>
30	20 min.
50	22
95	27
125	31
200	39
250	45
350	56

It should be noted that these factors can not be converted directly to gate requirements without certain refinements. The character of the airport itself will dictate different "gate occupancy" rates. The "exclusive gate" arrangement at most airports prohibits an occupancy of more than about one-half of the gates at a given time. Two noted exceptions to this, however, are National and LaGuardia which achieve as high as 55-65 percent occupancy during peak periods. Another criteria in determining the number of gates required is the level of enplaned passengers as shown in Figure 1. This graph also illustrates the high utilization of gates at the aforementioned airports.

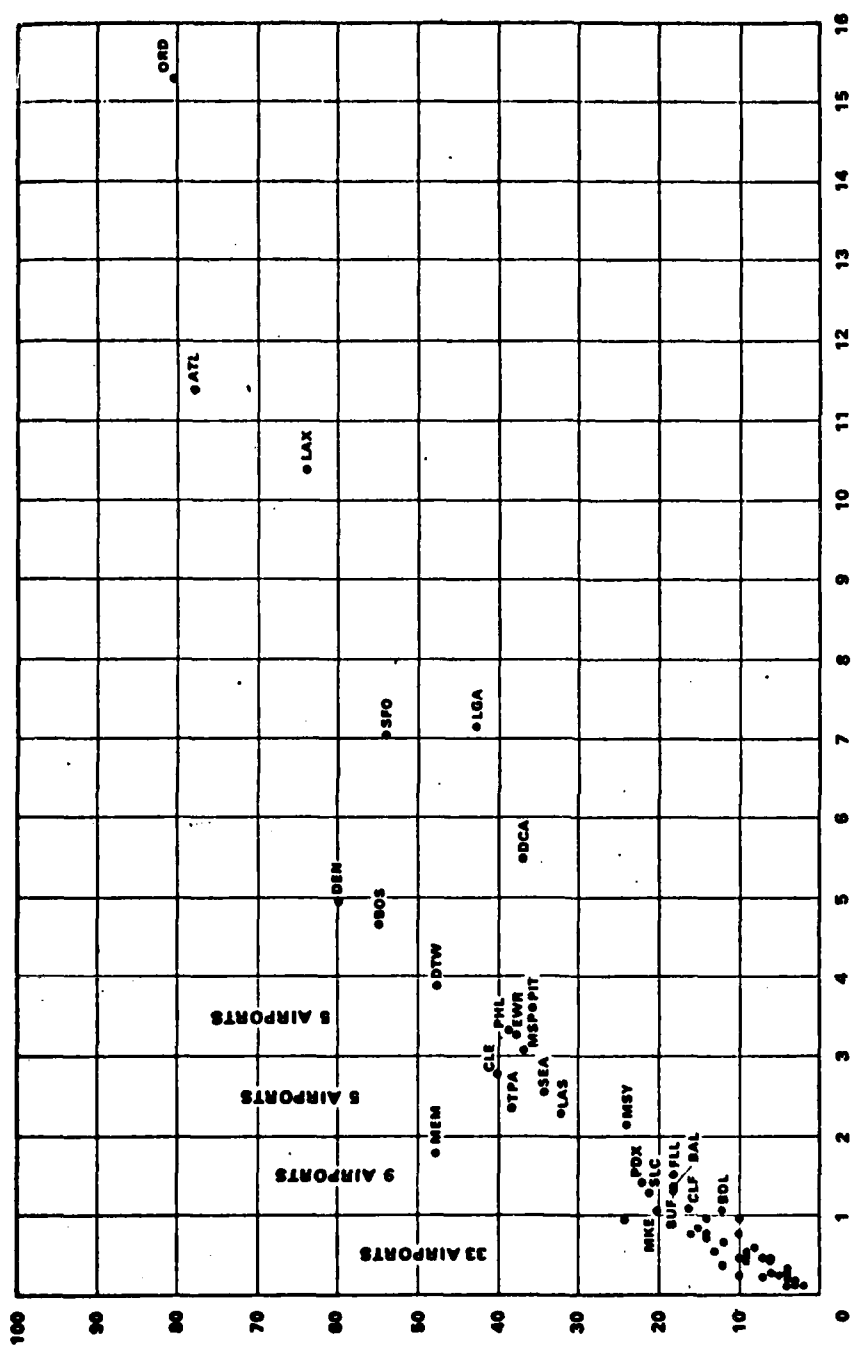
The peak hour gate requirements can then be determined by application of the following formula:

$$\text{Number of Gates} = \frac{\text{Number of Peak Hour Departures} \times \text{Peak Hour Factor}}{\text{Peak Hour Factor}}$$

where

$$\text{Peak Hour Factor} = \frac{\text{Dwell Time (in hours)} \times 2}{\text{Gate Occupancy Factor}}$$

Figure 1



1973 ANNUAL ENPLANEMENTS (IN MILLIONS) FOR SCHEDULED DOMESTIC OPERATIONS - 60 AIRPORTS

TERMINAL GATES PER ANNUAL ENPLANEMENTS

APPROXIMATE NUMBER OF TERMINAL GATES (1973-AUGUST) CONSIDERED AS ACTIVE LOADING POSITIONS (SCHEDULE OPS.-DOMESTIC ONLY)

Source: The Apron and Terminal Building: Planning Manual, FAA, July 1975.

As previously explained, the gate occupancy factor employed in this study is 60 percent. The Dwell Time for each aircraft type has been enumerated as well. The factor of two must be used to reflect two conditions. Firstly, with a high gate occupancy, aircraft arriving in the peak hour but not departing in the same peak hour will require a gate. Secondly, as will be discussed in ensuing paragraphs, airline scheduling practices are such that peaks within the peak hour occur. For example, a 30 seat aircraft has a 20 minute dwell time. Theoretically, if efficiently scheduled, one gate could accommodate 3 aircraft in any given hour. In practice, this rarely occurs and must be reflected in gate requirement factors.

The peak hour factors employed in this study are as follows:

Peak Hour Gate Utilization Factors

<u>Aircraft Seating Capacity</u>	<u>Peak Hour Factor</u>
30	1.12
50	1.22
95	1.50
125	1.72
200	2.17
250	2.50
350	3.11

The specific characteristics of the future demand at the three airports varies with each alternative mode. Tables 4a and 4e present the basic data relating to facility,

TABLE 4a

CASE 2

FORECAST OF DEPARTURES DURING PEAK PERIODS

AIRCRAFT TYPE	NATIONAL			BALTIMORE- WASHINGTON			DULLES		
	11-12 AM	12-1 PM	1-2 PM	7-8 AM	8-9 AM	9-10 AM	7-8 AM	8-9 AM	9-10 AM
30	3	4	-	-	5	1	-	-	-
50	2	1	1	-	1	-	-	-	1
95	-	3	7	16	11	12	15	9	18
125	20	21	13	3	2	5	4	1	4
200	-	-	-	1	-	1	1	-	1
250	-	-	-	-	6	1	-	12	3
350	-	-	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-	-	-
TOTAL	25	29	21	20	25	20	20	22	27

CASE 2

FORECAST OF ENPLANING PASSENGER ACTIVITY

ITEM	DCA	BWI	IAD	CDCA <u>1</u>
ANNUAL	8.2 x 10 ⁶	3.6 x 10 ⁶	5.4 x 10 ⁶	0.5 x 10 ⁶
AVERAGE DAY	24,273	10,670	16,034	1,352
PEAK HOUR	1,963	1,505	2,411	56
PEAK HOUR TIME	5 - 6 PM	8 - 9 AM	8 - 9 AM	N/A

1 CDCA (COMMUTER ACTIVITY AT NATIONAL AIRPORT) IS ALWAYS TAKEN DURING THE PEAK HOUR FOR DCA.

NOTE: FORECAST YEAR IS 1990.

TABLE 4b

CASE 6
FORECAST OF DEPARTURES DURING PEAK PERIODS

AIRCRAFT TYPE	NATIONAL			BALTIMORE- WASHINGTON			DULLES		
	11-12 AM	12-1 PM	1-2 PM	7-8 AM	8-9 AM	9-10AM	7-8 AM	8-9 AM	9-10AM
30	2	3	-	-	4	1	-	-	-
50	2	3	1	-	1	-	-	-	1
95	-	-	2	16	12	13	8	6	27
125	10	14	8	3	1	5	11	6	13
200	-	-	-	1	1	1	-	1	3
250	-	-	-	-	6	1	1	12	3
350	-	-	-	-	-	-	-	-	1
500	-	-	-	-	-	-	-	-	-
TOTAL	14	20	11	20	25	21	20	25	48

CASE 6**FORECAST OF ENPLANING PASSENGER ACTIVITY**

ITEM	DCA	BWI	IAD	CDCA <u>1</u>
ANNUAL	4.3 x 10 ⁶	3.9 x 10 ⁶	8.9 x 10 ⁶	0.5 x 10 ⁶
AVERAGE DAY	12,791	11,485	26,446	1,481
PEAK HOUR	1,140	1,661	3,571	55
PEAK HOUR TIME	5 - 6 PM	8 - 9 AM	9 - 10 AM	N/A

1 CDCA (COMMUTER ACTIVITY AT NATIONAL AIRPORT) IS ALWAYS TAKEN DURING THE PEAK HOUR FOR DCA.

NOTE: FORECAST YEAR IS 1990.

TABLE 4d

CASE 13
FORECAST OF DEPARTURES DURING PEAK PERIODS

AIRCRAFT TYPE	NATIONAL			BALTIMORE- WASHINGTON			DULLES		
	11-12 AM	12-1 PM	1-2 PM	7-8 AM	8-9 AM	9-10AM	7-8 AM	8-9 AM	9-10AM
30	3	4	-	-	5	1	-	3	-
50	2	1	1	-	1	-	-	-	1
95	1	6	11	16	10	9	16	8	11
125	15	14	5	3	3	4	3	2	3
200	-	1	-	1	-	-	1	1	1
250	4	3	4	-	6	1	-	11	2
350	-	-	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-	-	-
TOTAL	25	29	21	20	25	15	20	25	18

CASE 13
FORECAST OF ENPLANING PASSENGER ACTIVITY

ITEM	DCA	BWI	IAD	CDCA <u>1</u>
ANNUAL	9.2 x 10 ⁶	3.4 x 10 ⁶	4.6 x 10 ⁶	0.5 x 10 ⁶
AVERAGE DAY	27,151	10,077	13,721	1,352
PEAK HOUR	2,191	1,559	2,400	56
PEAK HOUR TIME	5 - 6 PM	8 - 9 AM	8 - 9 AM	N/A

1 CDCA (COMMUTER ACTIVITY AT NATIONAL AIRPORT) IS ALWAYS TAKEN DURING THE PEAK HOUR FOR DCA.

NOTE: FORECAST YEAR IS 1990.

TABLE 4e

CASE 17

FORECAST OF DEPARTURES DURING PEAK PERIODS

AIRCRAFT TYPE	NATIONAL			BALTIMORE- WASHINGTON			DULLES		
	11-12 AM	12-1 PM	1-2 PM	7-8 AM	8-9 AM	9-10 AM	7-8 AM	8-9 AM	9-10 AM
30	4	4	-	-	4	1	-	3	-
50	2	1	1	-	1	-	-	-	1
95	-	1	5	16	11	10	15	8	23
125	11	14	6	3	3	5	4	2	4
200	-	1	-	1	-	-	1	1	1
250	4	3	4	-	6	1	-	11	2
350	-	-	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-	-	-
TOTAL	21	24	16	20	25	17	20	25	31

CASE 17

FORECAST OF ENPLANING PASSENGER ACTIVITY

ITEM	DCA	BWI	IAD	CDCA ¹⁾
ANNUAL	7.8 x 10 ⁶	3.7 x 10 ⁶	5.7 x 10 ⁶	0.5 x 10 ⁶
AVERAGE DAY	23,047	10,833	16,938	1,374
PEAK HOUR	1,904	1,568	2,354	56
PEAK HOUR TIME	5 - 6 PM	8 - 9 AM	8 - 9 AM	N/A

¹⁾ CDCA (COMMUTER ACTIVITY AT NATIONAL AIRPORT) IS ALWAYS TAKEN DURING THE PEAK HOUR FOR DCA.

NOTE: FORECAST YEAR IS 1990.

and in turn the investment, requirements. A review of the detailed forecast data revealed that a given peak level of aircraft departures frequently occurred more than once per day thus the critical peak hour was assumed to be the one with the highest activity in two adjacent hours. The importance of examining more than one isolated hour becomes apparent when the aircraft departing during the peak hour arrived at the terminal during the previous hour, while aircraft scheduled to depart during the previous hour were still at the gate. This feature is illustrated in Figure 2, which depicts the forecasted three-hour segment of arrivals and departures for National Airport under Case 2. The airlines also establish schedules in a manner that does not evenly distribute flights throughout the hour thus some parking will actually occur within the hour as noted in Figure 3.

The demand for facilities is, as discussed earlier, related to both numbers of aircraft and passenger activity levels. These two peaks do not necessarily coincide thus the peak demand for passenger facilities does not necessarily occur during the same hour as does the peak demand for aircraft space and facilities.

WASHINGTON NATIONAL AIRPORT Sample Theoretical Distribution of Arriving and Departing Flights

(Example is for 1990 Demand Under Case -2)

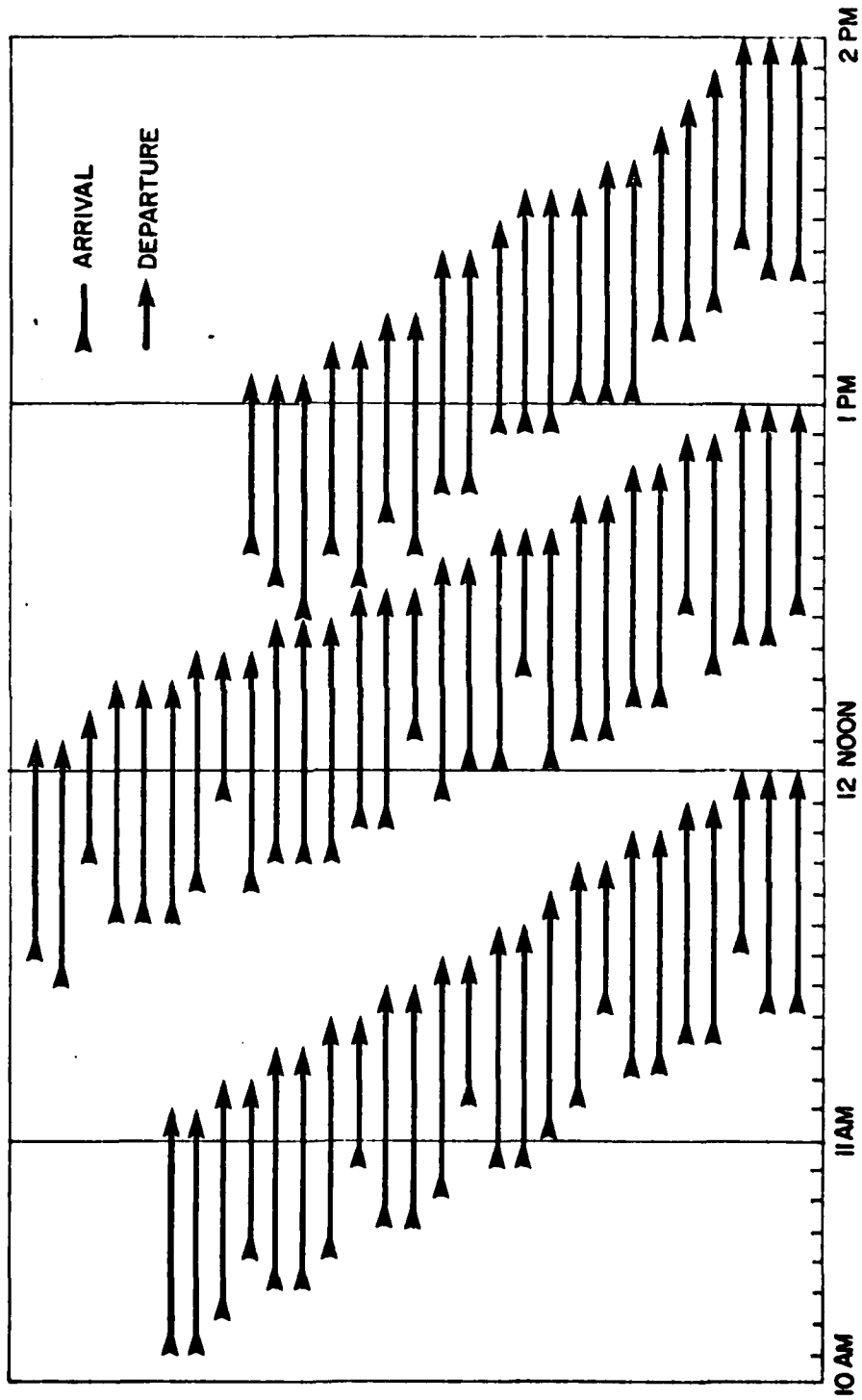
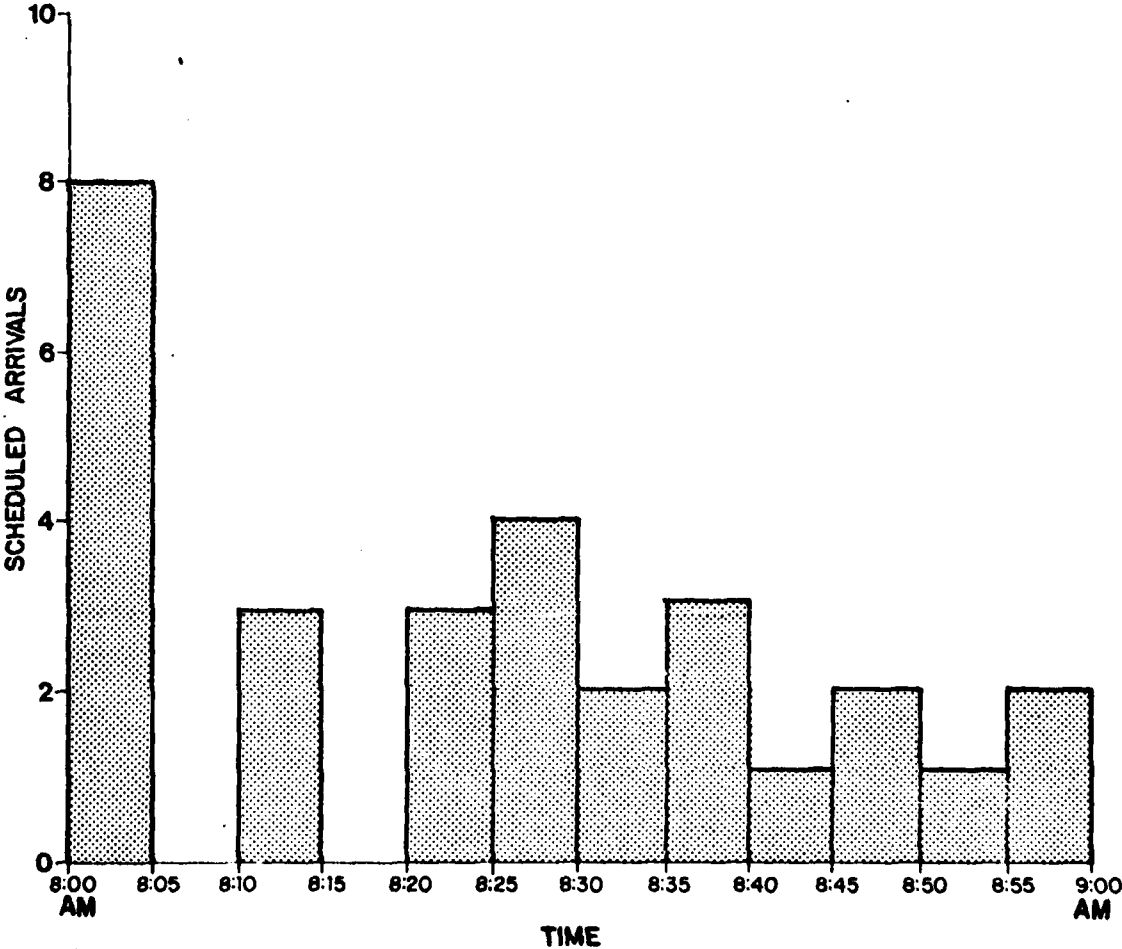


FIGURE 2

FIGURE 3

WASHINGTON NATIONAL AIRPORT Distribution of Scheduled Arriving Flights During the Hour 8:00 AM to 8:59 AM



Source: Official Airline Guide, July 15, 1976

V. Investment Data Base

Basic unit costs were developed, to the degree of detail practical, for use in this study. The unit costs were derived from a variety of sources including but not limited to comparable airport construction nationwide, previous studies, Mean's Building Construction Cost Data, and current construction projects at Baltimore-Washington International Airport as well as Washington National Airport.

The unit costs employed in this study are presented in Table 5. In certain cases basic unit costs were converted into units which can be more easily applied and compared in the cost estimating process. For example, square yardage costs for roadway pavements were converted into costs per linear foot of roadway for two and four lane roadway systems. Since this study does not provide for any level of design of facilities, certain designs were assumed (such as pavement thickness) based on the detail available, similar projects, and "standard" construction techniques.

All of the basic unit costs include 15 percent for contingencies, 20 percent for contractor overhead and profit, and 6 percent for architectural and engineering fees. All costs are in 1976 dollars.

These unit costs were brought up-to-date by applying

UNIT COSTS (1976 DOLLARS)

	<u>Narrow-Body</u>	<u>Wide-Body</u>
<u>1. Airside</u>		
- Loading Bridges		
Standard	\$ 90,000	\$120,000
Telescoping	\$150,000	\$215,000
- Pavement		
Apron ^{1/}	\$ 40.00/S.Y.	\$ 40.00/S.Y.
Filleting	---	\$353,200 L.S. ^{2/}
- Transporters	\$375,000	\$375,000
 <u>2. Terminal</u>		
- Baggage Handling Systems		
- Outbound (from ticket counter to make-up area)		
\$270,000/Module (manual sortation) ^{3/}		
Each module accomodates up to six peak hour aircraft		
- Inbound		
\$100,000/claim device		
Each device accomodates 2 peak hour aircraft		

<u>1/</u> Paving:	Site Preparation	\$ 7.00
	Base Course	5.75
	Surface Course	8.50
	Sealer	1.50
	Drainage	2.75
	Marking & Lighting	2.75
	4% Mark-up	11.60
		<u>\$39.85</u> or \$40.00/S.Y.

2/ 8,830 S.Y. @ \$40.00/S.Y.

3/ Mechanized sortation is \$375,000 per Module.

2. Terminal (Continued)

- Shell costs: \$40.00/S.F.
- Public Areas: Passenger processing facilities, lounge areas, rest rooms, shops, etc., \$50.00/S.F. plus shell.
- Administrative Areas: Airline and airport offices, operations offices, Federal Aviation Administration offices: \$40.00/S.F. plus shell.
- Remodeling existing terminal: \$80.00 S.F. total.

3. Groundside

	<u>On-Grade</u>	<u>Structural</u>
- Access		
Two Lane	\$ 83/L.F. <u>1/</u>	\$ 556/L.F. <u>2/</u>
Four Lane	\$167/L.F.	\$1,111/L.F.
- Auto Parking	\$1,000/Space	\$5,000/Space

1/\$ 83/L.F. = Two lane (25 foot total width) @ \$30.00/S.Y.
\$167/L.F. = Four lane (50 foot total width) @ \$30.00/S.Y.
2/\$556/L.F. = Two lane (25 foot total width) @ \$30.00/S.Y.
\$1,111/L.F. = Four lane (50 foot total width) @ \$30.00/S.Y.

a 7 percent inflation factor to 1975 costs. This inflation factor was considered to be somewhat lower than experience of the past few years and is a judgment by the consultants. The support for this lower inflation factor is drawn from recent experience of high engineering estimates as noted in the items shown in Figure 4.

CONSTRUCTION COST INFLATION TRENDS

Denver airport job priced 22% below estimate

A contract for the improvement of a runway complex at Denver's Stapleton International Airport was awarded to Peter Kiewit Sons' Co., Omaha, with a \$12,122,308 low bid that was 22% below the \$15,450,937 estimate and 4% under the next lowest competitor.

1C Peter Kiewit Sons' Co., Denver, CO	\$12,122,308
2 Gordon H. Hall, Inc., Danville, CA	\$12,740,013
8 Western Contracting Corp., Sioux City, IA	\$15,487,670
EE Denver Dept. of Public Works, Denver, CO	\$15,450,937

Bids: Apr 21, 1976	Unit	Quantity	Unit Price	
Items			1C	2
Phase I				
Asphalt removal	sy	58,839	0.25	0.40
Concrete removal	sy	4,406	1.25	2.00
Unclass. excavation	cy	98,659	1.25	0.70

Engineering News Record,
July 8, 1976, p. 47.

Tied-arch bridge bid 15% under estimate

The winner of a \$11,662,660 contract for construction of a 780-ft-long steel tied-arch bridge over the Ohio River at Wheeling, W. Va., came in 15% beneath the engineer's \$13,679,889 estimate in a field of seven bidders.

functional during construction of the bridge.

A concrete deck and approaches for the bridge will be let in a separate contract.

Engineering News Record,
August 28, 1975, p. 40.

Hawaii viaduct bid cuts estimate by \$3.7 million

Competition among four contractors for a 3,453-ft-long concrete viaduct in Honolulu resulted in a \$16,866,380 contract that was 18% or \$3,766,466 under the \$20,632,846 estimate and 2.1% beneath the second low bid.

appurtenances, as well as 138 trees.

Some minimum hourly wage rates, including fringe benefits, are: laborers, \$7.37; iron workers, \$9.25; equipment operators, \$9.58; and carpenters, \$8.40.

1C Dillingham Corporation, Honolulu, Hawaii	\$16,866,380
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Engineering News Record,
August 28, 1975, p. 40.

Bid 23% under estimate takes bridge project

A New York City contractor priced a northern New Jersey bridge and paving job 23% below the engineer's \$1,525,000 estimate and took the contract with a bid that was 4.3% beneath its closest competitor in a field of 11 bidders.

A 18 to 46 ft-wide roadway will parallel the river and require extensive shoring of the bank with steel sheet-piles.

1C JV Cayuga-Caycon Constructors, New York, NY	\$1,178,750
2 J. H. Reid, West Orange, New Jersey	729,391
11 Diversified R & T. Const. Co., No. Brunswick, New Jersey	1,587,438

Engineering News Record,
August 7, 1975, p. 83.

All bids under estimate for San Francisco rail station

All five bidders for construction of a San Francisco Municipal Railway station and upgrading sections of trolley track dropped below the Bay Area Rapid Transit's \$7,044,000 estimate. The low bidder took the job with prices totaling 10.4% or \$726,637 under the estimate.

All bidders under estimate for Henry Hudson Parkway repair

All six bidders for rehabilitating a 1.75-mile-long section of viaduct on the Henry Hudson Parkway in New York City dropped below the state department of transportation's \$13,528,788 estimate, and the low bidder took a \$10,670,651 contract coming in 5.4% under its closest competitor.

Engineering News Record,
June 24, 1976, p. 116.
December 18, 1975, p. 84.

VI. Washington National Airport

A. AIRPORT FACILITIES

The most dramatic effect of the alternatives under consideration would occur at National Airport. The impact, in terms of investments, occurs based on two factors, those being the investments required to equip the airport to handle wide-body aircraft and the investment associated with expansion to meet increased levels of demand. National Airport is currently one of the most intensely utilized airports in the world today. Limitations in available space have created significant constraints on the expansion of the airport and at the same time political and community attitudes have acted to deter major investment programs. Unfortunately, the demand has continued to increase to the point that the terminal now functions in what is, in esoteric terms, an oversaturated condition. In common terms, this is a way of saying that the terminal facilities are so crowded that the service level to the passenger has dropped below accepted standards of the aviation industry. As a rule of thumb, the airport terminal requires a gross floor area equivalent to about 200 square feet per Typical Peak Hour Passenger (T.P.H.P.). The passenger surge effect of wide-body aircraft would increase this by about 10 percent or 220 sq. ft. per T.P.H.P. The current terminal of approximately 600,000 square feet with a demand of about 2,510 T.P.H.P. ^{1/} is equivalent to 239 square feet per passenger which is slightly above the standard. However, certain facilities within the terminal are inadequate to meet the demand. Specifically identified are: gate positions (of the 42 officially designated gates only 35 are

^{1/} 1,506 P.H. Enplanements + 0.60 directional in balance = 2,510 T.P.H.P. (Source - CAP Data, May, 1975).

positions at the terminal); the baggage claim devices are considered inadequate; the passenger flow areas constrict passenger movement; the curb space is divided forcing passengers to cross as much as three lanes of traffic; and the parking spaces are inadequate. Thus the initial step in analyzing the investment requirements involved an analysis of costs associated with bringing the current facilities up to more acceptable standards. It should be noted that National functions differently in character from other airports and thus not all criteria used for standard design is applicable; instead through varying sources of information, the specific needs of the passengers at National were used in the investment analysis^{1/}. The current terminal facilities are discussed in the following three areas: Airside, Terminal and Groundside.

Figure 5 depicts the present terminal configuration and ground access facilities as well as some conceptual development features. Figures 6a and b illustrate a basic terminal expansion concept utilized for this analysis. An effort was made to utilize the most standard form of expansion which would be compatible and functional at National and meet the demand requirements. At present the terminal at National (Main and North Terminals) is in need of major remodeling and for this analysis it was estimated that such a remodeling effort would involve about 300,000 square feet and would accomplish such features as receiving passengers from an elevated roadway and improved passenger circulation. It should be noted that some remodeling is currently planned by the airlines; however, this focuses primarily on the hold room and gate areas.

^{1/}The high ratio of business travelers produces lower than normal baggage per passenger, passenger arrival times nearer flight departure times etc. Also, the ratio of originating vs. connecting passengers is higher.

Two other facilities at National were checked in relation to this study: firstly the present apron areas around the terminal and general airfield operating surfaces were reviewed in terms of adequacy to accommodate wide-body

WASHINGTON NATIONAL AIRPORT

Existing and Conceptual Facilities

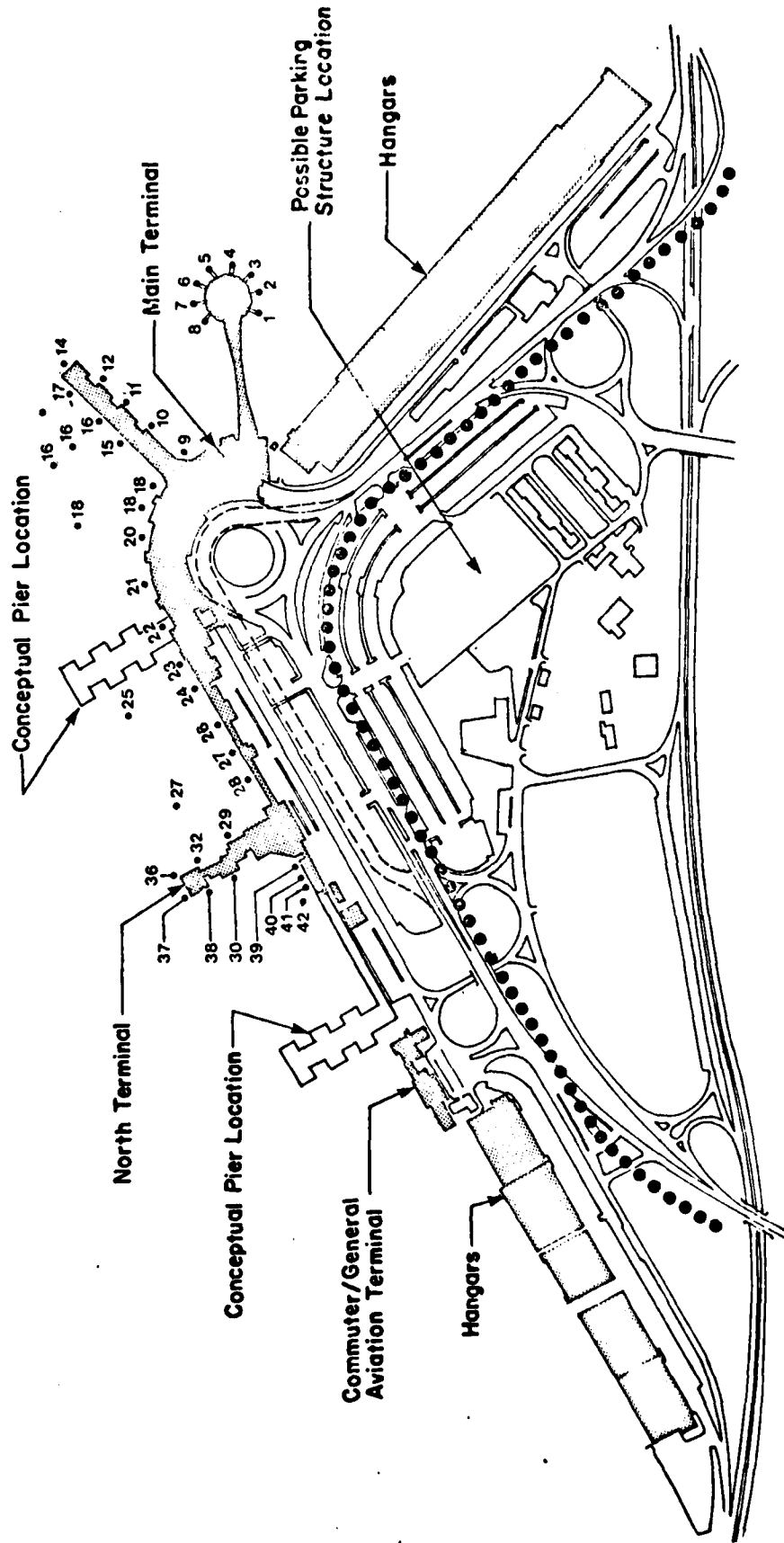
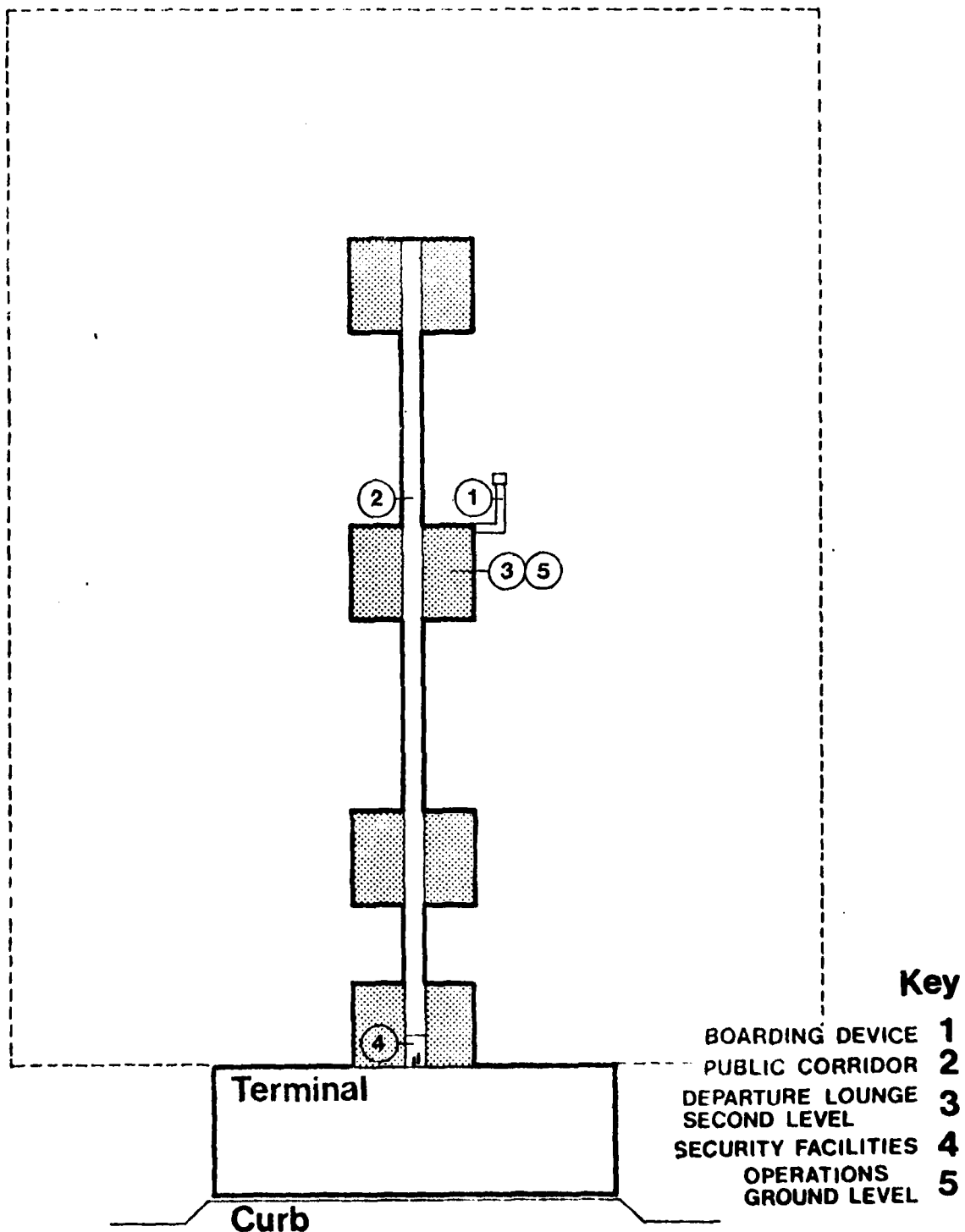


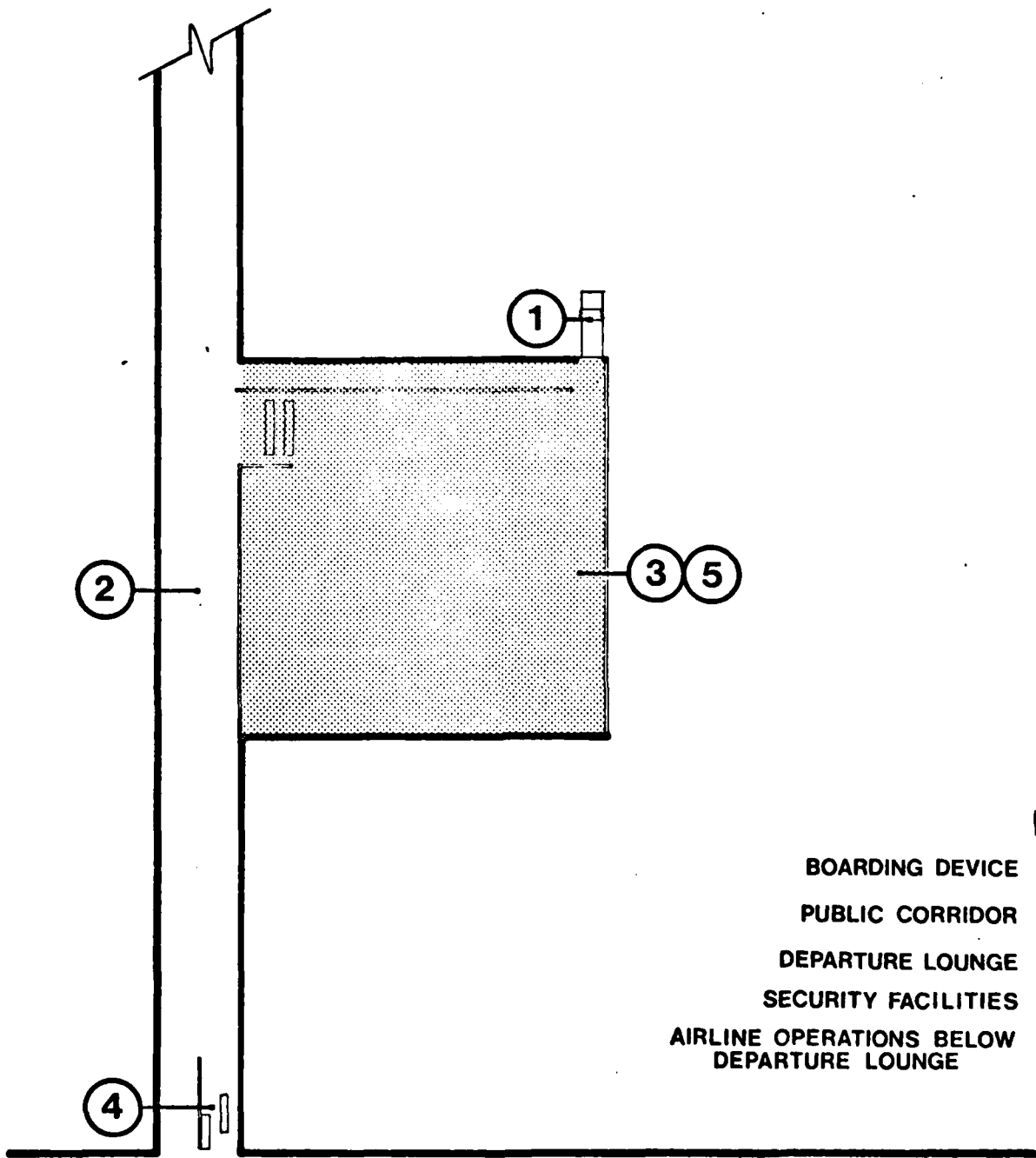
FIGURE 5

FIGURE 6a



CONNECTOR - PIER CONCEPT

Source: Department of Transportation, FAA, Systems Research & Development Service, Washington, D.C., July, 1975.



Terminal

Key	
BOARDING DEVICE	1
PUBLIC CORRIDOR	2
DEPARTURE LOUNGE	3
SECURITY FACILITIES	4
AIRLINE OPERATIONS BELOW DEPARTURE LOUNGE	5

CONNECTOR - PARTIAL PLAN

Source: Department of Transportation, FAA, Systems Research & Development Service, Washington, D.C., July, 1975.

aircraft and it was determined that increasing the fillets would be the only significant change necessary; secondly the Crash Fire and Rescue capabilities to handle large aircraft was reviewed and it was determined that any expense of meeting such needs would be minimal.

Airside: There are 42 gate positions at Washington National Airport, of which 32 are at the Main Terminal and the remaining 10 are at the North Terminal. Allegheny, American, Eastern, Northwest, TransWorld and United comprise the Main Terminal airline tenants with Braniff, Delta, National and Piedmont occupying the North Terminal.

The following gates at the Main Terminal can accommodate wide-bodied aircraft without a loss in total positions:

Gates 1,3,5,7 Northwest, TWA finger
Gates 9,14..... American Airlines finger
Gates 20,23..... Eastern Airlines
Gate 24..... United Airlines

Thus, there are a total of 9 gate positions for use by wide-bodied equipment that would not affect the total of 42 positions. Servicing a wide-body aircraft at the North Terminal would require approximately two gate positions per aircraft. It should be noted that the use of wide-body aircraft on the airfield would require about 8,800 square yards of additional pavement in the fillets.

Terminal Areas: The Washington National Airport terminal complex consists of three elements: the Main Terminal, the North Terminal and the Commuter Airline and General Aviation Terminal. The Main Terminal and the North Terminal are connected. However, the Commuter/General Aviation Terminal is a separate facility located approximately 1,000 feet northwest of the North Terminal. The total square footage of the complex is 607,150 square feet. A detailed inventory of the square footage and function is presented in Table 6.

The introduction of wide-body aircraft will affect the terminal requirements in a number of ways. The primary causal feature of wide-body requirements in the terminal is the surge of passengers generated by the arrival of the aircraft (the surge effect of a departing wide-body is not so pronounced). This surge of passengers would tend to congest corridors and specifically the baggage claim areas. In most cases the airline baggage claim devices are only one half the size recommended to serve wide-body aircraft.

As general guidelines for determining future terminal area requirements at National Airport, the FAA guidelines mentioned earlier of 200 sq. ft. per T.P.H.P., increased 10 percent when wide-body aircraft were introduced, were checked with the standard area requirements per gate. These requirements established for the FAA and published in The Apron & Terminal Building Planning Manual suggest a range of 15,000 - 17,000 square feet per gate for an airport with the number of enplanements as National. This checks favorably with the current conditions and thus was also utilized; the low range was used when no wide-body aircraft were involved and the high range was used for wide-body aircraft gates.

Table 6

TERMINAL AREA INVENTORY

Component	Main Terminal	North Terminal	Subtotal	Commuter Terminal	Total
Ticketing Areas	26,500	9,400	35,900	1,250	37,150
Public-Concourse Related	82,250	8,600	90,850	-0-	90,850
Public-General	70,100	6,050	76,150	8,500	84,650
Passenger Departure Areas	57,350	16,000	73,350	800	74,150
Airline Operations	97,600	15,250	112,850	7,200	120,050
Baggage Claim Areas	10,650	2,100	12,750	-0-	12,750
Baggage Make-up & Breakdown Areas	48,250	4,750	53,000	-0-	53,000
Concessions	46,550	2,900	49,450	350	49,800
Building Services	76,450	650	77,100	7,650	84,750
Totals	515,700	65,700	581,400	25,750	607,150

In a general sense about one half of the current terminal space is in need of major remodeling including HVAC and electrical systems.

The total baggage claim frontage available in the terminal is 695 linear feet. In effect, each airline operating at National Airport has its own baggage claim area (or device). It was assumed that this practice will be continued in the future. In developing the baggage claim device requirements for this exclusive system, it was only necessary to distinguish those modes permitting wide-body operation versus those that do not. The critical peaking factor is not the total peak hour, but each individual peak hour. In any given peak hour in any given mode, it is assumed that each airline would have two arrivals within a 15-20 minute span. Therefore, the requirements are based on the claim frontage needed for two narrow-bodies (baseline, Case 2 and Case 6) or one narrow-body and one wide-body (Cases 13 and 17). It is assumed that all of the airlines, with the exception of Allegheny, Piedmont and the commuters, will be candidate to require the ability to accommodate wide-bodies. The results of this analysis are found in Table 7.

BAGGAGE CLAIM FACILITIES

Airline	LINEAR FEET OF CLAIMING FRONTAGE ^{1/}				
	Existing	Without Wide Bodies (Baseline, Cases 2 & 6)		With Wide Bodies (Cases 13 & 17)	
		Total	New	Total	New
Piedmont	25	100	75	N/A	N/A
National	100	100	0	175	75
Braniff	0	100	100	175	175
Delta	65	100	35	175	110
United	100	100	0	175	75
Eastern	100+	100+			
	40 for Shuttle	40 for Shuttle	0	175	35
Allegheny	45	100	55	N/A	N/A
American	90	90	0	175	85
TWA	65	100	35	175	110
Northwest	65	100	35	175	110
Commuters ^{2/}	0	50	50	N/A	N/A
TOTALS	695	1080	385	1650	955

^{1/} Based on 1.3 average bags per passenger.

^{2/} Commuters currently in their own terminal but it is assumed that they would relocate to Main or North Terminal if adequate space was provided.

Groundside: The capacities of the groundside system serving National Airport are presented in three components - access, curbside and automobile parking facilities.

The access roadway capacity shown below reflects the capacity of the new one-way road scheme scheduled for completion in late 1976. The hourly vehicular capacity of the airport's three major entrance/exit points, based on the 1965 Highway Capacity Manual (Special Report Number 87) and a "D" service level, which is a typical design level for urban streets, is presented in the table below:

<u>Access Road</u>	<u>Peak Hour Capacity</u>
Smith Boulevard North	2,025
Route 233 Viaduct	1,100
Smith Boulevard South	350

The public auto parking facilities can be classified into three categories - short term (metered parking), medium term (Lots 1,2,3 and 4 - all within walking distance to the terminal), and long term (Lot 5, which is referred to as satellite parking). The capacities of these facilities are listed below:

<u>Facility</u>	<u>Capacity (approximate)</u>
Metered Parking	200
Lots 1, 2, 3 and 4	2,500
Satellite Parking	<u>1,000</u>
Total	3,700

Employee parking (3200 spaces) is well distributed throughout the airport.

There is a total of 2,000 linear feet of curb frontage available for private automobiles. The Main Terminal has 1,500 feet curbside and the North Terminal has 500 feet of curb frontage.

B. COST ESTIMATES FOR WASHINGTON NATIONAL TO
MEET CURRENT NEEDS

Upgrading the current facilities at National Airport was considered as a basic cost which would be incurred independent of the policy determination. This realism is evident in the fact that expansion plans are currently being prepared by many of the airlines and prior consultant studies have been funded to determine possible improvements to the ground access. Also, a request is currently being considered to design a parking structure.

The following standards and facilities were determined and analyzed for investment requirements of the current demand.

Airside: Of the current 42 aircraft positions at the airport (discounting commuters), 7 are not "at terminal" positions but instead require that passengers walk across the apron to board the aircraft. Therefore adequate space for 7 more terminal positions should be provided. Standard loading bridges at these positions require an investment of about \$90,000 each or \$630,000.

Terminal: An additional 120,000 square feet of space, probably associated with the seven aircraft positions mentioned above plus some currently planned widening of the northern extension of the Main Terminal, would provide for the current need for additional facilities. ^{1/} Associated with this would be at least one additional complete baggage handling system (Outbound and Inbound). In addition about 50 percent of the existing terminal space needs major remodeling. These costs

^{1/} Estimated space requirements per gate is 15,000 sq. ft. (Source: The Apron and Terminal Building Planning Manual - R.M. Parsons; July 1975) and 15% was added to improve the constriction in the Northern end of the Main Terminal.

are itemized below:

- Additional space		
120,000 sq. ft. shell	=	\$ 4,800,000
60,000 sq. ft. public areas		3,000,000
30,000 sq. ft. administrative	=	<u>1,200,000</u>
Subtotal		\$9,000,000
- Additional baggage system		
Outbound	\$	270,000
Inbound		<u>100,000</u>
Subtotal	\$	370,000
- Remodeling		
300,000 sq. ft.	=	<u>24,000,000</u>
Total Terminal Areas	=	\$33,370,000

Groundside: The current access roadway is inadequate both in capacity and in providing curb space for passenger use. The basic concept therefore assumes a two lane elevated roadway passing along the Main Terminal for a distance of about 1,600 linear feet and containing a segment four lanes wide for a distance of 800 feet. In addition, based upon data presented in a recent access study for National Airport and studies on parking demands at LaGuardia, it was assumed that public parking spaces equivalent to one space per each one thousand annual originating enplaned passengers should be provided at National. Therefore, an additional 1,300 spaces are needed to serve the current demand (based on 5 million annual originating enplanements).

1/ Washington National Airport: Interim Access Improvement Program; HNTB, August 1973.

The costs for these groundside improvements are estimated as follows:

- Elevated Roadway		
800 feet of two lane roadway	= \$	444,800
800 feet of four lane roadway	=	889,600
Ramps 800 feet, two lane	=	<u>444,800</u>
Subtotal		\$1,779,200
- Parking Structure		
1,300 spaces	=	<u>\$6,500,000</u>
Total Groundside		\$8,279,200

The total investment required to meet the current demand can then be summarized as follows:

Current Demand Cost Summary

- Airside	\$	630,000
- Terminal		33,370,000
- Groundside		<u>8,279,200</u>
		\$42,279,200

Based upon the analysis of the 1990 demand forecasts the following basic facility requirements were projected (see Appendix for detailed calculations):

CASE 2 - 1990 COST ANALYSIS

Airside:

- 49 gates required, none for wide-body aircraft
- Requires 14 new positions at the terminal building 9 of which would be equipped with standard loading bridges (5 are for commuter aircraft and no loading bridges are provided.)

Cost:

9 bridges @ \$90,000 = \$810,000.

Terminal:

- 673,000 sq. ft. required based on T.P.H.P.
- 735,000 sq. ft. required based on number of gates.
- Requires two additional baggage handling systems.
- Assumes remodeling of 300,000 sq. ft. of existing terminals.

Cost:

- 128,000 sq. ft. (735,000-607,000)		
100% shell @ \$40/S.F.	=	\$5,120,000
50% Public @ \$50/S.F.	=	3,200,000
25% Administrative @ \$40/S.F.	=	<u>1,280,000</u>
Subtotal <u>1/</u>		\$ 9,600,000
- 300,000 sq. ft. remodel @ \$80/S.F.	=	\$24,000,000
- Baggage handling, 2 systems		
Outbound	=	\$ 540,000
Inbound	=	<u>200,000</u>
Subtotal	=	\$ 740,000
Total Terminal Area	=	\$34,340,000

Groundside:

- Elevated roadway as required to meet the current needs is considered to provide adequate access and curb facilities.

1/ Assumes 25% of space unfinished for HVAC, Mechanical and Electrical Space and so forth.

- Parking for 5.8 million annual enplanements requires approximately 2,100 (5,800 - 3,700) additional spaces; all are assumed to be provided in a parking structure.

Cost:

- Elevated Roadway

800 feet of two lane @ \$556/L.F. = \$ 444,800

800 feet of four lane @ \$1111/L.F.= 889,600

800 feet of two lane ramp @ \$556/L.F.= 444,800

Subtotal \$1,779,200

- Parking Structure

2,100 spaces @ \$5,000/Space = \$10,500,000

Total Groundside = \$12,279,200

CASE 2 COST SUMMARY:

Airside = \$ 810,000

Terminal = 34,340,000

Groundside = 12,279,200

TOTAL = \$47,429,200

CASE 6 - 1990 COST ANALYSIS

Airside:

- 33 gates required, none for wide-body aircraft
- Requires no new gates or loading bridges
- Cost: (None)

Terminal:

- 398,000 sq. ft. required based on T.P.H.P.
- 495,000 sq. ft. required based on number of gates
- Requires no expansion and would suggest that only 118,000 sq. ft. of the existing terminal would require remodeling.
- Cost:
 - 188,000 sq. ft. remodeled @ \$80/S. F. = \$15,040,000

Groundside:

- Elevated roadway is estimated to require two lane section only, for about 1600 feet plus ramps.
- Parking for 2.9 million annual originating passengers can be met by the existing parking facilities.
- Cost:
 - Elevated roadway
 - 1600 feet of two lane @ \$556 /L.F. = \$889,600
 - 800 feet of two lane ramp @ \$556/L.F. = 444,800
 - \$1,334,400

CASE 6 COST SUMMARY:

Airside	=	(None)
Terminal	=	\$15,040,000
Groundside	=	<u>1,334,400</u>
TOTAL	=	\$16,374,400

CASE 13 - 1990 COST ANALYSIS

Airside:

- 52 gates required, 13 gates capable of serving wide-body aircraft. For this mode it was assumed that the nine gates and two loading bridges capable of serving wide-body aircraft would be used. In addition 17 gates would be provided through a terminal expansion project, at least four of which would be capable of serving wide-body equipment.
- The additional loading bridges are expected to include four new telescoping bridges to serve wide-body aircraft and 13 standard, to serve narrow-body planes. In addition seven of the nine existing gates with wide-body handling capability will require a conversion of the loading bridges to handle wide-body aircraft.
- Additionally the taxiway fillets on the airfield must be enlarged to accomodate the larger aircraft. The total requirements are 8,830 square yards of additional pavement.

Cost:

- Loading bridges

7 converted to wide body @ 30,000	=	\$ 210,000
4 new Telescoping @ \$215,000	=	860,000
13 standard for narrow-body @ \$90,000	=	<u>1,170,000</u>
Subtotal	=	\$2,240,000
Fillets 8,830 sq. yd. @ \$40/S.Y.	=	<u>353,200</u>
Total Airside	=	\$2,593,200

Terminal:

- 824,000 sq. ft. required based on T.P.H.P.
- 806,000 sq. ft. required based on number of gates.
- Requires the equivalent of 7 additional baggage handling systems for wide-body use.
- Assumes remodeling of 300,000 sq. ft. of existing terminal space.

Cost:

- 217,000 sq. ft. new terminal	
100% shell @ \$40/S.F.	= \$ 8,680,000
50% public @ \$50/S.F.	= 5,425,000
25% administration @ \$40/S.F.	= 2,170,000
Subtotal 1/	= \$16,275,000
- Remodeling 300,000 sq. ft @ \$80/S.F.	= 24,000,000
- Baggage handling, 7 systems	
Outbound	= 1,890,000
Inbound	= 700,000
Subtotal	= \$ 2,590,000
Total Terminal	= \$42,865,000

Groundside:

- An elevated roadway is assumed and it is estimated that a four lane segment will be required the full length of the main terminal section, 1600 linear feet, plus two ramps each 400 feet in length.
- Parking facilities for the 6.8 million annual originating passengers is assumed to require structural parking for 3,100 (6,800 - 3,700) autos.

Cost:

- Elevated Roadway	
1600 feet of four lane @ \$1111/L.F.	= \$ 1,779,200
800 feet of two lane ramp @ \$556/L.F.	= 444,800
Subtotal	= \$ 2,224,000
- Parking Structure	
3100 spaces @ \$5,000/Space	= \$15,500,000
Total Groundside	= \$17,724,000

CASE 13 COST SUMMARY

Airside	=	\$ 2,593,200
Terminal	=	42,865,000
Groundside	=	<u>17,724,000</u>
TOTAL	=	\$63,182,200

1/ Assumes 25% of space unfinished as noted previously.

CASE 17 - 1990 COST ANALYSIS

Airside:

- 45 gates required, 13 gates capable of serving wide-body aircraft. For this mode it was assumed that the nine gates identified earlier as being capable of handling wide-body aircraft would be used. One additional wide-body gate can be provided by using two of the gates at the North Terminal. This leaves a need for 13 new gate positions of which at least three should be able to accommodate wide-body planes.
- Loading bridges at 8 of the 10 existing gates to be used for wide-bodies must be converted for their use. Of the new gates, 3 should be equipped with telescoping loading bridges for wide-body aircraft and the remaining 10 can be standard narrow-body aircraft service type.
- Additionally, taxiway fillets must be enlarged on the airfield for use by wide-body aircraft. The requirement for pavement in these fillets is estimated at 8,830 square yards.

Cost:

- Loading Bridges

10 converted for wide-body use @ \$30,000	= \$	300,000
3 new telescoping @ \$215,000	=	645,000
10 new standard for narrow body use @ \$90,000	=	<u>900,000</u>
Subtotal	=	\$1,845,000

- Fillets 8,830 sq.yds. @ \$40/S.Y.	=	<u>353,000</u>
Total Airside	=	\$2,198,000

Terminal:

- 719,000 sq. ft. required based on T.P.H.P.
- 701,000 sq. ft. required based on number of gates,
- Requires the equivalent of 6 additional baggage handling systems to serve wide-body aircraft plus additional gate positions.

- Assumes 300,000 sq. ft. of the existing terminal must be remodeled.

Cost:

- 112,000 sq. ft. new terminal	
100% shell @ \$40/S.F.	= \$ 4,480,000
50% public @ \$50/S.F.	= 2,800,000
25% administrative @ \$40/S.F.	= <u>1,120,000</u>
Subtotal <u>1/</u>	= \$ 8,400,000
- Remodeling 300,000 sq.ft. @ \$80/S.F.	= 24,000,000
- Baggage handling, 6 systems	
Outbound	= 1,620,000
Inbound	= <u>600,000</u>
Subtotal	= \$ <u>2,220,000</u>
Total Terminal	= \$34,620,000

Groundside:

- An elevated roadway is assumed necessary and is estimated to require four lanes of pavement for a 1,600 foot segment along the main terminal. An additional 800 feet of two lanes will be required in the ramps.
- The 7.0 million annual originating passengers are estimated to require 3,300 (7,000 - 3,700) new parking spaces in a parking structure.

Cost:

- Elevated Roadway	
1600 feet of four lane @ \$1111/L.F.	= \$ 1,779,200
800 feet of two lane ramp @ \$556/L.F.	= <u>444,800</u>
Subtotal	= \$ 2,224,000
- Parking Structure	
3,300 spaces @ \$5000/Space	= <u>16,500,000</u>
Total Groundside	= \$18.724,000

1/ Assumes 25% of space unfinished as noted previously.

CASE 17 COST SUMMARY

Airside	=	\$ 2,198,000
Terminal	=	34,620,000
Groundside	=	<u>18,724,000</u>
TOTAL	=	\$55,542,000

VII. Baltimore - Washington International Airport

A \$64.5 million terminal remodeling program, which will be completed in 1978, is underway at the Baltimore-Washington International Airport. The design for the new terminal will provide approximately 700,000 square feet of terminal area and 26 aircraft gates. The airport also operates two transporters (Plane-Mates). The design capacity of the expanded terminal is 11.2 million annual passengers. This is equivalent to approximately 3,500 passengers during a typical peak hour. The required gate positions will be determined by the gates per peak hour departure relationships established in the analysis of National Airport.

For the purpose of analyzing alternative system concepts, the following data and assumptions were used:

- Terminal area requirements
 - 15,000 to 17,000 square feet per gate
 - 220 square feet per T.P.H.P.
- Cost per square foot of terminal: \$92.00 (including all terminal related items; e.g. roadway, baggage handling system, loading bridges, etc.)

BWI's facility requirements, based on the demand presented in the DEMAND PROFILE Chapter, are summarized in the following table (see Appendix for detailed calculations):

TERMINAL REQUIREMENTS

CASE	Current Program		Terminal Requirements		
	Terminal S.F.	No of Gates ^{1/}	S.F. Based On T.P.H.P.	S.F. Based on Gate Requirements	No of Gates ^{2/}
2	700,000	26	552,000	690,000	44
6	700,000	26	609,000	705,000	45
13	700,000	26	572,000	690,000	44
17	700,000	26	575,000	705,000	45

1/ The airport also operates two transporters (Plane-Mates).

2/ All modes require 15 wide-body gates.

It should be pointed out that in no case do the projections in this analysis exceed the annual or peak hour passenger design levels employed in the current construction program. As can be seen from the above table, the planned terminal square footage will adequately satisfy the projected demand. The airport may require some additional gates or transporters. However, the projected gate requirement may be met by joint use (or common use) of gates. For example, the calculations in the table are based on a 60 percent gate occupancy factor. If the factor can be increased to 90 percent then no additional gates will be needed. In fact, the State of Maryland has standardized all functional installations throughout the holdrooms and gate positions to provide flexibility in common utilization of facilities when needed. Therefore, the current program of \$64.5 million will be adequate to accommodate the future demand in all of the five modes studied.

VIII. Dulles International Airport

The Dulles Airport passenger terminal is vastly different from National in concept and utilization patterns. At Dulles, the 188,000 square feet of passenger access area constitutes 63 percent of the total terminal area (300,000 square feet). The combination of transporters and ground level passenger gates is the primary factor permitting the more favorable length to width relationship and a more uniform distribution of people throughout the terminal. The initial design (1964) contemplated about 224 square feet per T.P.H.P. for gross terminal area. These areas compare very closely with the FAA's terminal requirements standards issued in 1967 for conventional terminal concepts. Experience with the terminal has generally indicated a capability of greater efficiency to the point that 170 square feet per T.P.H.P. appears more reasonable. 1/

The use of the transporter concept eliminates, to a large extent, the concern for aircraft positioning at terminal gates. Terminal gates are, however, needed to serve the smaller aircraft (30-95 seats). The larger aircraft plus some of the 95 seat configuration can be served by the transporters. The number of transporters that will service a specific aircraft will be determined to a large extent by the size of the aircraft, the boarding load factor, and the type of transporter.

The cost of expansion of the Dulles terminal will depend to a large extent upon the type of construction. The increase in terminal space requirements expected in the

1/ National Capital Airports, by James Wilding, 1972.

future justify some deviation from the current terminal concept. Previous analyses of the terminal reflecting this very consideration are utilized in this study.^{1/} The future terminal expansions at Dulles are therefore projected to occur in two forms, the "main terminal" concept, and a "low profile" concept. The "main terminal" concept is merely an extension of the current type of terminal building. Some additional space can be accommodated in a "low profile" terminal concept which would serve primarily the deplaning passengers. These concepts afford savings in costs as well as providing aesthetic variation possibilities for the future terminal design.

The present concept and low profile expansion are estimated at \$111 per square foot and \$93 per square foot respectively in 1976 constant dollars. The cost of a new transporter is estimated at \$535,000.

1/References: Dulles International Airport Master Plan Report; FAA, 1964.
The Future of Washington's Airports; Metropolitan Washington Council of Governments, 1975.

For the purpose of the comparative analyses, the following data are utilized in this study for Dulles:

- Present gross terminal area = 300,000 square feet
- Transporter docking space = 24 spaces
- Terminal gates = 10
- Aircraft parking positions (Jet Ramp) = 30
- Automobile parking spaces = 3,400
- Transporters = 33 (21 mobile lounges and 12 Plane-Mates)
- Gross terminal area per T.P.H.P. = 170 square feet
- Transporters, aircraft parking positions and terminal gate utilization:

<u>Aircraft Size</u>	<u>Transporters Per Peak Hour Departure 1/</u>		<u>Gates or Aircraft Parking Positions Per Peak Hour Departure 2/</u>
	<u>50-80 Passenger Capacity 3/</u>	<u>85-120 Passenger Capacity 4/</u>	
95 seats or less	1	1	1.50
125	2	1	1.72
200	3	2	2.17
250	4	3	2.50
350	5	4	3.11

1/ To account for possible low average utilization per vehicle in the transporter operations due to airline schedule imbalances and to allow flexibility for such things as equipment down time, a spare transporter should be available for each five in operation.

2/ Assumes 60 percent gate occupancy factor.

3/ Older mobile lounge capacity.

4/ New Plane-Mate capacity.

Using the demand presented in Tables 4a - 4e the requirements for Dulles International Airport are summarized below (detailed calculations are presented in the Appendix).

CASE	Terminal Space (S.F.)			Total Trans- porters	Total A/C Parking Po- sitions or Gates	Total Auto Parking Spaces
	Main <u>1/</u> Terminal	Low Profile	Total			
2	480,000	203,000	683,000	54	46	6,800
6	480,000	532,000	1,012,000	65 <u>2/</u>	84	12,700
13	480,000	200,000	680,000	56	52	5,100
17	480,000	187,000	667,000	56	52	7,500

1/ Includes constant 300,000 S.F. existing space.

2/ In Case 6, the peak hour in terms of passenger enplanements (or deplanements) does not coincide with the peak hour in terms of aircraft departures (or arrivals) as explained in the section on DEMAND PROFILE).

The cost of the additional facilities required is detailed in the Appendix and summarized in the table below:

CASE	Terminal <u>1</u> / Building (\$ Millions)	Transporters and Apron <u>2</u> / (\$ Millions)	Auto <u>3</u> / Parking (\$ Millions)	Total (\$ Millions)
2	38.9	T.P.* + Apron Tot. 7.9 2.4 10.3	6.8	56.0
6	69.5	12.0 11.5 23.5	12.7	105.7
13	38.6	8.6 3.8 12.4	5.1	56.1
17	37.4	8.6 3.8 12.4	7.5	57.3

*T.P. (Transporters)

1/ All modes include \$20.0 million for Main Terminal construction. Difference is all for low profile construction.

2/ All new transporters are assumed to be the larger Plane-Mate type equipment.

3/ Future auto parking is assumed to be all on-grade.

IX. Appendix

WASHINGTON NATIONAL AIRPORT
CALCULATIONS

1990 DCA SUMMARY OF TERMINAL BUILDING REQUIREMENTS
(BASED ON T.P.H.P. FACTOR)

<u>CASE</u>	<u>TOTAL 1/ REQUIREMENTS (S.F.)</u>	<u>NEW CONSTRUCTION REQUIRED (S.F.)</u>
2	673,000	66,000
6	398,000	None
13	824,000	217,000
17	719,000	112,000

1/ Square footage of existing terminal building
(including Main, North and Commuter Terminals) =
607,000 S.F.

1990

DCA

CASE 2

Terminal Square Footage

Gross Terminal Area = T.P.H.P. x utilization factor
= 3,365 x 200 S.F./T.P.H.P.
= 673,000 S.F.

Total New Construction = Gross Area - Existing Area
= 673,000 S.F. - 607,000 S.F.
= 66,000 S.F.

1990

DCA

CASE 6

Terminal Square Footage

Gross Terminal Area = T.P.H.P. x utilization factor
= 1,992 x 200 S.F./T.P.H.P.
= 398,000 S.F.

Total New Construction = Gross Area - Existing Area
= 398,000 S.F. - 607,000 S.F.
= None

Terminal Square Footage

Gross Terminal Area = T.P.H.P. x utilization factor
= 3,745 x 220 S.F./T.P.H.P.
= 824,000 S.F.

Total New Construction = Gross Area - Existing Area
= 824,000 S.F. - 607,000 S.F.
= 217,000 S.F.

1990

DCA

CASE 17

Terminal Square Footage

Gross Terminal Area = T.P.H.P. x utilization factor
= 3,267 x 220 S.F./T.P.H.P.
= 719,000 S.F.

Total New Construction = Gross Area - Existing Area
= 719,000 S.F. - 607,000 S.F.
= 112,000 S.F.

1990

DCA

SUMMARY OF TERMINAL BUILDING REQUIREMENTS
(BASED ON GATE REQUIREMENTS)

<u>CASE</u>	<u>TOTAL 1/ REQUIREMENTS (S.F.)</u>	<u>NEW CONSTRUCTION REQUIRED (S.F.)</u>
2	735,000	128,000
6	495,000	None
13	806,000	199,000
17	701,000	94,000

1/ Square footage of existing terminal building (including Main, North and Commuter Terminals) = 607,000 S.F.

1990

DCA

CASE 2

Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements

49 Gates x 15,000 S.F./Gate = Terminal S.F.

= 735,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.

0 Gates x 17,000 S.F./Gate = Terminal S.F.

= 0 S.F.

Total Terminal Required = 735,000 S.F.

1990

DCA

CASE 6

Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirement

33 Gates x 15,000 S.F./Gate = Terminal S.F.

= 495,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.

0 Gates x 17,000 S.F./Gate = Terminal S.F.

= 0 S.F.

Total Terminal Required = 495,000 S.F.

1990

DCA

CASE 13

Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements

39 Gates x 15,000 S.F./Gate = Terminal S.F.

= 585,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.

13 Gates x 17,000 S.F./Gate = Terminal S.F.

= 221,000 S.F.

Total Terminal Required = 806,000 S.F.

1990

DCA

CASE 17

Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements

32 Gates x 15,000 S.F./Gate = Terminal S.F.

= 480,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.

13 Gates x 17,000 S.F./Gate = Terminal S.F.

= 221,000 S.F.

Total Terminal Required = 701,000 S.F.

BALTIMORE-WASHINGTON INTERNATIONAL AIRPORT
CALCULATIONS

1990

BWI

CASE 2

A. Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements
29 Gates x 15,000 S.F./Gate = Terminal S.F.
= 435,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.
15 Gates x 17,000 S.F./Gate = Terminal S.F.
= 255,000 S.F.

Total Terminal Required = 690,000 S.F.

B. Terminal Square Footage based on T.P.H.P.

Gross Terminal Area = T.P.H.P. x Utilization Factor
= 2,508 x 220 S.F./T.P.H.P.
= 552,000 S.F.

C. Terminal Gates

<u>AIRCRAFT</u>	x	<u>PEAK HOUR FACTOR</u>	=		<u>GATE REQUIREMENT</u>
30 Seats -	5	x 1.12	=	5.60 OR	6
50 Seats -	1	x 1.22	=	1.22 OR	2
95 Seats -	11	x 1.50	=	16.50 OR	17
125 Seats -	2	x 1.72	=	3.44 OR	4
200 Seats -	0	x 2.17	=		0
250 Seats -	6	x 2.50	=	15.00 OR	<u>15</u>
TOTAL GATES REQUIRED				=	44

1990

BWI

CASE 6

A. Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirement:
30 Gates x 15,000 S.F./Gate = Terminal S.F.
= 450,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.
15 Gates x 17,000 S.F./Gate = Terminal S.F.
= 255,000 S.F.

Total Terminal Required = 705,000 S.F.

B. Terminal Square Footage based on T.P.H.P.

Gross Terminal Area = T.P.H.P. x Utilization Factor
= 2,768 x 220 S.F./T.P.H.P.
= 609,000 S.F.

C. Terminal Gates

<u>AIRCRAFT</u>	x	<u>PEAK HOUR FACTOR</u>	=		<u>GATE REQUIREMENT</u>
30 Seats	4	x 1.12	=	4.48 OR	5
50 Seats	1	x 1.22	=	1.22 OR	2
95 Seats	12	x 1.50	=	18.00 OR	18
125 Seats	1	x 1.72	=	1.72 OR	2
200 Seats	1	x 2.17	=	2.17 OR	3
250 Seats	6	x 2.50	=	15.00 OR	<u>15</u>
TOTAL GATES REQUIRED =					45

1990

BWI

- CASE-13

A. Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements
29 Gates x 15,000 S.F./Gate = Terminal S.F.
= 435,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.
15 Gates x 17,000 S.F./Gate = Terminal S.F.
= 255,000 S.F.

Total Terminal Required = 690,000 S.F.

B. Terminal Square Footage based on T.P.H.P.

Gross Terminal Area = T.P.H.P. x Utilization Factor
= 2,598 x 220 S.F./T.P.H.P.
= 572,000 S.F.

C. Terminal Gates

<u>AIRCRAFT</u>	x	<u>PEAK HOUR FACTOR</u>	=		<u>GATE REQUIREMENT</u>
30 Seats	- 5	x 1.12	=	5.60 OR	6
50 Seats	- 1	x 1.22	=	1.22 OR	2
95 Seats	- 10	x 1.50	=	15.00 OR	15
125 Seats	- 3	x 1.72	=	5.16 OR	6
200 Seats	- 0	x 2.17	=		0
250 Seats	- 6	x 2.50	=	15.00 OR	<u>15</u>

TOTAL GATES REQUIRED = 44

1990

BWI

-CASE 17

A. Terminal Square Footage based on Gate Requirements

No. of Narrow-Body Gates x 15,000 S.F./Gate = Terminal Area Requirements
30 Gates x 15,000 S.F./Gate = Terminal S.F.
= 450,000 S.F.

No. of Wide-Body Gates x 17,000 S.F./Gate = Terminal S.F.
15 Gates x 17,000 S.F./Gate = Terminal S.F.
= 255,000

Total Terminal Required = 705,000

B. Terminal Square Footage based on T.P.H.P.

Gross Terminal Area = T.P.H.P. x Utilization Factor
= 2,613 x 220 S.F./T.P.H.P.
= 575,000 S.F.

C. Terminal Gates

<u>AIRPORT</u>	x	<u>PEAK HOUR FACTOR</u>	=		<u>GATE REQUIREMENT</u>
30 Seats -	4	x 1.12	=	4.48 OR	5
50 Seats -	1	x 1.22	=	1.22 OR	2
95 Seats -	11	x 1.50	=	16.50 OR	17
125 Seats -	3	x 1.72	=	5.16 OR	6
200 Seats -	0	x 2.17	=		0
250 Seats -	6	x 2.50	=	15.00 OR	<u>15</u>
				TOTAL GATES REQUIRED =	45

DULLES INTERNATIONAL AIRPORT
CALCULATIONS

1990

IAD

CASE 2

A. Terminal Square Footages

Gross Terminal Area = T.P.H.P. x utilization factor
= 4,018 x 170 S.F./T.P.H.P.
= 683,000 S.F.

New Construction = Gross Terminal Area - Existing Area
= 683,000 S.F. - 300,000 S.F.
= 383,000 S.F.

B. Terminal Costs

Expansion using the present terminal design
= 180,000 S.F. x \$111/S.F.
= \$20.0 Million

Expansion using low profile terminal design
= (New construction - 180,000 S.F.) x \$93/S.F.
= (383,000 S.F. - 180,000 S.F.) x \$93/S.F.
= 203,000 S.F. x \$93/S.F.
= \$18.9 Million

Terminal Cost = Present design + low profile
= \$20.0 Million + \$18.9 Million
= \$38.9 Million

C. Gate and Transporter Requirements

No. of Gates:

10 Gates
1.50 (Peak Hour Factor) = 6.7 or 6 Aircraft

6 95 Seats
6 Aircraft
(3 95 seats must use Transporters)

No. of Transporters:

<u>AIRCRAFT</u>	X	<u>TRANSPORTERS PER</u>		=	<u>TRANSPORTERS REQUIRED</u>	
		<u>50-80 PAX</u> <u>CAPACITY</u>	<u>85-120 PAX</u> <u>CAPACITY</u>		<u>50-80 PAX</u> <u>Capacity</u>	<u>85-120 PAX</u> <u>CAPACITY</u>
95 Seats	3	x	1	-	3	-
125 Seats	1	x	2	-	2	
250 Seats	12	x	4	3	<u>16</u>	<u>24</u>
Total Each Type Required					21	24
Total Transporters						45
Spares <u>1/</u>						<u>9</u>
Total Transporters Required						54
Total On Hand						33 <u>2/</u>
New Transporters Required						21

Cost = New Transporters X \$375,000
= 21 X \$375,000
= \$7,875,000

- 1/ Assumes one space for every five used.
2/ 21 mobile lounges (50-80 passenger capacity)
11 Plane mates (85-120 passenger capacity)
33 Total transporters.

D. Aircraft Parking Positions

<u>AIRCRAFT</u>		<u>PEAK HOUR FACTOR</u>	=	<u>AIRCRAFT POSITIONS</u>		<u>PARKING REQUIRED</u>
95 Seats (or less)	9	x 1.50	=	13.50	OR	14
125 Seats	1	x 1.72	=	1.72	OR	2
200 Seats	0	x 2.17	=	0	OR	0
250 Seats	12	x 2.50	=	30.00	OR	30
350 Seats	0	x 3.11	=	0	OR	0

Total Parking Positions Required = 46

Number of Peak Hour Departures at Terminal Gates = 6

Total Parking Positions To Be Served by Transporters = 40

Existing Parking Positions = 30

New Positions Required = 10

Cost = New Positions x 6,000 S.Y. x \$40.00/S.F.
 = 10 x 6,000 x \$40.00
 = \$2.4 Million

1990

IAD

CASE 6

A. Terminal Square Footages

Gross Terminal Area = T.P.H.P. x utilization factor
= 5,952 x 170 S.F./T.P.H.P.
= 1,012,000 S.F.

New Construction = Gross Terminal Area - Existing Area
= 1,012,000 S.F. - 300,000 S.F.
= 712,000 S.F.

B. Terminal Costs

Expansion using the present terminal design
= 180,000 S.F. x \$111/S.F.
= \$20.0 Million

Expansion using low profile terminal design
= (New construction - 180,000 S.F.) x
\$93/S.F.
= (\$712,000 S.F. - 180,000 S.F.) x \$93/S.F.
= 532,000 S.F. x \$93/S.F.
= \$49.5 Million

Terminal Cost = Present Design + Low Profile
= \$20.0 Million + \$49.5 Million
= \$69.5 Million

C. Gate and Transporter Requirements

No. of Gates:

$$\frac{10 \text{ Gates}}{1.50 \text{ (Peak Hour Factor)}} = 6.7 \text{ or } 6 \text{ Aircraft}$$

1 50 Seats
5 95 Seats
6 Aircraft

(22 95 seats must use transporters)

No. of Transporters:

AIRCRAFT	X	TRANSPORTERS PER P.H. DEP.		= TRANSPORTERS REQUIRED	
		50-80 PAX CAPACITY	85-120 PAX CAPACITY	50-80 PAX CAPACITY	85-120 PAX CAPACITY
95 Seats	22 x	1	1	21	1
125 Seats	13 x	-	1	-	13
200 Seats	3 x	-	2	-	6
250 Seats	3 x	-	3	-	9
350 Seats	1 x	-	4	-	4
Total Each Type Required				21	33
Total Transporters				54	
Spares 1/				11	
Total Transporters Required				65	
Total on Hand				33 2/	
New Transporters Required				32	

Cost = New Transporters X \$375,000
 = 32 X \$375,000
 = 12,000,000

1/ Assumes one space for every five used.

2/ 21 mobile lounges (50-80 passenger capacity)
 11 Plane-Mates (85-120 passenger capacity)

3/ Total Transporters

D. Aircraft Parking Positions

<u>AIRCRAFT</u>		<u>PEAK HOUR FACTOR</u>	=	<u>AIRCRAFT POSITIONS</u>		<u>PARKING REQUIRED</u>
95 Seats (or less)	28	x 1.50	=	42.00	OR	42
125 Seats	13	x 1.72	=	22.36	OR	23
200 Seats	3	x 2.17	=	6.51	OR	7
250 Seats	3	x 2.50	=	7.50	OR	8
350 Seats	1	x 3.11	=	3.11	OR	4

Total Parking Positions Required = 84

Number of Peak Hour Departures at Terminal Gates = 6

Total Parking Positions To Be Served by Transporters = 78

Existing Parking Positions = 30

New Positions Required = 48

Cost = New Positions x 6,000 S.Y. x \$40.00/S.F.
 = 48 x 6,000 x \$40.00
 = \$11.5 Million

1990

IAD

CASE 13

A. Terminal Square Footages

Gross Terminal Area = T.P.H.P. x utilization factor
= 4,000 x 170 S.F./T.P.H.P.
= 680,000 x S.F.

New Construction = Gross Terminal Area - Existing Area
= 680,000 S.F. - 300,000 S.F.
= 380,000 S.F.

B. Terminal Costs

Expansion using the present terminal design
= 180,000 S.F. x \$111/S.F.
= \$20.0 Million

Expansion using low profile terminal design
= (New construction - 180,000 S.F.) x \$93/S.F.
= (380,000 S.F. - 180,000 S.F.) x \$93/S.F.
= 200,000 S.F. x \$93/S.F.
= \$18.6 Million

Terminal Cost = Present design + low profile
= \$20.0 Million + \$18.6 Million
= \$38.6 Million

C. Gate and Transporter Requirements

No. of Gates:

10 Gates
1.50 (Peak Hour Factor) = 6.7 or 6 Aircraft

3 30 Seats
 3 95 Seats
6 Aircraft

(5 95 seats must use transporters)

No. of Transporters:

<u>AIRCRAFT</u>	X	<u>TRANSPORTERS PER P.H. DEP.</u>		=	<u>TRANSPORTERS REQUIRED</u>	
		<u>50-80 PAX CAPACITY</u>	<u>85-120 PAX CAPACITY</u>		<u>50-80 PAX CAPACITY</u>	<u>85-120 PAX CAPACITY</u>
95 Seats	5 x	1	-	5	-	
125 Seats	2 x	2	-	4	-	
200 Seats	1 x	3	-	3	-	
250 Seats	11 x	4	3	8	27	
Total Each Type Required				20	27	
Total Transporters				47		
Spares <u>1/</u>				9		
Total Transporters Required				56		
Total on Hand				33	<u>2/</u>	
New Transporters Required				23		

Cost = New Transporters X \$375,000
 = 23 X \$375,000
 = \$8,625,000

1/ Assumes one spare for every five used.

2/ 21 mobile lounges (50-80 passenger capacity)
11 Plane-Mates (85-120 passenger capacity)

33 Total Transporters

D. Aircraft Parking Positions

<u>AIRCRAFT</u>	<u>PEAK HOUR FACTOR</u>	=	<u>AIRCRAFT POSITIONS</u>		<u>PARKING REQUIRED</u>
95 Seats (or less)	11 x 1.50	=	16.50	OR	17
125 Seats	2 x 1.72	=	3.44	OR	4
200 Seats	1 x 2.17	=	2.17	OR	3
250 Seats	11 x 2.50	=	27.50	OR	28
350 Seats	0 x 3.11	=	0	OR	0

Total Parking Positions
Required = 52

Number of Peak Hour
Departures at Terminal
Gates = 6

Total Parking Positions
To Be Served by Trans-
porters = 46

Existing Parking Positions = 30

New Positions Required = 16

Cost = New Positions x 6,000 S.Y. x \$40.00/S.F.
= 16 x 6,000 x \$40.00
= \$3.8 Million

1990

IAD

CASE 17

A. Terminal Square Footages

Gross Terminal Area = T.P.H.P. x utilization factor
= 3,923 x 170 S.F./T.P.H.P.
= 667,000 S.F.

New Construction = Gross Terminal Area - Existing Area
= 667,000 S.F. - 300,000 S.F.
= 367,000 S.F.

B. Terminal Costs

Expansion using the present terminal design
= 180,000 S.F. x \$111/S.F.
= \$20.0 Million

Expansion using low profile terminal design
= (New construction - 180,000 S.F.) x \$93/S.F.
= (367,000 S.F. - 180,000 S.F.) x \$93/S.F.
= 187,000 S.F. x \$93/S.F.
= \$17.4 Million

Terminal Cost = Present design + low profile
= \$20.0 Million + \$17.4 Million
= \$37.4 Million

C. Gate and Transporter Requirements

No. of Gates:

$$\frac{10 \text{ Gates}}{1.50 \text{ (Peak Hour Factor)}} = 6.7 \text{ or } 6 \text{ Aircraft}$$

3 30 Seats
 3 95 Seats
 6 Aircraft

(5 95 seats must use transporters)

No. of Transporters:

<u>AIRCRAFT</u>	X	TRANSPORTERS PER P.H. DEP.		=	TRANSPORTERS REQUIRED	
		<u>50-80 PAX CAPACITY</u>	<u>85-120 PAX CAPACITY</u>		<u>50-80 PAX CAPACITY</u>	<u>85-120 PA CAPACITY</u>
95 Seats	5 x	1	-	5	-	
125 Seats	2 x	2	-	4	-	
200 Seats	1 x	3	-	3	-	
250 Seats	11 x	4	3	8	27	
Total Each Type Required				20	27	
Total Transporters					47	
Spares <u>1/</u>					9	
Total Transporters Required					56	
Total on Hand					33 <u>2/</u>	
New Transporters Required					23	

$$\begin{aligned} \text{Cost} &= \text{New Transporters} \times \$375,000 \\ &= 23 \times \$375,000 \\ &= \$8,625,000 \end{aligned}$$

1/ Assumes one space for every five used.

2/ 21 mobile lounges (50-80 passenger capacity)
 11 Plane-Mates (85-120 passenger capacity)

33 Total Transporters

D. Aircraft Parking Positions

<u>AIRCRAFT</u>		<u>PEAK HOUR</u> <u>FACTOR</u>	=	<u>AIRCRAFT</u> <u>POSITIONS</u>		<u>PARKING</u> <u>REQUIRED</u>
95 Seats (or less)	11	x 1.50	=	16.50	OR	17
125 Seats	2	x 1.72	=	3.44	OR	4
200 Seats	1	x 2.17	=	2.17	OR	3
250 Seats	11	x 2.50	=	27.50	OR	28
350 Seats	0	x 3.11	=	0	OR	0

Total Parking Positions Required = 52

Number of Peak Hour Departures at Terminal Gates = 6

Total Parking Positions To Be Served by Transporters = 46

Existing Parking Positions = 30

New Positions Required = 16

Cost = New Positions x 6,000 S.Y. x \$40.00/S.F.
 = 16 x 6,000 x \$40.00
 = \$ 3.8 Million

IAD AUTO PARKING REQUIREMENTS

- Present capacity = 3,400
- Demand Factor = 2.2 Per 1,000 Originating Passengers
- Cost at \$1,000 per space

<u>Case</u>	<u>Originating Pax. (000)</u>	<u>Auto Parking Demand</u>	<u>Additional Spaces Required</u>	<u>Cost (\$ Millions)</u>
2	4,639	10,200	6,800	6.8
6	7,303	16,100	12,700	12.7
13	3,864	8,500	5,100	5.1
17	4,949	10,900	7,500	7.5