Washington Dulles International Airport

Capacity Plan

October 1990

Prepared jointly by:
U.S. Department of Transportation
Federal Aviation Administration
Metropolitan Washington Airports Authority,
Air Transport Association, and Airlines serving Dulles.
Photographs courtesy of Victoria E. Pannell, MWAA, and the Washington Airports Task Force.

Executive Summary

The Washington Dulles (IAD) Capacity Design Team was formed to evaluate potential airport capacity enhancement and delay reduction options at IAD. The analysis was limited to the airfield and its immediate airspace, composed of the common approach and departure corridors.

The Design Team recommendations identify several improvements at Washington Dulles International Airport which will enhance capacity and reduce flight delays. These recommendations are based on the potential cost savings and delay reduction benefits. The Design Team considers the technical feasibility of airport development, the application of new technology and new airspace procedures. Environmental, political and social-economic considerations of capacity projects are studied in subsequent airport master planning and associated forums.

During 1987, Dulles handled 289,167 aircraft operations and over 5.3 million passenger enplanements. From this historical data, the Design Team established three annual traffic levels as benchmarks to represent the expected growth in aircraft operations. This document will retain its validity until the last benchmark is reached — regardless of how rapidly that may occur.

The first benchmark reflects activity level of 320,000 annual operations and 1,000 daily operations. The other benchmarks represent 400,000 and 450,000 annual operations; 1,250 and 1,406 daily operations, respectively.

The Design Team studied[1,2] 23 proposals for increasing capacity and reducing delays.

Based on the Design Team analysis, the simulated items providing the greatest measurable delay savings are:

Delay Reduction Options	**320,000 OPS**	**400,000 OPS**	**450,000 OPS**
<u>Airfield Improvements</u>			
(1) Construct Runway 1W/19W, 3,500' West of 1L/19R (Includes Benefit of Triple Simultaneous Precision Approaches)	Not Simulated	3,860 ($ 5.3)	6,230 ($ 8.5)
(2) Construct Runway 12R/30L, South of 12/30			
With 1.5 NM Staggered Approaches to Existing Parallels	Not Simulated	2,700 ($ 3.7)	6,950 ($ 9.5)
With Simultaneous Approaches to Existing Parallels	Not Simulated	3,600 ($ 4.9)	8,370 ($ 11.4)
Portion of Above Savings Due to 30L in NW Operation	Not Simulated	2,450 ($ 3.3)	6,560 ($ 9.0)
<u>Facility and Equipment Improvements</u>			
(17) Touchdown RVR & Touchdown Zone Lights on Runway 1L	300 ($ 0.4)	1,910 ($ 2.6)	3,560 ($ 4.9)
<u>Operational Improvements</u>			
(19) Simultaneous ILS Approaches to Existing Parallel Runways	310 ($ 0.4)	900 ($ 1.2)	1,420 ($ 1.9)
(20) Simultaneous Converging Instrument Approaches (SCIA) To Runways 12 & 19R, or 12 & 19L	160 ($ 0.2)	560 ($ 0.8)	980 ($ 1.3)
<u>User Options</u>			
(23) Improve Reliever Airports			
Reduce Small-Slow Aircraft by 25%	640 ($ 0.9)	2,800 ($ 3.8)	4,680 ($ 6.4)
Reduce Small-Slow Aircraft by 50%	1,170 ($ 1.6)	4,420 ($ 6.0)	7,900 ($ 10.8)

THE SAVINGS ARE NOT NECESSARILY ADDITIVE

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1. Using computer simulation and modeling to compare various alternatives, the FAA Technical Center's Aviation Capacity Branch was responsible for the technical support. For each proposal simulated, the potential dollar savings were based on aircraft delay and the average direct operating cost for the IAD fleet mix. Aircraft delay is the difference between (1) the actual time an aircraft takes to perform an operation, and (2) the time it would take to perform that operation without interference from other aircraft in the immediate area. The average direct operating cost for the IAD fleet mix was $1,365 per hour in 1988 dollars.
2. The benefits of other delay reduction options were narrated. Delay savings were not calculated for these items because they were underway, completed, or better suited to a verbal description than computer simulation:
   - Widen turnback fillets on Runways 1L and 19L.
   - Complete construction of east/west Taxiway R-2.
   - Add GA exits to Runways 19R and 19L.
   - Extend Runway 12/30 southeast and enlarge 30's holding pad.
   - Add 19R staging improvements.
   - Add midfield ramp.
   - Add centerfield north/south taxiway.
   - Phase 1A and 1B of midfield terminal development.
   - Add east/west Taxiway R-3, south of Taxiway R-2.
   - Additional Fixed Base Operator (FBO), east of Runway 19R threshold.
   - Install a touchdown RVR on Runways 12 and 30, centerline lights on 12/30, and touchdown zone lights on Runway 12.
   - Use 2.5 NM longitudinal spacing inside the outer marker.
3. These projects include the provision of simultaneous north/south approaches to the existing parallel runways, departure staging improvements to Runway 19R, and a second FBO.

Figure 1

Washington Dulles International Airport Layout

Figure 2

Delay Reduction Options and Annual Delay Savings

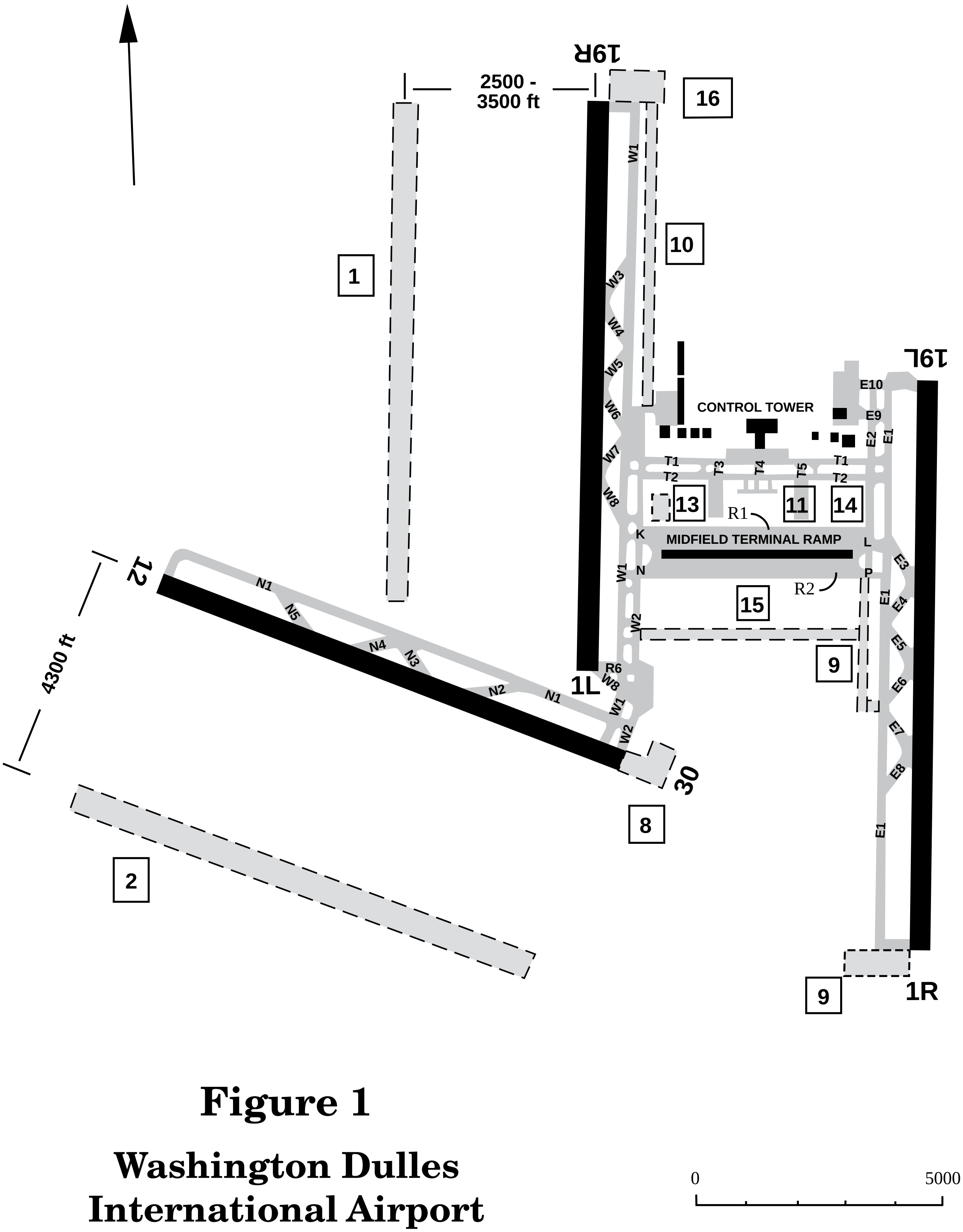

Figure 1

Washington Dulles International Airport

Figure 2
Delay Reduction Options and Annual Delay Savings

	Delay Reduction Options	Type of Action *1	Time Frame *2
	Airfield Improvements		
(1)	Construct Runway 1W/19W, 3,500' West of 1L/19R (Includes Benefit of Triple Simultaneous Precision Approaches Which May Require a Precision Runway Monitor) [4,5]	Planned	Post 1997
(2)	Construct Runway 12R/30L, South of 12/30[5] With 1.5 NM Staggered Approaches to Existing Parallels With Simultaneous Approaches to Existing Parallels *Portion of Above Savings Due to 30L in NW Operation*	Planned	Post 1997
(3)	Segregate Small-Slow Traffic on Independent Runway 1W/19W, With Triple Precision Approaches	Not Recommended	
(4)	Widen Turnback Fillets on Runway 1L (At Exits W-3 & W-5)	Completed	1989
(5)	Widen Turnback Fillets on Runway 19L (At Exits E-6 & E-8)	Completed	1989
(6)	Complete Construction of East/West Taxiway R-2	Completed	1989
(7)	Add GA Exits to Runway 19R (North of W-3) & Runway 19L (North of E-3)	Programmed Planned	1992 Post 1997
(8)	Extend Runway 12/30 Southeast & Enlarge Runway 30's Holding Pad	Programmed Recommended	1992 Post 1990
(9)	Add Runway 1R Holding Pad & Extend Taxiway E-2 (To South of Exit E-7)	Programmed Programmed	1993 1994
(10)	19R Staging Improvements: Extension of Taxiway W-2 North 19R Holding Pad 19R Bypass Taxiway	 Completed Programmed Recommended	 1990 1992 Post 1997
(11)	Add Midfield Ramp	Underway	1990
(12)	Add Centerfield North/South Taxiway	Further Study	Post 1990
(13)	Midfield Terminal — Phase 1A (24 Gates)	Planned	Post 1993
(14)	Midfield Terminal — Phase 1B (48 Gates)	Planned	Post 1993
(15)	Add East/West Taxiway R-3, South of R-2, With 2 North/South Stubs	Further Study	Post 1997
(16)	Additional FBO, East of Runway 19R Threshold	Underway	1990

Responsible Agency [*3]	Estimated Annual Delay Savings for IAD in Hours (in millions of 1988 dollars) 320,000 OPS	400,000 OPS	450,000 OPS
MWAA	Not Simulated	3,860 ($ 5.3)	6,230 ($ 8.5)
MWAA			
	Not Simulated	2,700 ($ 3.7)	6,950 ($ 9.5)
	Not Simulated	3,600 ($ 4.9)	8,370 ($ 11.4)
	Not Simulated	*2,450 ($ 3.3)*	*6,560 ($ 9.0)*
MWAA	No Added Savings over Use of 1W/19W for Air Carriers		
MWAA	In the Base for All Simulations		
MWAA	In the Base for All Simulations		
MWAA	See Narration — Savings Were Not Computed		
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Figure 2 (concluded)
Delay Reduction Options and Annual Delay Savings

	Delay Reduction Options	Type of Action *1	Time Frame *2
Facility and Equipment Improvements			
(17)	Touchdown RVR	Planned	1990
	& Touchdown Zone Lights on Runway 1L	Programmed	1992
(18)	Touchdown RVR on Runways 12 & 30	Recommended	Post 1990
	& Centerline Lights on Runway 12/30	Programmed	1992
	& Touchdown Zone Lights on Runway 12	Programmed	1992
Operational Improvements			
(19)	Simultaneous ILS Approaches to Existing Parallel Runways	Underway	1990
(20)	Simultaneous Converging Instrument Approaches (SCIA) To Runways 12 & 19R, or 12 & 19L	Completed	1989
(21)	2.5 NM Longitudinal Spacing Inside the Outer Marker (Between Similar Class, Non-Heavy Arrivals)	Completed	1988
User Options			
(22)	Redistribute Traffic More Uniformly Within the Hour	Further Study	Post 1990
(23)	Improve Reliever Airports	Further Study	Post 1990
	Reduce Small-Slow Aircraft by 25%		
	Reduce Small-Slow Aircraft by 50%		

THE SAVINGS ARE NOT NECESSARILY ADDITIVE.

*1: Types of Action:
Programmed — Improvements which are in the Metropolitan Washington Airports Authority Capital Development Program (MWAA CDP).
Planned — Improvements which are on the approved Airport Layout Plan (ALP) or in the FAA's FY-90 budget.
Recommended — Improvements which are recommended by the IAD Capacity Enhancement Design Team.
Further Study — Items which the IAD Capacity Enhancement Design Team believes require further study.
Not Recommended — Items which the IAD Capacity Enhancement Design Team does not recommend.

*2: Time Frame:
It represents the expected completion date for items planned or underway.
For improvements recommended or requiring further study, it represents the earliest date the improvement can be implemented.

Responsible Agency [*3]	Estimated Annual Delay Savings for IAD in Hours (in millions of 1988 dollars) 320,000 OPS	400,000 OPS	450,000 OPS
FAA MWAA	300 ($ 0.4)	1,910 ($ 2.6)	3,560 ($ 4.9)
FAA MWAA MWAA	See Narration — Savings Were Not Computed		
FAA	310 ($ 0.4)	900 ($ 1.2)	1,420 ($ 1.9)
FAA	160 ($ 0.2)	560 ($ 0.8)	980 ($ 1.3)
FAA	See Narration — Savings Were Not Computed		
IAD Users	3,970 ($ 5.4)	8,120 ($ 11.1)	12,140 ($ 16.6)
FAA/MWAA/IAD Users	640 ($ 0.9) 1,170 ($ 1.6)	2,800 ($ 3.8) 4,420 ($ 6.0)	4,680 ($ 6.4) 7,900 ($ 10.8)

*3: Responsible Agency:
FAA — Federal Aviation Administration
MWAA — Metropolitan Washington Airports Authority

4: A Precision Runway Monitor (PRM) may be required for simultaneous approaches to runways separated by less than 4,300 feet.

5: Assumes the provision of simultaneous ILS approaches to the existing parallel runways, departure staging improvements to Runway 19R, and a second FBO.

Design Team Recommendations

These improvements should be implemented soon:

Recommended Options[1]

(17) Touchdown RVR and Touchdown Zone Lights on Runway 1L.

(18) Touchdown RVR on Runways 12 & 30, Centerline Lights on 12/30, and Touchdown Zone Lights on 12.

The next priority for projects:

(1) Construct 1W/19W, 3,500' West of 1L/19R. Obtain the capability to run triple simultaneous precision approaches.

(2) Construct 12R/30L. It should be at least 2,500' south of 12/30 in order to allow parallel operations under all meteorological conditions.

(7) Add GA Exits to Runways 19R & 19L.

(8) Extend 12/30 Southeast & Enlarge Runway 30 Holding Pad.

(9) Add Runway 1R Holding Pad & Extend Taxiway E-2.

(10) Add 19R Staging Improvements. The extension of W-2 was completed in 1990. The holding pad will open in 1992. The 19R bypass is also recommended.

(13) Develop Midfield Terminal — Phase 1A.

(14) Develop Midfield Terminal — Phase 1B.

Options Completed

These improvements were completed by 1989:

(4) Turnback Fillets on Runway 1L.

(5) Turnback Fillets on Runway 19L.

(6) Construction of East/West Taxiway R-2.

(20) Simultaneous Converging Instrument Approaches (SCIA).

(21) 2.5 NM Longitudinal Spacing Inside the Outer Marker.

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1. In addition, the Design Team recommends:
   - A CATII/III precision approach at both ends of any new runway.
   - Studying the benefit of a CATII/III precision approach on an existing runway, since 1R is the only new runway capable of CAT II/III approaches.

Options Underway

These improvements will be completed in 1990:

(11) Midfield Ramp.
(16) Additional FBO, East of 19R Threshold.
(19) Simultaneous ILS Approaches to Existing Parallel Runways.

Options Which Require Further Study

The Design Team: (1) did not quantify the savings of passenger time, and (2) did not assess delay reduction options in terms of capital cost, adverse economic impact, secondary displacements, and relocation of supporting facilities. These issues, as well as safety and policy concerns, should be considered when evaluating the following items.

(12) Add Centerfield North/South Taxiway.
(15) Add East/West Taxiway R-3 (South of Taxiway R-2).
(22) Redistribute Traffic More Uniformly Within the Hour. May not be consistent with a hubbing operation, and the resulting efficiencies.
(23) Improve Reliever Airports (relocate small-slow aircraft).[1]

Options Not Recommended

(3) Segregate Small-Slow Traffic on Independent Runway 1W/19W, With Triple Precision Approaches. This does not provide added savings over its use as an air carrier runway. As demand increases, using 1W/19W for air carriers will continue to provide even greater savings.

1. Some of the existing relievers interfere with IAD operations.

Summary

Estimated Annual Delay Savings for IAD in Hours (in Millions of 1988 Dollars)

Delay Reduction Options	**320,000 OPS**	**400,000 OPS**	**450,000 OPS**
Airfield Improvements			
(1) Construct Runway 1W/19W, 3,500' West of 1L/19R (Includes Benefit of Triple Simultaneous Precision Approaches)	Not Simulated	3,860 ($ 5.3)	6,230 ($ 8.5)
(2) Construct Runway 12R/30L, South of 12/30			
With 1.5 NM Staggered Approaches to Existing Parallels	Not Simulated	2,700 ($ 3.7)	6,950 ($ 9.5)
With Simultaneous Approaches to Existing Parallels	Not Simulated	3,600 ($ 4.9)	8,370 ($ 11.4)
Portion of Above Savings Due to 30L in NW Operation	Not Simulated	2,450 ($ 3.3)	6,560 ($ 9.0)
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User Options			
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Reduce Small-Slow Aircraft by 25%	640 ($ 0.9)	2,800 ($ 3.8)	4,680 ($ 6.4)
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THE SAVINGS ARE NOT NECESSARILY ADDITIVE

Annual Delay Costs — Without Airfield Improvements — Washington Dulles International Airport

This figure presents the annual delay costs in millions of 1988 dollars for the three demand levels. The annual delay cost for the "Do Nothing" case increases dramatically as demand increases: $10.3, $23.5, and $39.2 million.

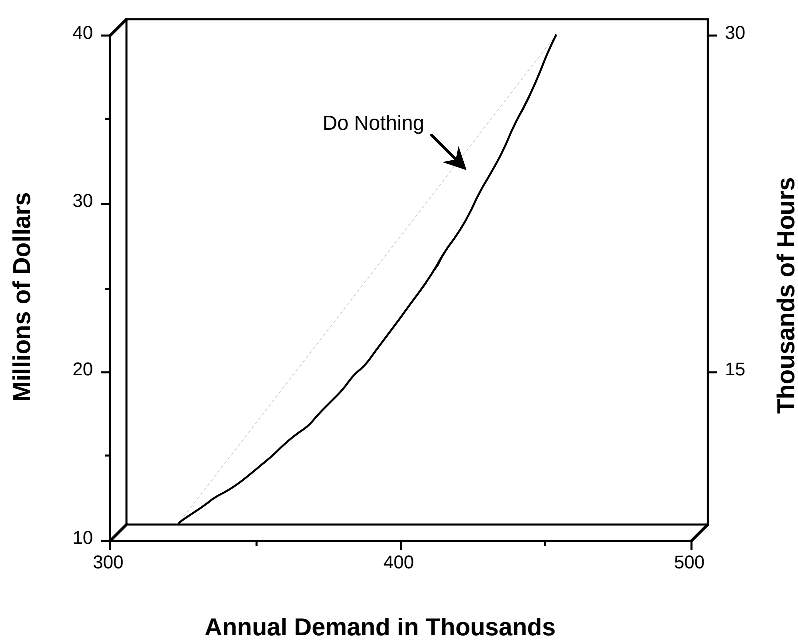


Table of Contents

List of Figures

1.0 — Introduction

1.1 Background

One of the continuing challenges facing the air transportation industry is the enhancement of existing airport capacity and the development of new facilities to handle future demand.

The FAA, airport operators, and user groups initiated airport capacity design team studies to enhance airport capacity, and to identify and evaluate alternative means of reducing delays at high activity air carrier airports in the United States.

The Dulles Airport Capacity Design Team was formed to evaluate potential capacity enhancement and delay reduction options at IAD.

During 1987, Dulles handled 289,167 aircraft operations and over 5.3 million passenger enplanements. From this historical data, the Design Team established three annual traffic levels as benchmarks to represent the expected growth in aircraft operations. This document should retain its validity until the last benchmark is reached — regardless of how rapidly that may occur.

The Design Team studied 23 proposals for increasing capacity and reducing delays. They are listed in Figure 2. The current airport layout to which improvements will be added is shown in Figure 1.

1.2 Objectives

The major objective of the Design Team Study was to develop recommendations which, if implemented, would increase airport capacity, improve airport efficiency, and reduce aircraft delays.

In addition to achieving this objective, the Design Team accomplished the following:

- Assessed current airport capacity.
- Examined the causes of delays associated with the airfield and its immediate airspace, and apron/gate area operations.
- Evaluated capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield changes, and user options.
- Examined the relationship between air traffic demand and delay to aid in establishing acceptable air traffic levels.

The Dulles Design Team limited its analyses to aircraft activity on the airfield and within the immediate airspace, composed of

1.3 Scope

the common approach and departure corridors. It considered alternatives that could increase capacity and reduce delays.

The Design Team did not examine landside and environmental issues, which are beyond the scope of the study. They will be addressed in future airport planning studies. The data developed in this study will provide important inputs to future studies.

1.4 Methodology

The Design Team developed a list of alternatives for increasing capacity and reducing delays at IAD. This list was refined during the study. Several improvements were eliminated because they were not feasible. Some delay reduction options were narrated because they were underway, completed, or better suited to a verbal description than a computer simulation. The remainder were simulated and their potential annual delay savings calculated.

Model simulations included present and future air traffic control procedures, various airfield improvements, and three traffic demand levels. To assess projected airfield improvements, the FAA used different airfield configurations for present and future airport layouts. The time frame for improvements and ATC procedures determined the appropriate aircraft separations used to simulate VFR and IFR weather conditions. Improvements involving new runways were simulated only for the two

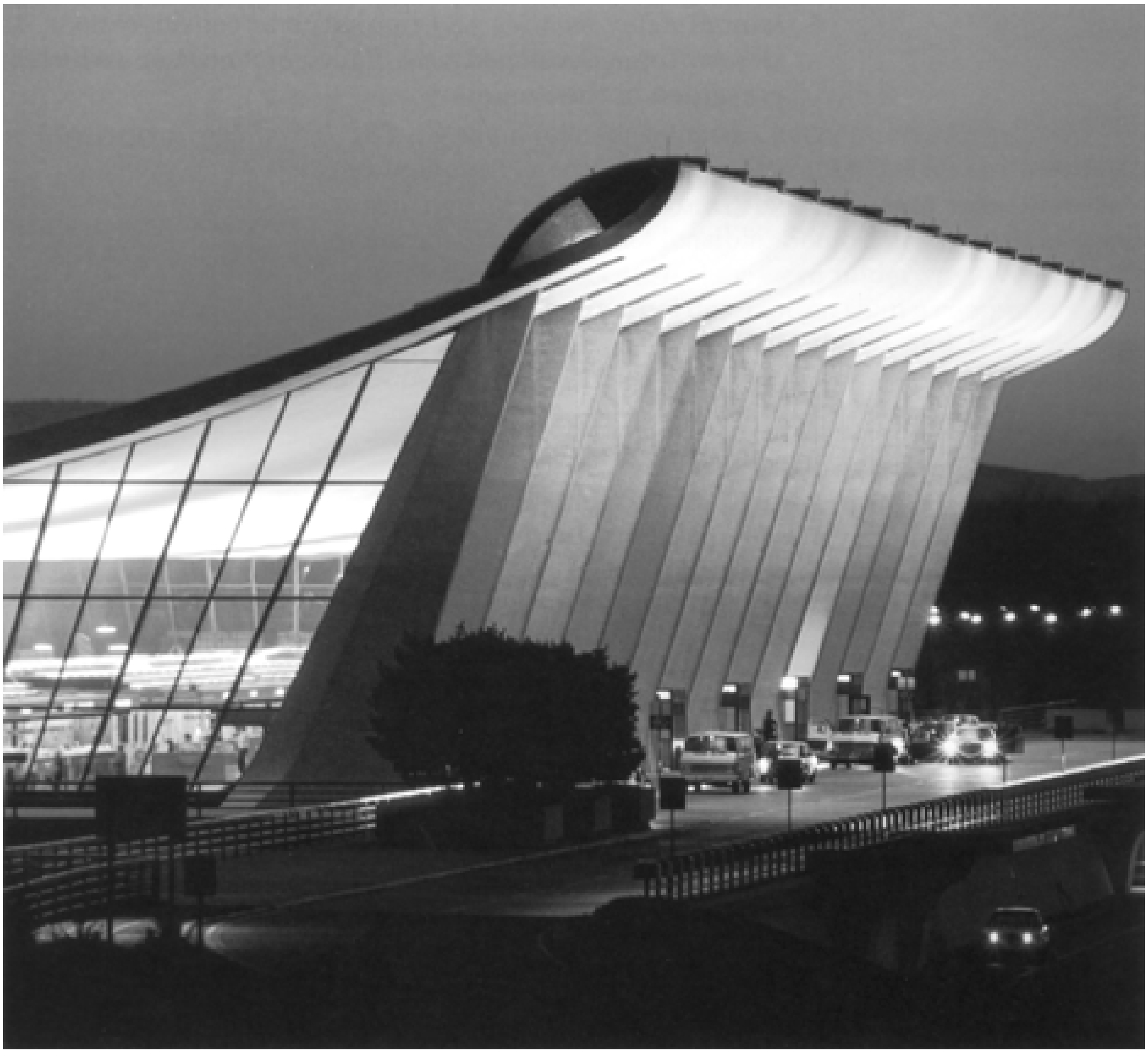
higher demand levels.

For the delay analysis, the FAA developed traffic demands based on the Official Airline Guide, historical data, and MWAA forecasts. Aircraft volume, mix, and peaking characteristics were used to generate a demand profile for each of the three demand levels. Annual delay estimates for the proposed improvement options were extrapolated from the simulation results. The estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data. They did not reflect exceptional circumstances, such as closing a runway for snow removal. The technical details of the simulation methodology are described in Section 3.0.

The Design Team then compared the annual delay estimates and assessed the potential delay reductions. Based on the annual delay savings and marketplace considerations, the Design Team developed a set of recommendations which are presented in the Summary.

The delay reduction options, studied by the Dulles Design Team and described in this report, are intended to meet anticipated growth in demand without excessive delays.

Figure 2 summarizes the delay reduction options and their



2.1 Airfield Improvements

estimated annual delay savings. The yearly savings are in hours and in millions of 1988 dollars for each of the three demand levels — 320,000; 400,000; and 450,000 annual operations. Delay savings are not necessarily additive.

The alternatives for increasing airport capacity and reducing aircraft delays at IAD are categorized and discussed under the following four headings:

- Airfield Improvements.
- Facility and Equipment (F & E) Improvements.
- Operational Improvements.
- User Options.

The following describes the delay reduction options in more detail.

The Design Team analyzed the benefits of a new air carrier runway, 1W/19W, with a Category I precision approach capability at each end of the runway. Located 3,500 west of 1L/19R, and

(1) Construct Runway 1W/19W 3,500 Feet West of 1L/19R

11,000 feet long, the third north/south parallel runway will reduce delays in both the north and south flows.

Current MWAA plans permit this runway to be constructed 2,500 feet to 3,500 feet west of 1L/19R. The Design Team recommends the 3,500 runway separation. The Design Team anticipates future ATC rules will allow simultaneous precision approaches to runways separated by 3,500 feet, but not 2,500 feet.

The primary benefits of the new runway are:

- A runway strictly for departures in the south flow.
- Two departure-only runways and two arrival-only runways in the north flow.

In addition, it will provide redundancy for periods when other runways are closed for major reconstruction, routine maintenance, and snow removal.

Three improvements will be in place by 1991, before a new runway is constructedTherefore, this analysis was based on their presence: 19R staging improvements, a new FBO, and simultaneous ILS approaches to the existing parallel runways.

With simultaneous ILS approaches to the existing parallels, the new parallel runway will save 3,790 hours, or $ 5.2 million, per year at the 400,000 demand. At the highest demand the annual savings will increase to $ 8.3 million.

If 1W/19W is independent of 1L/19R, the new runway will provide redundancy for simultaneous precision approaches when 1L/19R is closed, as well as when 1R/19L is closed.

(2) Construct Runway 12R/30L, South of 12/30

A few days each year, Dulles experiences strong winds (at least 30 knots) from the northwest. All arrivals and departures are restricted to the single crosswind runway. Delays escalate dramatically.

To address this problem, the Design Team analyzed the benefits of a second crosswind runway, 10,000 feet long and south of 12/30, operating independently under VFR conditions. Runway 30L was used for arrivals and departures to simulate the presence of the strong northwest winds, when operations are restricted to the crosswind runways. Runway 12R was used for arrivals from the northwest when winds favored the South flow.

Over 90% of the annual delay savings are due to the use of Runway 30L when there are strong winds from the northwest — about 3 days a year. A small change in the frequency of occurrence of the strong northwest winds can cause a great fluctuation in the savings. Therefore, the Design Team strongly recommends that great care be taken when evaluating the benefits of this new runway.

With 1.5 NM staggered approaches to the existing parallels, Runway 12R/30L will save $ 3.7 million per year at the 400,000 demand, and $ 9.5 at the highest demand. With simultaneous ILS approaches to the existing parallels, the savings at those activity levels will increase to $ 4.9 million and $ 11.4 million, respectively.

With or without staggered approaches to the existing parallel runways, the use of Runway 30L in the northwest operation will save $ 3.3 million at the middle demand, and $ 9.0 million at the highest demand.

(3) Segregate Small-Slow Traffic on Independent Runway 1W/19W, with Triple Presision Approaches

The Design Team evaluated the benefit of segregating small-slow GA traffic on an independent runway, 1W/19W, with triple precision approaches. The simulations assumed separate and non-interfering operations for the different arrival and departure fixes.

Segregating small-slow GA traffic on 1W/19W will provide no additional savings over the use of 1W/19W as an air carrier runway.

(4) Widen Turnback Fillets on Runway 1L (at Exits W-3 & W-5)

Before the turnback fillets were widened, heavy aircraft arriving on 1L could not make the sharp turn from the high speed exits, southbound onto Taxiway W-2. Instead, they stopped on the runway and took a reverse exit. Widening the turnback fillets on 1L, at the high speed exits W-3 and W-5, reduced the arrival runway occupancy times of the heavies.

The widened fillets, completed in 1989, were considered operational for all three demand levels.

(5) Widen Turnback Fillets on Runway 19L (at Exits E-6 & E-8)

Before the turnback fillets were widened, heavy aircraft arriving on 19L could not make the sharp turn from the high speed exits, northbound onto Taxiway E-2. Instead, they stopped on the runway and took a reverse exit. Widening the turnback fillets on 19L, at the high speed exits E-6 and E-8, reduced the arrival runway occupancy times of heavies.

The widened fillets, completed in 1989, were considered operational for all three demand levels.

(6) Complete Construction of East/West Taxiway R-2

The south side of Taxiway R-2 was widened in 1989 to: (1) improve east/west access to the midfield ramp area, and (2) accommodate widebody aircraft at any gate along R-2. The drainage system was revised and the taxiway lighting was replaced.

(7) Add GA Exits to Runways 19R & 19L (North of Exits W-3 & E-3)

A GA exit on 19R, north of W-3, will reduce arrival runway occupancy times and taxi times for small GA aircraft going to the new FBO, on the west side of the airport. A GA exit on 19L, north of E-3, will reduce occupancy times and taxi times for small GA aircraft going to the existing FBO, on the airport's east side.

Reduced GA occupancy times can also benefit both GA and non-GA operations. Since an aircraft can depart as soon as an arrival has exited the runway, a departure may be able to takeoff sooner. The reduced occupancy times may result in there being enough time for a departure to takeoff between successive arrivals on the same runway.

Based on the MWAA Capital Development Program, the GA exit on 19R will be completed in 1992. Although the GA exit on 19L is not in the MWAA CDP, it is included in the Airport Layout Plan.

(8) Extend Runway 12/30 Southeast and Enlarge Runway 30's Holding Pad

In accordance with Federal Aviation Regulations (FAR) Part 151, aircraft departing Runway 30 must hold outside of the clear zone for Runway 1L. During periods of heavy activity on both these runways, the departure capacity of Runway 30 may be constrained because of the additional time required to position the aircraft for takeoff on 30.

Currently, the tower can handle the situation operationally without delaying departures, by putting southwest bound departures on 30. The Design Team analysis was based on the tower being able to do this at all demand levels. However, this may not always be possible at higher demand levels, resulting in departure delays.

According to the MWAA Capital Development Program, the extension of 12/30 southeast will be completed in 1992, before IAD reaches the 400,000 activity level.

Although it is not in the MWAA Capital Development Program, enlarging the Runway 30 holding pad will give controllers more flexibility in staging Runway 30 departures based on destination.

Extending 12/30 southeast and enlarging the Runway 30 holding pad will allow more aircraft to depart on Runway 30.

(9) Add Runway 1R Holding Pad and Extend Taxiway E-2 (to South of Exit E-7)

The holding pad on 1R will provide a staging area for departures based on destination. The extension of Taxiway E-2, to south of E-7, will enable departures to taxi south to 1R without interfering with northbound arrivals taxiing on E-1. Together, they will enable more aircraft to depart on 1R.

Based on the MWAA Capital Development Program, these improvements will be completed by 1994.

(10) 19R Staging Improvements

As the demand at IAD increases, so does the importance of providing 19R staging improvements. By staging departures based on destination, more aircraft will be able to depart on 19R.

The Design Team considered three types of staging improvements:

- Extension of Taxiway W-2 north.
- 19R holding pad.
- 19R bypass taxiway.

They may be constructed individually or in combination. The greatest flexibility in staging aircraft can be achieved by implementing all three improvements.

The extension of Taxiway W-2 north to the approach end of 19R, completed in 1990, will allow more departures to use 19R. It will also permit unrestricted two-way taxiing adjacent to the new FBO.

The 19R holding pad, to be completed in 1992, will enable controllers to more easily stage departures.

The 19R bypass taxiway is not in the MWAA Capital Development Program, although it can provide alternate access for departures on 19R. It is included in the Dulles Airport Layout Plan.

The analysis of the proposed north/south parallel runway, 1W/19W, was based on staging improvements being in place, which allowed much greater use of 19R for departures.

(11) Add Midfield Ramp

MWAA is designing a midfield ramp, located south of the main terminal and north of Concourses C and D. Capable of accommodating four widebodies, the ramp would serve as (1) remote gate positions, (2) a hardstand for overnight parking, or (3) a "penalty box" for aircraft unable to access their assigned gates.

The midfield ramp, to be completed in 1990, will eventually become part of the supporting apron for the permanent midfield terminal complexes.

(12) Add Centerfield North/South Taxiway

Construction of a centerfield north/south taxiway, from the base of the tower to Taxiway R-1, was considered an advance element of the permanent midfield terminal complex. For aircraft using R-1, the taxiway will reduce pushback interference, taxi delays, and taxi travel times. Controllers will have more flexibility in routing aircraft on the ground. This becomes more significant with the increasing number of mixed operations to each runway.The centerfield taxiway is not part of the MWAA Capital Development Program and was not requested by the Metropolitan Washington Airlines Committee. United Airlines' recent request to restructure the midfield complex excluded the centerfield taxiway. Consequently, MWAA is investigating its impact on the efficiency of the evolving midfield taxiway network.

(13) Midfield Terminal — Phase 1A (24 Gates)

MWAA planned its first permanent midfield building, accommodating 24 gates, for the west side of the vacant area between the Main Terminal and Concourse D. Although there is no construction schedule, the midfield terminal will remain in the CDP and MWAA will eventually build it.

The terminal will upgrade the current standards of midfield service, namely passenger and baggage conveyance to and from the Main Terminal, and replace a portion of the temporary concourses in use at Dulles.

(14) Midfield Terminal — Phase 1B (48 Gates)

This project represents the second half of the midfield terminal construction. Located in the area between the Main Terminal and Concourses C and D, it will be built immediately east of Phase 1A and directly north of Concourse C.

Phase 1B will provide an additional 24 gates if it is constructed as a separate building. Several more gates could be realized if both phases are linked in one structure. The net effect of linking both phases would provide several more gates, even though it would incorporate the midfield ramp as a building apron.

(15) Add East/West Taxiway R-3, South of R-2, With 2 North/South Stubs

Construction of Taxiway R-3 is not in the MWAA Capital Development Program. Ground traffic moves east-to-west in the north flow, and west-to-east in the south flow. As an additional east/west taxiway, R-3 could handle aircraft taxiing in the opposite direction from the normal ground traffic.

(16) Additional FBO, East of Runway 19R Threshold

An additional FBO is under construction, east of Runway 19R threshold, to accommodate the increase in corporate jet activity at IAD. The connector from Taxiway W-2 to the FBO ramp was completed in 1990. Since the FBO will be operational in 1990, the analysis of the proposed north/south parallel runway, 1W/19W, was based on the new FBO being in place.

2.2 Facility and Equipment Improvements

(17) Touchdown RVR & Touchdown Zone Lights on Runway 1L

A touchdown RVR (TDRVR) and touchdown zone (TDZ) lights on Runway 1L will reduce visibility minimums for Category I ILS approaches from one-half (1/2) mile to 1,800 feet, and will reduce departure minimums.

The Design Team simulated the effect of not having a TDRVR and TDZ lights on 1L in the affected visibility range. Only small-slow GA arrivals used 1L, while all other arrivals and all departures used 1R. Air carrier arrivals were restricted to 1R by FAR Parts 121 and 135. Departure minimums were reduced by FAR Part 91, causing all aircraft to depart on 1R.

The annual delay savings are based on the use of TDRVR and TDZ lights on 1L for only 0.33% a year. It represents the estimated amount of time IAD operates in the north flow when the visibility is at least 1,800 feet RVR and less than 1/2 mile. A small change in the amount of time this weather condition exists can cause a large increase or decrease in the annual delay savings.

With the existing airfield and current ATC procedures, a Touchdown RVR and TDZ lights on 1L will save $ 0.4 million per year at the lowest demand level, $ 2.6 million at the middle demand, and $ 4.9 at the highest demand.

(18) Touchdown RVR on Runways 12 & 30, Centerline Lights on Runway 12/30, and Touchdown Lights on Runway 12

A touchdown RVR and centerline lights on Runway 30 will reduce departure minimums for Runway 30.

A touchdown RVR, centerline lights, and touchdown zone lights on 12 will permit CAT I approaches to Runway 12 down to 1,800 feet RVR.

Operational improvements will be made possible by the installation of facilities and equipment, and by procedural changes in the terminal ATC system. Their primary benefit will be in adverse weather, when instrument approaches must be used instead of visual approaches. They will reduce arrival delays by allowing arrivals to operate with reduced separation minimums. Although the improvements may be implemented either independently or in combination, the cost savings presented are not necessarily cumulative.

2.3 Operational Improvements

(19) Simultaneous ILS Approaches to Existing Parallel Runways

With the addition of a VHF frequency and a controller to operate the monitor scope, IAD expects to conduct simultaneous (independent) ILS approaches to the existing parallel runways by the end of 1990.

The analysis of the proposed north/south parallel runway, 1W/19W, was based on independent ILS approaches to the existing parallels.

With the current airfield, simultaneous ILS approaches to the existing parallels will save $ 0.4 million per year at the lowest demand, $ 1.2 million at the middle demand, and $ 1.9 million at the highest demand.

(20) Simultaneous Converging Instrument Approaches (SCIA) to Runways 12 & 19R, or 12 & 19L

During the last quarter of 1989, IAD started conducting Simultaneous Converging Instrument Approaches to Runway 12 and 19R/19L. This was possible by moving the Missed Approach Points (MAP) and issuing new approach procedures.

The annual delay savings for the SCIA may be conservative. If the wind direction favors the north flow, and winds are less than 10 knots, the IAD ATCT may switch the operation to the south flow to take advantage of the SCIA.

With the existing runways, the SCIA will save $ 0.2 million per year at the lowest demand level, $ 0.8 million at the middle demand, and $ 1.3 million at the highest demand.

(21) 2.5 nm Longitudinal Spacing Inside the Outer marker (Between Similar Class, Non-Heavy Arrivals)

The FAA recently improved minimum longitudinal separation required between certain aircraft on final approach from 3 nautical miles to 2.5 nautical miles. Several criteria must be met to implement the reduced separation: dry runways, exits visible from the control tower, arrival runway occupancy times of 50 seconds or less, and weight class restrictions.

The Design Team based all analyses on the improved longitudinal spacing, which IAD is already authorized to use.

2.4 User Options

User options affect air carriers, air taxis, commuters, general aviation, cargo, and Air National Guard using IAD. These are major policy change issues and require extensive coordination and cooperation between the FAA, the airport operator, and the airport users. The delay savings indicate the potential benefit of techniques to smooth out the user demand at IAD, both on the ground and in the airspace. To be acceptable to the airport users, economic efficiency and service to the public must be maintained.

(22) Redistribute Traffic More Uniformly Within the Hour

The Design Team simulated the uniform distribution of scheduled air carrier, air taxi, and commuter operations; the arrival and departure times of GA aircraft were not modified.

More uniform scheduling for both arrivals and departures will produce a more orderly flow of traffic. It will reduce arrival air delays, departure runway delays, and ground congestion.

With the existing airfield and current ATC procedures, annual delay savings will be $5.4 million at the lowest demand level and $16.6 million at the highest demand.

However, IAD is a connecting hub for passengers, and a uniform distribution of traffic may not be consistent with such an opera-

tion. Hubbing creates efficiencies that can't be measured in a delay study. The hub and spoke system provides frequent service between city pairs that could not support direct service.

(23) Improve Reliever Airports (Reduce Small-Slow Aircraft by 25% - 50%)

The percentage of GA activity was expected to remain constant at 20% of the annual operations for the three demand levels. To determine the benefits of improving reliever airports, the Design Team evaluated the effects of reducing the number of small-slow aircraft by 25% and 50%. Consequently, the number of daily operations for each demand was reduced by 3% and 6%, respectively. The reductions did not apply to air carrier, air taxi, or commuter operations.

Reducing the number of small-slow aircraft may not impact delays to air carriers to the extent suggested by the simulations since: (1) many of the small aircraft may purposely operate out of air carrier scheduling peaks and (2) they may not operate when there are strong winds from the northwest. With 25% and 50% reductions at the highest demand level, one-third of the delay savings occurred in the northwest operation, when all aircraft used Runway 30 due to strong northwest winds.The annual delay savings are based on the existing airfield and current ATC procedures. A 25% reduction in small-slow aircraft will save $ 0.9 million at the lowest demand, and $ 6.4 million at the highest. A 50% reduction will save $ 1.6 million at the lowest demand, and $ 10.8 million at the highest.

3.0 — Summary of Technical Studies

The Dulles Design Team evaluated the operation of the existing airfield and the potential benefits of the delay reduction options in terms of airfield capacity, aircraft delays, and aircraft operating costs.

Figures 3 and 4 illustrate airfield weather and runway utilization, and the demand levels at IAD, respectively.

3.1 Airfield Capacity

Airfield capacity is the maximum number of aircraft operations (landings or takeoffs) that can take place in a given time under the following conditions:

- Acceptable level of arrival delay.
- Airspace constraints.
- Ceiling and visibility.
- Runway configuration (layout and use).
- Aircraft mix.
- Percent arrival demand.

Figure 5 shows the capacity results in operations per hour, for both an average four-minute delay and for maximum throughput. These values were generated by the capacity/delay computer model described in Appendix A.

3.2 Aircraft Delays

Aircraft delay is the difference between (1) the actual time an aircraft takes to perform an operation and (2) the time it would take to perform that operation without interference from other aircraft in the Dulles area.

The major factors influencing aircraft delays are:

- Weather.
- Airfield demand.
- Airfield physical characteristics.
- Air traffic control procedures and equipment.
- Aircraft operational characteristics.

The Runway Delay Simulation Model (RDSIM) determined daily aircraft delays for current and future operations, based on the expected growth in aircraft operations.

The Design Team used three annual traffic levels as benchmarks: 320,000; 400,000; and 450,000 annual operations. They are associated with 1000; 1250; and 1406 daily operations, respectively. The number of daily operations for each demand level corresponded to an average busy day in the peak month.

The hourly traffic counts were derived from the tower counts for October 22, 1987. The air carrier data were based on the September 1, 1988 Official Airline Guide (OAG) which reflected United Airlines hubbing operation.

3.3 Annual Delay and Annual Delay Costs

The Dulles Design Team evaluated the operation of the existing airfield and the potential benefits of the delay reduction options in terms of aircraft delays and aircraft operating costs. Daily delays were annualized to determine the potential economic benefits of the proposed options. The annualized delays provide a baseline measurement for comparing the benefits of the proposed changes.

The dollar value of $ 22.75 per minute (or $ 1,365 per hour) was used to compute delay costs at all demand levels, for both present and proposed operations. It was the average direct operating cost per minute for the IAD fleet mix in 1988 dollars. It did not consider lost passenger time, disruption to airline schedules, market considerations, or other economic factors.

A comparison of the annual delay savings of the proposed improvements can indicate which are the most effective for a given demand level.

For an anticipated increase in demand, an optimum combination of improvements can be implemented in stages so that airfield capacity is increased and aircraft delays are kept within acceptable limits.

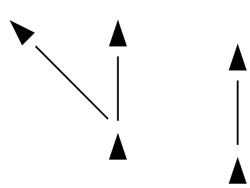
Figure 3

Airfield Weather and Runway Utilization

Washington Dulles International Airport

Weather	Definition (Visibility/Ceiling)	Occurence (%)
VFR	5 miles/2,000 feet or above Visual approaches, independent parallel runways Converging approaches allowed	85.5 %
IFR-1	2.5 miles/700 feet to 5 miles/2,000 feet IFR approaches, 1.5 NM stagger on existing parallels Simultaneous converging instrument approaches allowed	6.8 %
IFR-2	Less than 2.5 miles/700 feet IFR approaches, 1.5 NM stagger on existing parallels No simultaneous converging instrument approaches allowed	7.7 %

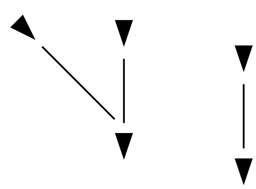
	Percentage Use			
Runway Configurations	**VFR**	**IFR-1**	**IFR-2**	**(All Weather)**
North Operations	47.0 %	4.3 %	4.9 %	56.2 %
South Operations	37.5 %	2.5 %	2.8 %	42.8 %
Northwest Operations	1.0 %	0.0 %	0.0 %	1.0 %
Total	85.5 %	6.8 %	7.7 %	100.0 %



EXISTING NORTH

ARR = 1R, 1L

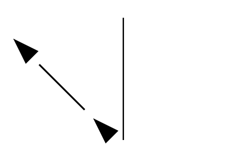
DEP = 1R, 1L, 30



EXISTING SOUTH

ARR = 12, 19R, 19L

DEP = 19R, 19L



EXISTING NORTHWEST

ARR = 30

DEP = 30

Figure 4
Airfield Demand Levels
Washington Dulles International Airport

Annual Demand	Daily Demand			Peak Hour Demand		
	Arr	Dep	Total	Arr	Dep	Total
320,000	500	500	1000	47	37	84
400,000	625	625	1250	58	46	104
450,000	703	703	1406	66	51	117

Hourly Variation of 1,000 Daily Operations
(Average Busy Day, Peak Month)

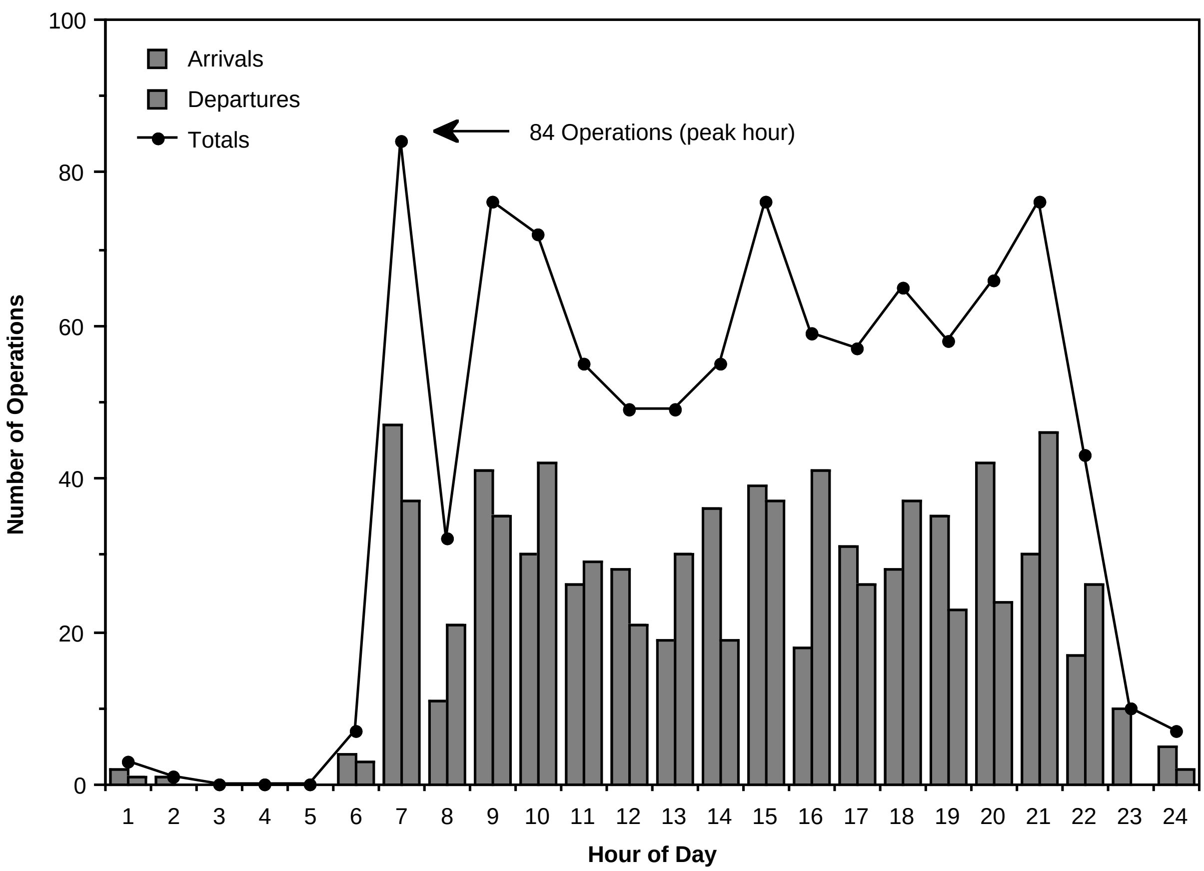
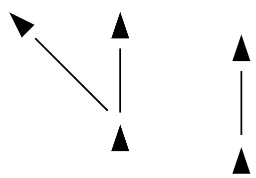
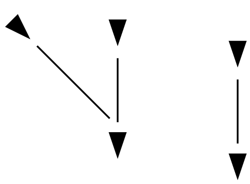
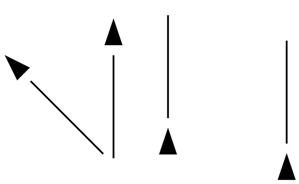
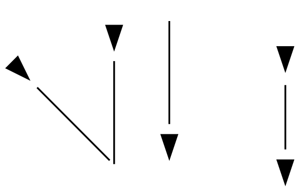


Figure 5
Airfield Capacity Analysis
Washington Dulles International Airport

		Capacity with a 4-minute average arrival delay Operations/Hour	Maximum throughput capacity Operations/Hour
1. EXISTING NORTH ARR = 1R, 1L DEP = 1R, 1L, 30	VFR	ARR = 51 DEP = 55 TOT = 106	ARR = 76 DEP = 103 TOT = 179
	IFR (WITH STAGGER)	ARR = 37 DEP = 40 TOT = 77	ARR = 56 DEP = 103 TOT = 159
2. EXISTING SOUTH ARR = 12, 19R, 19L DEP = 19R, 19L	VFR	ARR = 69 DEP = 67 TOT = 136	ARR = 90 DEP = 67 TOT = 157
	IFR (WITH STAGGER) (WITHOUT RWY 12)	ARR = 46 DEP = 44 TOT = 90	ARR = 54 DEP = 53 TOT = 107
3. FUTURE NORTH ARR = 1R, 1L DEP = 1W, 30	VFR	ARR = 64 DEP = 68 TOT = 132	ARR = 76 DEP =115 TOT = 191
	IFR (WITHOUT STAGGER)	ARR = 50 DEP = 55 TOT = 105	ARR = 62 DEP = 110 TOT = 172
4. FUTURE SOUTH ARR = 12, 19L, 19W DEP = 19R, 19L	VFR	ARR = 70 DEP = 75 TOT = 145	ARR = 90 DEP = 104 DEP = 194
	IFR (WITHOUT STAGGER) (WITHOUT RWY 12)	ARR = 52 DEP = 52 TOT = 104	ARR = 62 DEP = 80 TOT = 142

Notes:

(1) The airport capacity figures were generated by the capacity/delay computer model.

(2) Maximum throughput capacity means there is always an arrival or departure aircraft available for every possible slot under ideal weather conditions. This implies a large average delay would be required to achieve the maximum throughput capacity.

(3) Analysis was based on equal arrival and departure demands, and arrival priority. By adjusting the priority scheme when arrival flows exceed departure flows, departures can be substituted for arrivals to produce balanced flows.

Appendix A — Computer Models and Methodology

The FAA used the Runway Delay Simulation Model (RDSIM) to study the effects of proposed delay reduction and capacity enhancement options at Dulles.

RDSIM is the short form of ADSIM, the Airfield Delay Simulation Model. ADSIM is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques. It describes significant movements by aircraft on the airport and the effect of delay in the immediate airspace. ADSIM was validated in 1978 at Chicago's O'Hare International Airport against actual flow rates and delay data.

Model inputs are empirically derived from the collected field data. The model is calibrated against the field data to insure that the model is site specific.

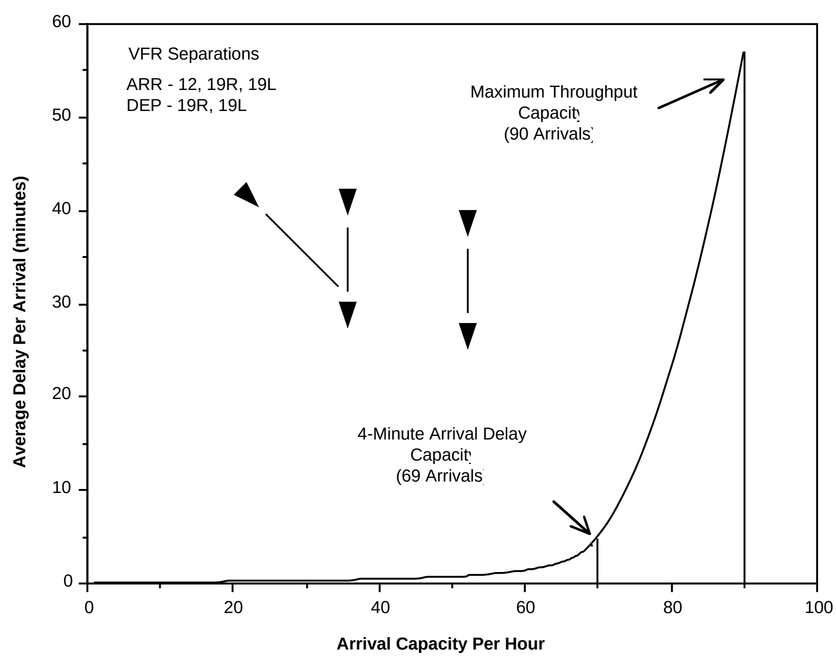
RDSIM simulates demand only for the runways and does not consider the taxiway network or the terminal complexes. It provides both capacity and delay information.

Delay Analysis

For a given demand, the model calculated the hourly flow rate and average delay per aircraft during the full period of airport operations. Arrival demand was assumed to equal departure demand, and aircraft were randomly assigned arrival and departure times. Arrivals received priority over departures.

The experiments were repeated 40 times using Monte Carlo

Figure 6
Airport Delay Curve
Washington Dulles
International Airport



sampling techniques to introduce system variability into each run. The results were then averaged to produce the capacity/delay outputs for a given demand level. Using the same aircraft mix, computer specialists simulated different demand levels for each improvement to generate demand versus delay relationships.

Capacity Analysis

Capacity was calculated for both an average four-minute arrival delay and for maximum throughput. The maximum throughput capacities were based on unlimited arrival and departure queues and produced very large delays. These delays are operationally unacceptable; therefore, the maximum throughput capacities are included for comparison purposes only.

To illustrate the severe penalty for obtaining the maximum throughput, Figure 6 shows the results of both types of calculations. The average arrival delay per aircraft is plotted against arrival capacity for the existing VFR south flow runway configuration.

The maximum throughput method, while increasing the arrival capacity by 21 aircraft (from 69 to 90 arrivals), severely increased the delay (from 4 minutes to 57 minutes per aircraft).

Therefore, the maximum throughput capacity is only theoretical; it is not operationally acceptable. The four-minute arrival delay capacity is more realistic, and as such, is operationally acceptable.

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