Indianapolis International Airport Capacity Enhancement Plan

Indianapolis International Airport

Capacity Enhancement Plan

May 1993

Prepared jointly by the U.S. Department of Transportation, the Federal Aviation Administration, the Indianapolis Airport Authority, and the airlines and general aviation operators serving Indianapolis.

Table of Contents

List of Figures

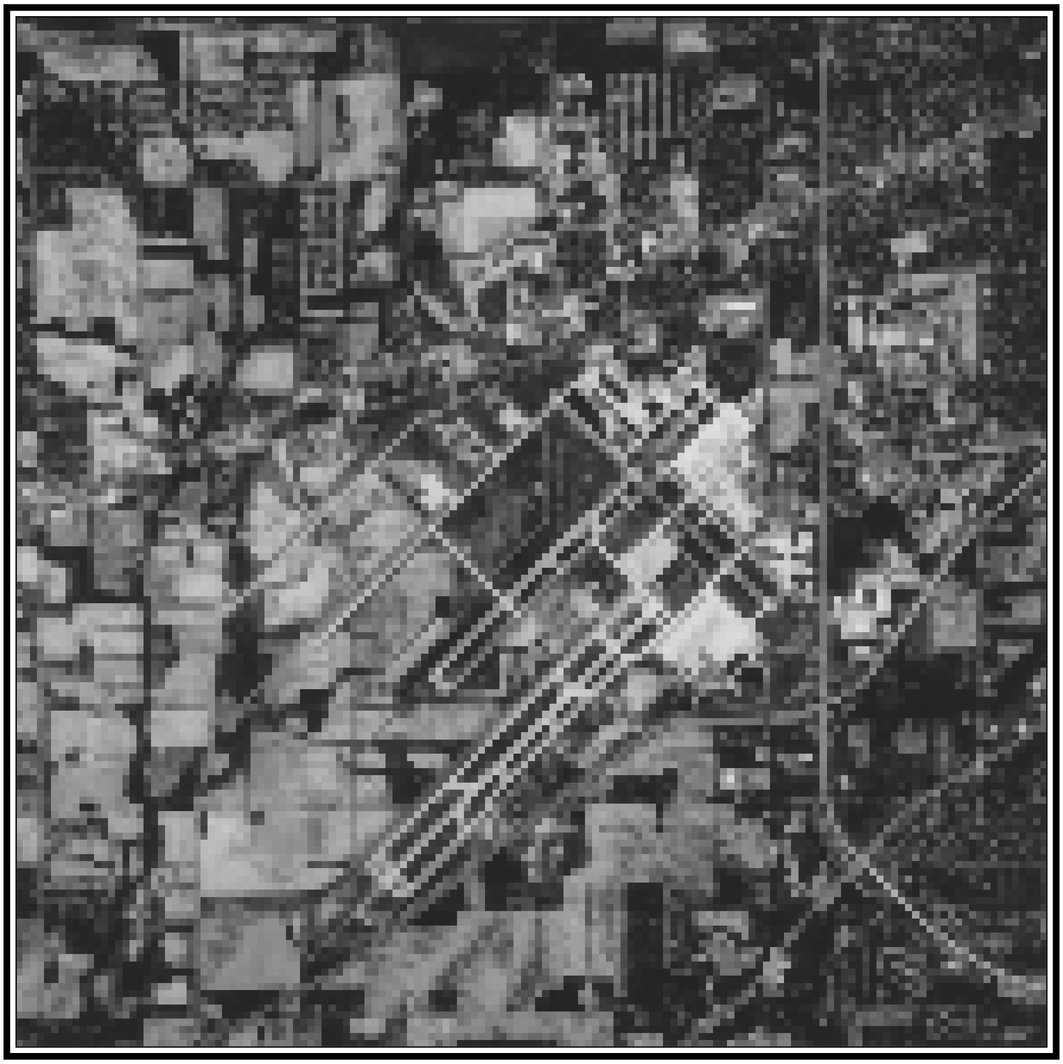


Figure 1. Indianapolis International Airport

Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Figure 1. Indianapolis International Airport, Indianapolis, Indiana

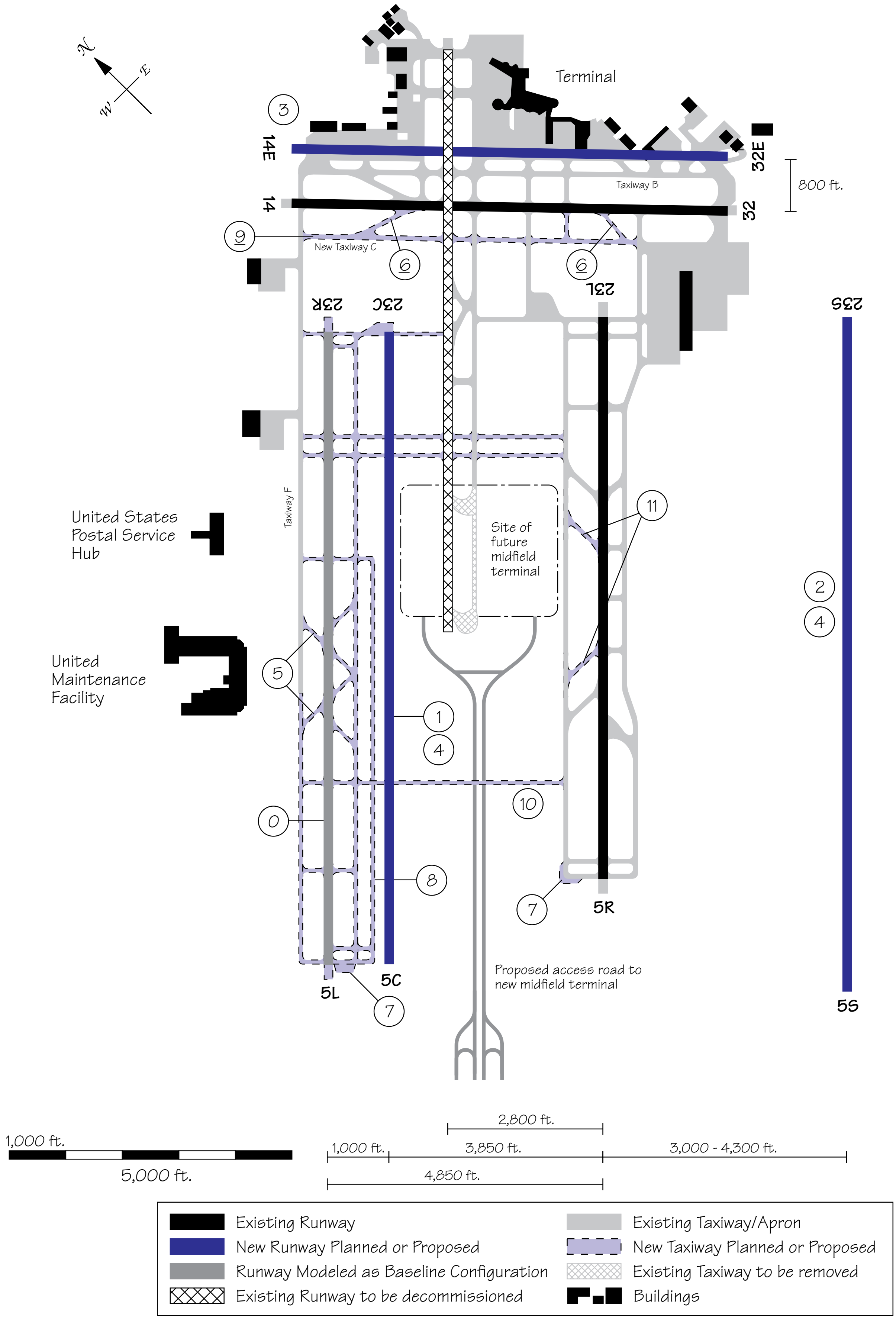


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives	Estimated Annual Delay Savings[1] (in hours and millions of 1992 dollars) Baseline (252,000)	Future 1 (314,000)	Future 2 (472,000)	Future 3 (628,000)
Airfield Improvements				
0. New Runway 5L/23R[2]	—	—	—	—
1. Build third dependent Runway 5C/23C 1,000 ft. east of new Runway 5L/23R	—	1,570/$2.42	9,680/$14.87	47,450/$72.91
2. Build third independent Runway 5S/23S (with Precision Runway Monitor (PRM))	—	2,150/$3.30	14,220/$21.86	78,830/$121.13
3. Build second dependent Runway 14E/32E 800 ft. northeast of Runway 14/32	—	680/$1.04	1,730/$2.65	12,890/$19.80
4. Build both third dependent Runway 5C/23C and fourth independent Runway 5S/23S (combines 1 and 2)	—	3,020/$4.64	16,750/$25.74	85,900/$131.99
5. Add angled exits to Taxiway F for new Runway 5L/23R	—	8/$0.01	100/$0.15	890/$1.37
6. Add angled exits on Runway 14/32[3]	—	—	—	17/$0.03
7. Build departure sequencing pads for Runways 5L (new) and 5R			†	
8. Build dual taxiway system for new Runway 5L/23R	—	1,100/$1.68	2,380/$3.65	8,740/$13.43
9. Build northeast crossover Taxiway C	—	1,130/$1.73	2,530/$3.89	6,950/$10.68
10. Build fourth crossfield taxiway at southwest end	—	1,150/$1.77	2,420/$3.72	16,550/$25.43
11. Add angled exits on Runway 5R/23L	—	20/$0.03	270/$0.42	3,820/$5.87
Facilities and Equipment Improvements				
12. Add centerline lights on Runway 14/32 and install touchdown RVR on Runway 14			†	
13. Install Airport Surface Detection Equipment (ASDE) radar			†	
14. Install surface movement guidance and control system			†	
15. Install Aircraft Situation Display (ASD)			†	
16. Install approach light system (ALSF-2) on Runway 14/32			†	
17. Upgrade low-level wind shear advisory system			†	
18. Upgrade RVR to CAT IIIB and ICAO standards on Runways 5R and 5L (new)			†	
19. Install doppler weather radar			†	
20. End-fire glide slope for Runways 23R (new) and 14			†	
Operational Improvements				
21. Reduce in-trail separations to 2.5 nm	100/$0.15	240/$0.37	1,710/$2.62	12,870/$19.77
22. Develop dependent converging instrument approaches	—	90/$0.14	450/$0.70	2,380/$3.65
23. Effect of removing noise restrictions	330/$0.50	660/$1.02	3,510/$5.39	54,030/$83.02
24. Reduce runway occupancy times	—	270/$0.42	2,330/$3.57	18,680/$28.70
25. Continue enhancement of reliever airports to accommodate a reduction in small/slow aircraft operations at IND.	—	690/$1.06	4,160/$6.39	25,400/$39.03

1. The savings benefits of these alternatives are not necessarily additive.
2. Runway 5L/23R is proposed for construction in the near future and was included as part of the Baseline airport configuration for modeling purposes.
3. See narrative in Section 2 — Capacity Enhancement Alternatives.

† These improvements were not simulated. Therefore, no dollar figures are available. There is a description of each of these items in Section 2 — Capacity Enhancement Alternatives.

Note: Construction costs for individual projects are included in the narrative in Section 2 — Capacity Enhancement Alternatives.

Summary

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA), airport operators, and aviation industry groups initiated a joint program of Airport Capacity Design Teams at various major air carrier airports in the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand, decrease delays, and improve airport efficiency, and works to develop a coordinated action plan for reducing airport delay. Over 35 Airport Capacity Design Teams have either completed their studies or have work in progress.

The need for this program continues. In 1991, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 36 by 2001.

Indianapolis International Airport

In 1992, 6.35 million passengers used Indianapolis International Airport (IND), a 128 percent increase since 1982. IND's total aircraft operations reached 251,600 in 1992. In addition to the dramatic passenger growth at the airport, there has been an explosive growth in air cargo service. In 1984, several carriers began using Indianapolis as a national overnight sort facility, and air cargo tonnage has increased over 500 percent. In 1992, IND ranked as the 12th largest cargo airport in the U.S.

Indianapolis International Airport and the City of Indianapolis are supported by an extensive network of general aviation reliever airports (see illustration on following page). Airports under the jurisdiction of the Indianapolis Airport Authority include Speedway Airport, Eagle Creek Airpark, Metropolitan Airport, and Mt. Comfort Airport. In addition, the Downtown Heliport accommodates helicopter service in the City Center.

The Indianapolis Airport Authority is currently in the process of completing an update to the *Indianapolis Metropolitan Airport System Plan*. The primary focus of the update will be to review and refine the role of general aviation facilities in the eight counties that constitute the Indianapolis metropolitan region. It will serve as a broad update to the *Indianapolis Metropolitan Airport Plan* completed in 1975, function as a major component of the *Indiana State Aviation System Plan*, and reinforce efforts by the Indianapolis Airport Authority to enhance the growth and services of general aviation facilities located throughout the Indianapolis metropolitan area. It is anticipated that the *Indianapolis Metropolitan Airport System Plan Update* will be completed during the spring of 1993.

As a result of the dramatic increase in air cargo and passenger traffic, the Indianapolis Airport Authority has examined the possibility of accelerating development plans for IND. An Airport Capacity Design Team for IND was formed in 1992. The Capacity Team identified and assessed various actions which, if implemented, would increase IND's capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity.

The Capacity Team limited its analysis to aircraft activity on the airfield and within terminal area airspace. They considered the operational feasibility of proposed improvements, but did not address the environmental, socioeconomic, or political issues of airport development. These issues will be addressed in future *airport planning studies, and data generated by the Capacity Team can be used in such studies.*

Selected alternatives identified by the Capacity Team were tested using computer models developed by the FAA to quantify the benefits provided. Different levels of activity were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout this report as:

Baseline — 252,000 operations;
Future 1 — 314,000 operations;
Future 2 — 472,000 operations; and
Future 3 — 628,000 operations.

Figure 3 illustrates the capacity and delay curves for IND operating with the depicted runway configuration, under instrument flight rules (IFR), with the replacement of Runway 5L/23R completed. It shows that aircraft delays will begin to escalate rapidly as hourly demand exceeds 90 operations per hour (50/50 arrival/departure ratio at 4 minutes average delay). Figure 4 shows that, although hourly demand does not exceed 90 operations at Baseline demand levels, 90 operations per hour is exceeded at the demand levels forecast for Future 2.

Airports in the vicinity of IND

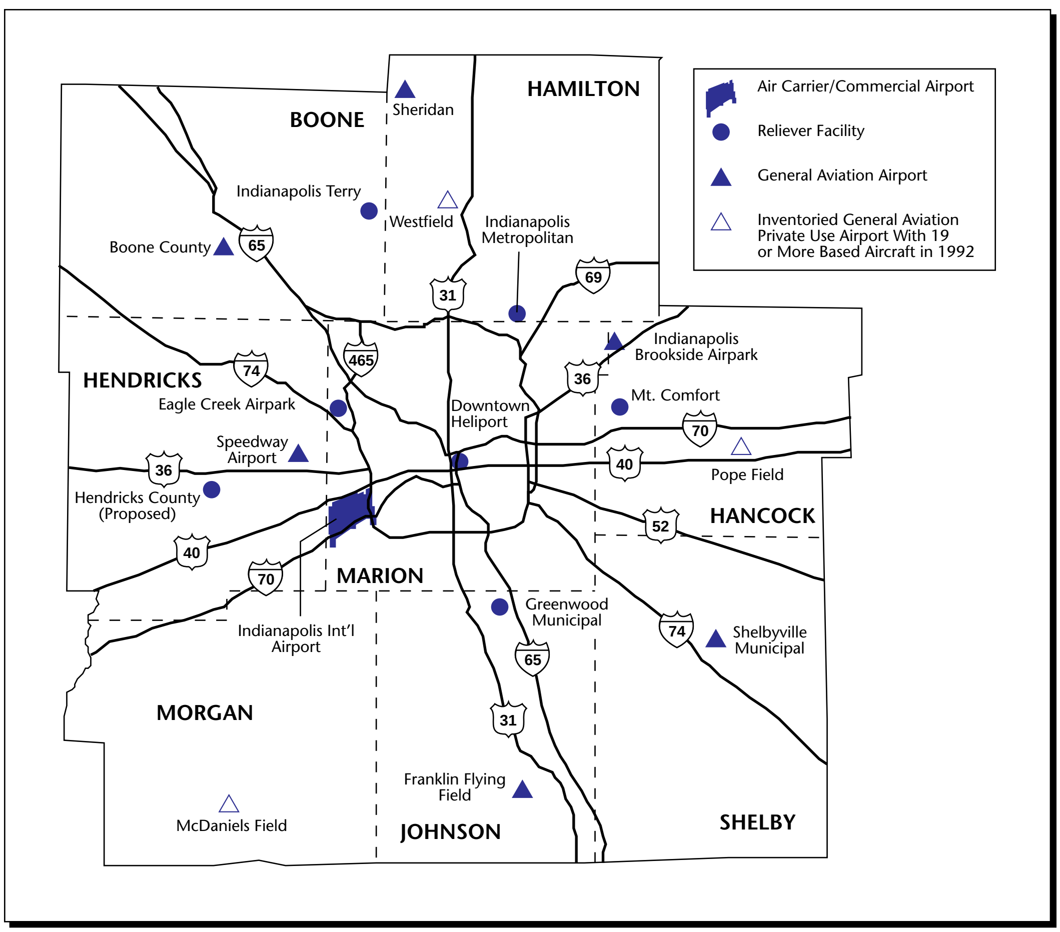


Figure 3. Airport Capacity Curve — Hourly Flow Rate Versus Average Delay — Under IFR

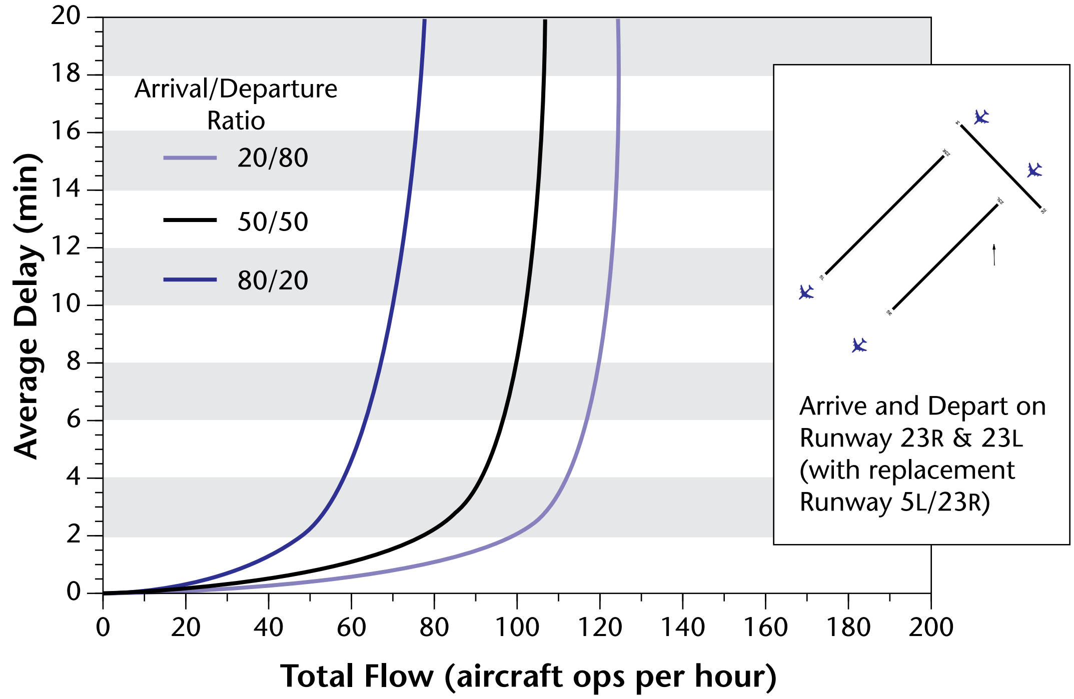
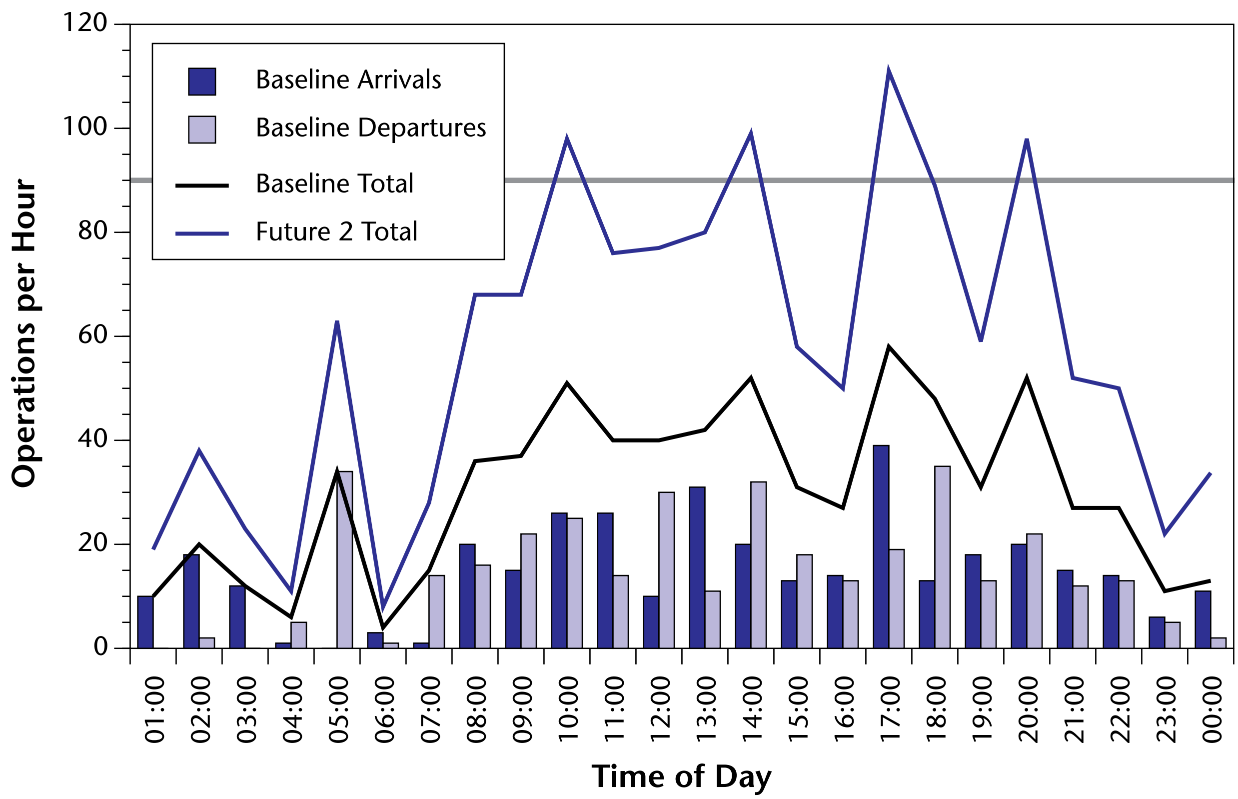


Figure 4. Profile of Daily Demand — Hourly Distribution



Conclusions

Figure 5 shows how delays will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. Annual delay costs will increase from 3,240 hours or $4.98 million at the Baseline level of operations to 25,450 hours or $39.11 million by Future 2 and 113,300 hours or $174.10 million by Future 3.

Figure 5 also shows the major delay-savings benefits from the improvement alternatives studied by the Capacity Team:

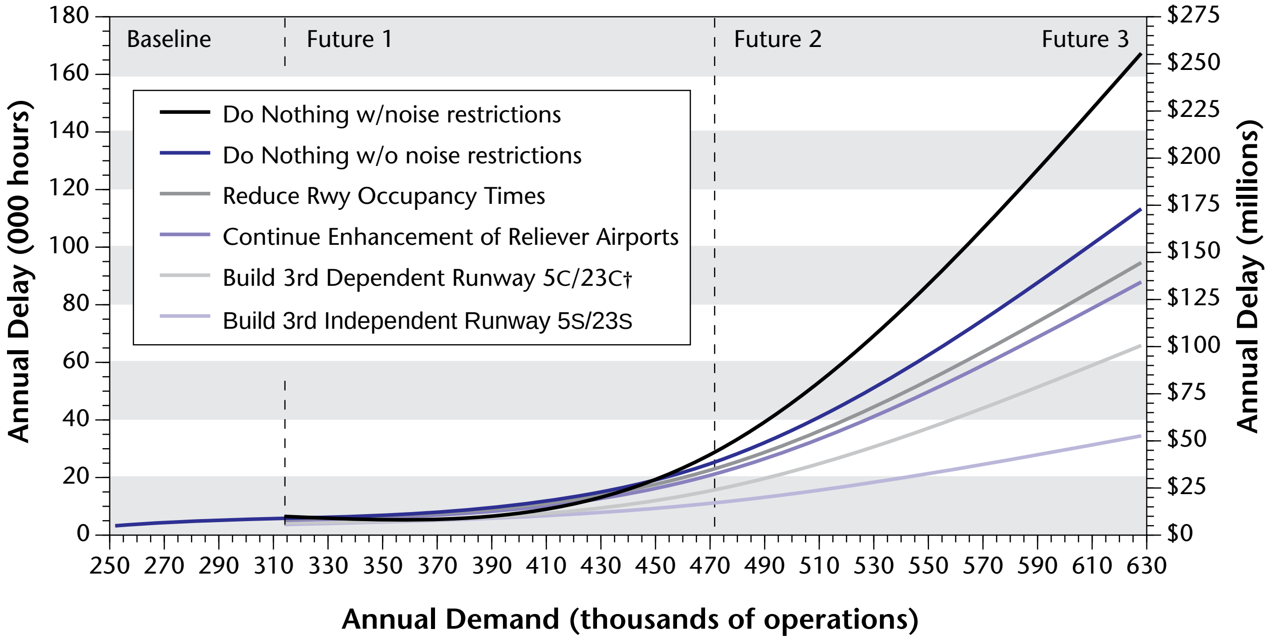
Major Delay Savings Alternatives

	Future 2 Annual Delay Savings	
	Hours	**Millions of 1992 $**
• Build a third independent Runway 5S/23S	14,220	$21.86
• Build a third dependent Runway 5C/23C (as an alternate to independent Runway 5S/23S)	9,680	$14.87
• Continue enhancement of reliever airports	4,160	$6.39
• Removal of noise restrictions	3,510	$5.39
• Reduce runway occupancy times	2,330	$3.57

Figure 6 illustrates the average delay in minutes per aircraft operation for these same alternatives. Under the Do Nothing alternative with noise restrictions, if there are no improvements made in airfield capacity, the average delay per operation of 0.8 minutes in Baseline will increase to 3.7 minutes per operation by Future 2 and 16 minutes by Future 3.

Figure 7 illustrates the annual delay-savings benefits for each of the improvement alternatives modeled at each of the four annual activity levels (operations per year). It serves to highlight the alternatives that will provide the greatest savings in delay costs.

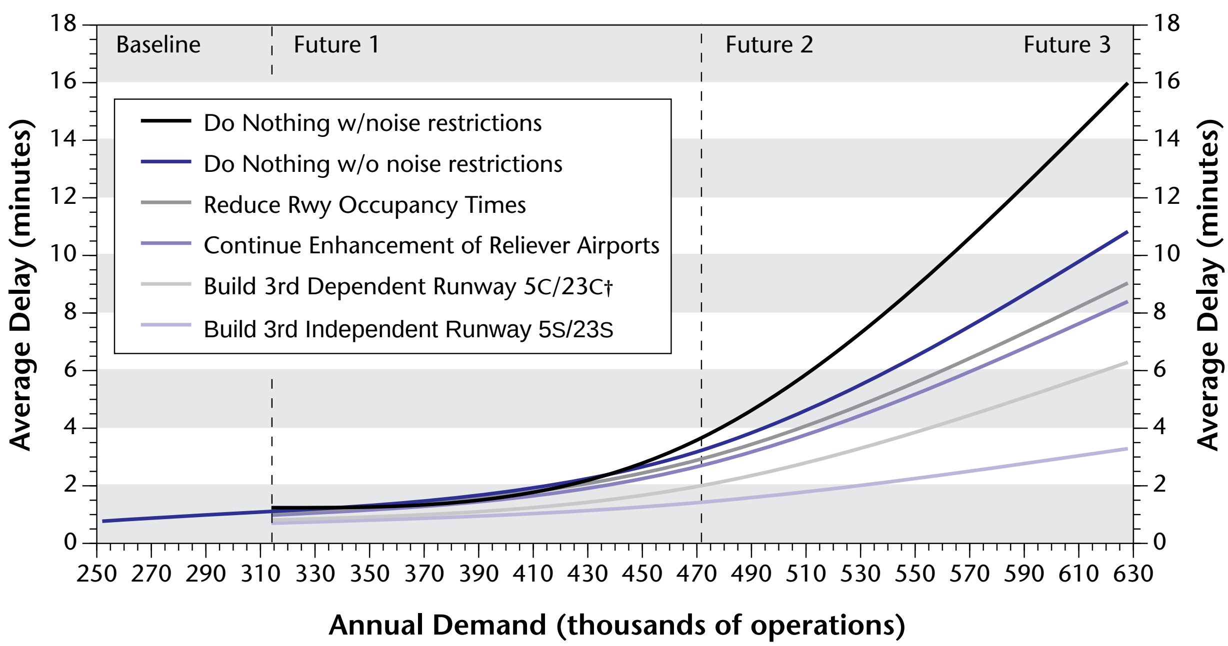
Figure 5. Annual Delay Costs — Capacity Enhancement Alternatives



Note: All alternatives include replacement Runway 5L/23R as part of the Baseline airport configuration for modeling purposes.

† = As an alternate to independent Runway 5S/23S.

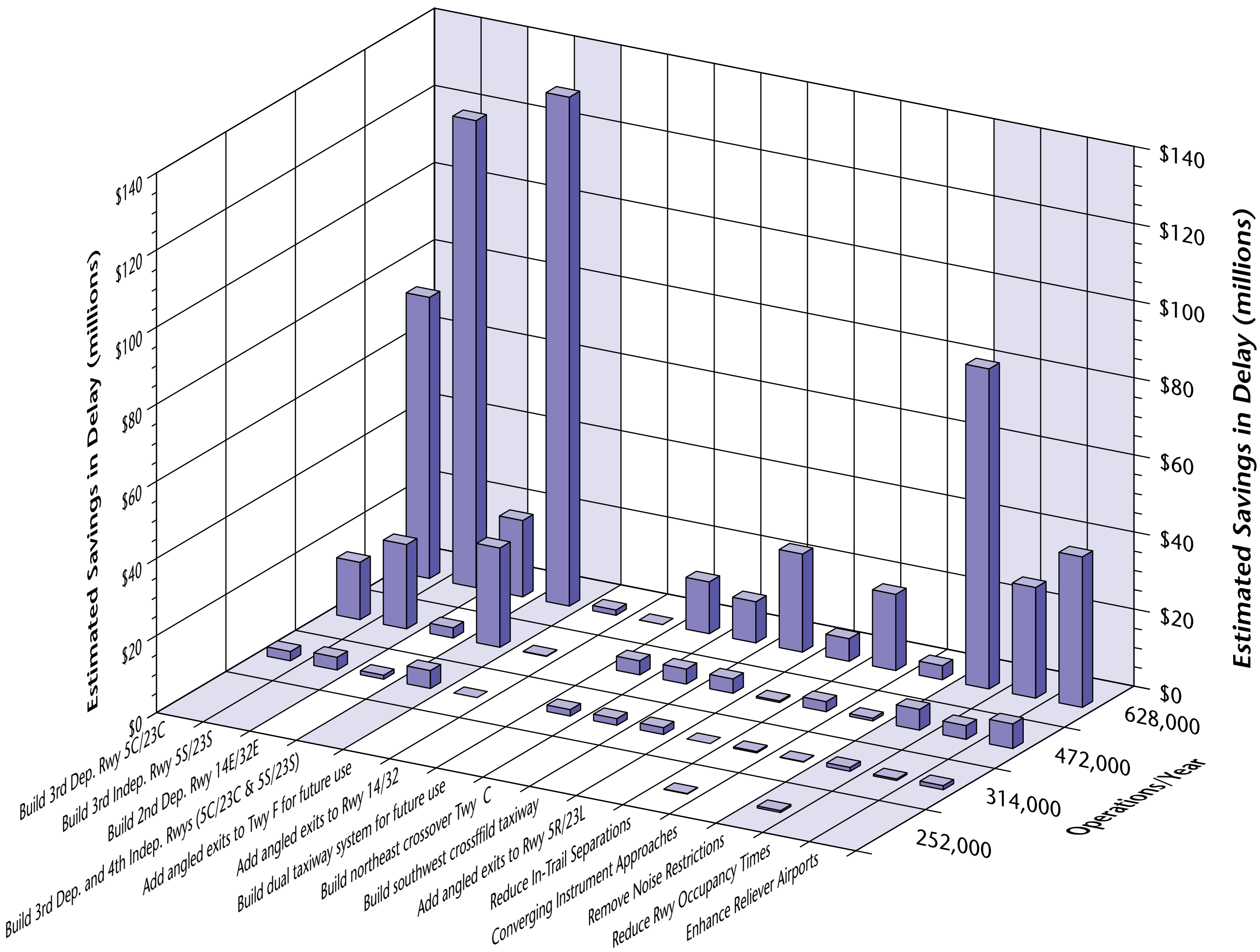
Figure 6. Average Delays — Capacity Enhancement Alternatives



Note: All alternatives include replacement Runway 5L/23R as part of the Baseline airport configuration for modeling purposes.

† = As an alternate to independent Runway 5S/23S.

Figure 7. Annual Delay-Savings Benefits — Capacity Enhancement Alternatives



Section 1 Introduction

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the FAA asked the aviation community to study the problem of airport congestion through the Industry Task Force (ITF) on Airport Capacity Improvement and Delay Reduction chaired by the Airport Operators Council International.

By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity and Requirements (ASC). The goal of this office and its capacity enhancement program is to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated within the system with a minimum of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand and works to develop a coordinated action plan for reducing airport delay. Over 35 Airport Capacity Design Teams have either completed their studies or have work in progress.

The need for this program continues. In 1991, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 36 by 2001. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

Indianapolis International Airport

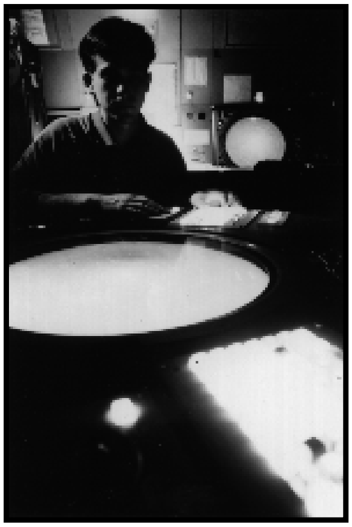
In 1992, 6.35 million passengers used Indianapolis International Airport (IND), a 128 percent increase since 1982. IND is served by 14 passenger airlines, with 200 scheduled departures daily. IND's total aircraft operations reached 251,600 in 1992. USAir recently opened a connecting hub at the airport. In addition to the dramatic passenger growth, there has been an explosive growth in air cargo service. Average cargo tonnage for the 10-year period ending in 1978 was about 45,000 tons per year. In 1984, several carriers began using Indianapolis as a national overnight sort facility, and air cargo tonnage has increased over 500 percent. In 1992, IND ranked as the 12th largest cargo airport in the U.S. Federal Express operates its second national hub at Indianapolis, and the U.S. Postal Service (USPS) has selected Indianapolis as the site of its permanent Eagle Hub Network. In addition, two major airline maintenance facilities are located at the Airport, with one operated by USAir and the other by American Trans Air. United Air Lines is currently constructing a third, even larger maintenance facility.

Indianapolis International Airport and the City of Indianapolis are supported by an extensive network of general aviation reliever airports. Airports under the jurisdiction of the Indianapolis Airport Authority include Speedway Airport, Eagle Creek Airpark, Metropolitan Airport, and Mt. Comfort Airport. In addition, the Downtown Heliport accommodates helicopter service in the City Center. Speedway Airport is scheduled to be closed sometime in the future, and construction of new hangars at Eagle Creek Airpark has begun to accommodate Speedway users who decide to relocate.

The Indianapolis Airport Authority is currently in the process of completing an update to the *Indianapolis Metropolitan Airport System Plan*. The primary focus of this update will be to review and refine the role of general aviation facilities in the eight counties that constitute the Indianapolis metropolitan region.

The *Indianapolis Metropolitan Airport System Plan Update* will serve as a broad update to the original plan completed in 1975, function as a major component of the *Indiana State Aviation System Plan*, and reinforce efforts by the Indianapolis Airport Authority to enhance the growth and services of general aviation facilities located throughout the Indianapolis metropolitan area. It is anticipated that the *Indianapolis Metropolitan Airport System Plan Update* will be completed during the spring of 1993.

As a result of the dramatic increase in air cargo and passenger traffic, the Indianapolis Airport Authority has examined the possibility of accelerating development plans for Indianapolis International Airport. The original 1975 Master Plan recommended two widely spaced parallel runways, with a new midfield terminal complex between the two runways. Implementation of this plan resulted in the opening of the first 10,000-foot parallel runway, Runway 5R/23L, in June 1990. A second parallel runway, 11,200 feet in length to support long-haul international operations, will replace the existing Runway 5L/23R. Originally, the need for a second parallel runway was not anticipated before the year 2000, but current forecasts indicate that it should be in place no later than 1996. Engineering design for the second parallel runway began in 1991, with the intent to construct the runway by late 1995.



Runway 5R/23L, which opened in 1990, is 10,000 feet long and has a complete Category III Instrument Landing System (ILS) on Runway 5R and a Category I system on Runway 23L. The existing Runway 5L/23R, which is also 10,000 feet in length, has a Category III ILS on Runway 5L and a Category I system on Runway 23R. These parallel runways have a centerline-to-centerline separation of 2,800 feet. When weather conditions reduce visibility to instrument meteorological conditions (IMC) and flight operations must be conducted under instrument flight rules (IFR), only staggered (dependent) parallel approaches are permitted. When the replacement Runway 5L/23R is in place, the two parallel runways will be 4,850 feet apart, allowing simultaneous (independent) instrument operations. IFR operations occur about 20 percent of the time at IND.

Indianapolis Airport Capacity Design Team

An Airport Capacity Design Team for Indianapolis International Airport was formed in 1992. The IND Capacity Team identified and assessed various actions which, if implemented, would increase capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

This report has established benchmarks for development based upon traffic levels and not upon any definitive time schedule, since actual growth can vary year to year from projections. As a result, this report should retain its validity until the highest traffic level is attained regardless of the actual date.

A *Baseline* benchmark of 252,000 aircraft operations (takeoffs and landings) was established based on the annual traffic level for 1992, the base year of the study. Three future traffic levels, *Future 1, Future 2, and Future 3,* were established at 314,000, 472,000, and 628,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Indianapolis. If no improvements are made at IND, annual delay levels and delay costs are expected to increase from an estimated 3,240 hours and $4.98 million at the Baseline activity level to nearly 25,450 hours and $39.11 million by the Future 2 demand level.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at IND. The improvements evaluated by the Capacity Team are delineated in Figure 2 and described in some detail in Section 2 — Capacity Enhancement Alternatives.

Objectives

The major goal of the Capacity Team was to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays. In achieving this objective, the Capacity Team:

- Assessed the current airport capacity.
- Examined the causes of delay associated with the airfield, the immediate airspace, and the apron and gate-area operations.
- Evaluated capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield development, and operational improvements.

Scope

The Capacity Team limited its analyses to aircraft activity within the terminal area airspace and on the airfield. They considered the operational feasibility of the proposed airfield improvements, but did not address environmental, socioeconomic, or political issues regarding airport development. These issues need to be addressed in future airport planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team, which included representatives from the FAA, the Indianapolis Airport Authority, the State of Indiana Department of Transportation, and various aviation industry groups (see Appendix A), met periodically for review and coordination. The Capacity Team members considered suggested capacity improvement alternatives. Alternatives that were considered practicable were developed into experiments that could be tested by simulation modeling. The FAA Technical Center's Aviation Capacity Branch provided expertise in airport simulation modeling. The Capacity Team validated the data used as input for the simulation modeling and analysis and reviewed the interpretation of the simulation results. The data, assumptions, alternatives, and experiments were continually reevaluated, and modified where necessary, as the study progressed. A primary goal of the study was to develop a set of capacity-producing recommendations, complete with planning and implementation time horizons.

The simulation models considered air traffic control procedures, airfield improvements, and traffic demands. Alternative airfield configurations were prepared from present and proposed airport layout plans. Various configurations were evaluated to assess the benefit of projected improvements. Air traffic control procedures and system improvements determined the aircraft separations to be used for the simulations under both VFR and IFR.

Air traffic demand levels were derived from *Official Airline Guide* data, historical data, and Capacity Team and other forecasts. Aircraft volume, mix, and peaking characteristics were considered for each of the four different demand forecast levels (Baseline, Future 1, Future 2, and Future 3). From this, annual delay estimates were determined based on implementing various improvements. These estimates took into account variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to the Baseline configuration to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team developed a plan of Recommended Alternatives for consideration, which is included in Figure 8.

Figure 8. Capacity Enhancement Alternatives and Recommended Actions

Alternatives		Action	Time Frame
Airfield Improvements			
0.	New Runway 5L/23R	Under Construction	—
1.	Build third dependent Runway 5C/23C 1,000 ft. east of new Runway 5L/23R	Option for alternative 2	Future 1–Future 2
2.	Build third independent Runway 5S/23S (with Precision Runway Monitor (PRM))	Recommended	Future 1–Future 2
3.	Build a second dependent Runway 14E/32E 800 ft. northeast of Runway 14/32	Further Study	—
4.	Build both third dependent Runway 5C/23C and fourth independent Runway 5S/23S (combines 1 and 2)	Recommended	Future 2–Future 3
5.	Add angled exits to Taxiway F for new Runway 5L/23R	Recommended	Future 1–Future 2
6.	Add angled exits on Runway 14/32	Further Study	—
7.	Build departure sequencing pads for Runways 5L (new) and 5R	Recommended	Baseline
8.	Build dual taxiway system for new Runway 5L/23R	Further Study	—
9.	Build northeast crossover Taxiway C	Recommended	Baseline–Future 1
10.	Build fourth crossfield taxiway at southwest end	Further Study	—
11.	Add angled exits on Runway 5R/23L	Recommended	Baseline-Future 1
Facilities and Equipment Improvements			
12.	Add centerline lights on Runway 14/32 and install touchdown RVR on Runway 14	Not Recommended	—
13.	Install Airport Surface Detection Equipment (ASDE) radar	Recommended	Baseline–Future 1
14.	Install surface movement guidance and control system	Recommended	Baseline–Future 1
15.	Install Aircraft Situation Display (ASD)	Recommended	Baseline
16.	Install approach light system (ALSF-2) on Runway 14/32	Not Recommended	—
17.	Upgrade low-level wind shear advisory system	Recommended	Baseline
18.	Upgrade RVR to CAT IIIB and ICAO standards on Runways 5R and 5L (new)	Recommended	Baseline
19.	Install doppler weather radar	Scheduled Late '93/Early '94	—
20.	End-fire glide slope for Runways 23R (new) and 14	Recommended	Baseline
Operational Improvements			
21.	Reduce in-trail separations to 2.5 nm	Recommended	Baseline
22.	Develop dependent converging approaches	Recommended	Baseline
23.	Effect of removing of noise restrictions	Further Study	—
24.	Reduce runway occupancy times	Recommended	Baseline
25.	Continue enhancement of reliever airports to accommodate a reduction in small/slow aircraft operations at IND	Recommended	Baseline

Note: "Further Study" suggests that a specific study be conducted or that it become part of a larger planning effort, such as a Master Plan Update or a FAR Part 150 Airport Noise Compatibility Study Update. These individual proposals require further investigation at a level of detail that is beyond the scope of this effort.

Section 2 Capacity Enhancement Alternatives

Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the Capacity Team.

Figure 2 lists the capacity enhancement alternatives evaluated by the Capacity Team and presents the estimated annual delay savings benefits for selected improvements. The annual savings are given for the activity levels *Baseline*, *Future 1, Future 2*, and *Future 3*, which correspond to annual aircraft operations of 252,000, 314,000, 472,000, and 628,000 respectively. The future activity levels have not been associated with a time frame, so that conclusions can be tied to activity levels rather than specific dates. The delay savings benefits of the improvements are not necessarily additive.

Figure 8 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

The capacity enhancement alternatives are categorized and discussed under the following headings:

- Airfield Improvements
- Facilities and Equipment Improvements
- Operational Improvements

Airfield Improvements

0. New Runway 5L/23R.

The existing parallel runways, Runways 5L/23R and 5R/23L, currently have a centerline-to-centerline separation of 2,800 feet, permitting only staggered (dependent) parallel approaches under instrument flight rules (IFR). The capacity of IND would be significantly increased by the ability to conduct simultaneous (independent) parallel approaches in all weather conditions. Currently, the separation between parallel runway centerlines must be at least 4,300 feet for independent operations to two runways under IFR.

Runway 5L/23R will soon be replaced, in part due to its deteriorating condition, with an 11,000-foot runway located 4,850 feet northwest of Runway 5R/23L. Construction plans are being finalized, and the first phase of construction is expected to begin in the spring of 1993. Completion of the new runway is anticipated in December 1995.

In this Capacity Team study, the baseline airport configuration was assumed to include the new Runway 5L/23R, with a centerline-to-centerline spacing of 4,850 feet permitting simultaneous (independent) parallel approaches under IFR. All of the simulation modeling assumed that the new Runway 5L/23R was in place.

Estimated 1992 project cost is $40.2 million.

1. Build a third dependent Runway 5C/23C 1,000 feet east of new Runway 5L/23R.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	1,570	9,680	47,450
$M	—	$2.42	$14.87	$72.91

Constructing a new dependent parallel Runway 5C/23C 1,000 feet from new Runway 5L/23R would provide for an additional parallel arrival and departure stream, but only under visual flight rules (VFR). Under IFR, runway separation distances of less than 2,500 feet require that parallel runways be treated as a single runway for arrivals and departures, although some capacity benefit is accrued by separating arrivals and departures.

Estimated 1992 project cost is $40 million.

Annual savings at the Future 1 activity level would be 1,570 hours or $2.42 million, and, at Future 2 activity levels, 9,680 hours or $14.87 million.

2. Build a third independent Runway 5S/23S (with Precision Runway Monitor (PRM)).

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	2,150	14,220	78,830
$M	—	$3.30	$21.86	$121.13

The use of triple independent arrival streams would result in a significant increase in arrival capacity under all weather conditions. Work is currently underway to develop the air traffic control procedures and provide the new technology to support these improvements. Simulations at the FAA Technical Center have resulted in preliminary approval of triple and quadruple simultaneous parallel approaches at Dallas-Fort Worth International Airport (contingent upon final runway location). The success of these simulations has led to further work to develop procedures that could be applied at any airport that met the basic criteria, and national standards for triple parallel approaches are under development. These standards are expected to require a minimum of 5,000 feet between the runways when using the current radar systems. New technology, such as the high-update-rate radar and improved controller displays associated with the PRM, may allow reduced runway spacings to as low as 4,000 feet.

Estimated 1992 project cost is $62 million (excluding the costs for the PRM and required NAVAIDs).

Annual savings at the Future 1 activity level would be 2,150 hours or $3.3 million, and, at Future 2 activity levels, 14,220 hours or $21.86 million.

3. Build a second dependent Runway 14E/32E 800 feet northeast of Runway 14/32.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	680	1,730	12,890
$M	—	$1.04	$2.65	$19.80

Constructing a new dependent parallel Runway 14E/32E 800 feet from the existing Runway 14/32 would provide for an additional parallel arrival and departure stream, but only under VFR. Under IFR, runway separation distances of less than 2,500 feet require that parallel runways be treated as a single runway.

Estimated 1992 project cost is $40 million.

Annual savings at the Future 1 activity level would be 680 hours or $1.04 million, and, at Future 2 activity levels, 1,730 hours or $2.65 million. These savings figures assumed increasd operations on Runway 14/32 with the new high-speed exits in place.

4. Build both a third dependent Runway 5C/23C and a fourth independent Runway 5S/23S (combines alternatives 1 and 2).

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	3,020	16,750	85,900
$M	—	$4.64	$25.74	$131.99

Under this alternative, a third dependent Runway 5C/23C would be constructed approximately 1,000 feet east of the new Runway 5L/23R and 3,850 feet west of the existing Runway 5R/23L, and a fourth independent Runway 5S/23S would be constructed 3,000 to 4,300 feet east of the existing Runway 5R/23L. This four-runway configuration would be flexible enough to accommodate either an arrival or departure push, using three of the runways for simultaneous (independent) operations.

Estimated 1992 project cost is $102 million.

Annual savings at the Future 1 activity level would be 3,020 hours or $4.64 million; at Future 2 activity levels, 16,750 hours or $25.74 million; and, at Future 3 activity levels, 85,900 or 131.99 million.

5. Add angled exits to Taxiway F for new Runway 5L/23R.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	8	100	890
$M	—	$0.01	$0.15	$1.37

Providing two high-speed exits in each direction (four total) for the new Runway 5L/23R would reduce runway occupancy times and enhance runway capacity.

Estimated 1992 project cost is $5 million.

Annual savings at the Future 1 activity level would be 8 hours or $0.01 million, and, at Future 2 activity levels, 100 hours or $0.15 million.

6. Add angled exits on Runway 14/32.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	—	—	17
$M	—	—	—	$0.03

Providing one high-speed exit in each direction (two total) on Runway 14/32 would reduce runway occupancy times and enhance runway capacity. This improvement could become more of a capacity factor should the utilization of Runway 14/32 increase or a second dependent runway 14E/32E be constructed.

Estimated 1992 project cost is $3 million.

Annual savings at the Future 3 activity levels would be 17 hours or $0.03 million.

7. Build departure sequencing pads for Runways 5L (new) and 5R.

Air traffic flow control often dictates that aircraft hold at the runway thresholds before take-off because of departure flow restrictions. Construction of holding areas would improve the ability of departing aircraft to bypass those aircraft waiting for departure clearance and relieve congestion on taxiways. These holding pads could also be used for secondary and remote deicing.

Estimated 1992 project cost is $6 million.

8. Build dual taxiway system for new Runway 5L/23R.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	1,100	2,380	8,740
$M	—	$1.68	$3.65	$13.43

By providing a dual taxiway system for the new Runway 5L/23R, this project would allow two-way traffic for arriving and departing aircraft to taxi to and from the terminal and the runway and would improve the flow of ground traffic and reduce taxi interference and delays.

Estimated 1992 project cost is $14 million.

Annual savings at the Future 1 activity level would be 1,100 hours or $1.68 million, and, at Future 2 activity levels, 2,380 hours or $3.65 million.

9. Build northeast crossover Taxiway C.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	1,130	2,530	6,950
$M	—	$1.73	$3.89	$10.68

Construction of Taxiway C would enable aircraft arriving on Runway 14/32 to taxi to the Federal Express apron, the U.S. Postal Service (USPS) apron, the future midfield terminal area, or other future facilities in the northwest quadrant of the airport, without crossing an active runway. It would also allow Runway 14/32 to be used for departures from these areas without having to cross the runway.

Estimated 1992 project cost is $4 million.

Annual savings at the Future 1 activity level would be 1,130 hours or $1.73 million, and, at Future 2 activity levels, 2,530 hours or $3.89 million.

10. Build fourth crossfield taxiway at southwest end.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	1,150	2,420	16,550
$M	—	$1.77	$3.72	$25.43

Constructing a fourth crossfield taxiway at the southwest end of the airfield would provide an additional taxiway for arriving and departing aircraft to taxi to and from the terminal area and the north and south runways. It would provide a better flow of aircraft traffic between the two runways, improve access for Federal Express and the USPS to and from the runways, and attract additional development to the northwest quadrant of the airport.

Estimated 1992 project cost is $7 million.

Annual savings at the Future 1 activity level would be 1,150 hours or $1.77 million, and, at Future 2 activity levels, 2,420 hours or $3.72 million.

11. Add angled exits on Runway 5R/23L.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	20	270	3,820
$M	—	$0.03	$0.42	$5.87

Providing one additional high-speed exit in each direction (two total) on Runway 5R/23L would reduce runway occupancy times and enhance runway capacity.

Estimated 1992 project cost is $3 million.

Annual savings at the Future 1 activity level would be 20 hours or $0.03 million, and, at Future 2 activity levels, 270 hours or $0.42 million.

Facilities and Equipment Improvements

12. Add centerline lights on Runway 14/32 and install touchdown zone runway visual range (RVR) on Runway 14.

Installing both centerline lights on Runway 14/32 and a touchdown zone RVR on Runway 14 would reduce visibility minimums for arrivals on Runway 14 from 2,400 feet to 1,800 feet and reduce visibility minimums for departures on Runway 14/32 to 1,800 feet. The primary benefit would be in adverse weather.

Estimated 1992 project cost is $0.6 million for the centerline lights and $0.2 million for the RVR for a total project cost of $0.8 million.

13. Install Airport Surface Detection Equipment (ASDE) radar.

Monitoring ground traffic flow during poor weather conditions is difficult and restricts the flow of aircraft to and from the runways and ramps. ASDE is a short-range, high-resolution radar designed to support air traffic controllers in the monitoring and control of ground traffic. ASDE would eliminate the need to rely totally on pilot position reports when aircraft are not visible from the tower and would provide the ability to independently monitor movement of aircraft on the ground in all weather conditions. It would enable air traffic controllers to verify aircraft positions, provide definitive control instructions to guide aircraft to and from the runways and ramps, and use anticipatory clearances to expedite air traffic movement.

14. Install surface movement guidance and control system.

The runway/approach path safety system provided by Airport Surface Traffic Automation (ASTA) will include an automated surveillance capability that will provide tower controllers with real-time data on the location and movement of all aircraft and vehicles on the airport surface and all aircraft on the final approach path. This capability provides an integrated display of the runway/approach path situation that is designed to prevent conflict situations from developing. It detects and presents conflict situations to controllers and provides automatic communications with the cockpit for ATC clearance, airport traffic situations, and automatic emergency conflict resolution messages. ASTA will provide an all-weather, automated capability that allows for safe, high-capacity operations under all weather conditions.

15. Install Aircraft Situation Display (ASD).

Improved access to timely information on arrival and departure aircraft is critical to managing runway and terminal airspace resources. The ASD would enhance the ability to implement, train, staff, and operate necessary traffic management functions. ASDs are currently planned only for Level 5 towers, but consideration should be given to installing ASDs at selected Level 4 towers.

16. Install approach light system (ALSF-2) on Runway 14/32.

Installation of an approach light system with sequenced flashers and a Category II modification (ALSF-2) on Runway 14/32 would improve visibility minimums for approaches in reduced visibility conditions.

17. Upgrade Low-Level Wind Shear Advisory System (LLWAS).

Wind shear conditions occurring at low altitude in the terminal area are hazardous to aircraft encountering them during takeoff or final approach. The Low-Level Wind Shear Alert System (LLWAS) provides a capability to monitor winds in the terminal area and alert the pilot, through the air traffic controller, when hazardous wind shear conditions are detected.

Upgrading the LLWAS to a Phase III system will increase the number of wind sensors and extend coverage in the approach and departure corridors. This upgrade will also increase the height of the sensors to reduce the effects of sheltering. These improvements will increase the LLWAS's capability to detect wind shear.

18. Upgrade Runway Visual Range (RVR) to Category IIIB and ICAO standards on Runways 5R and 5L (new).

Upgrading the RVR would reduce visibility minimums for arrivals and departures. It would allow continued operation of long-haul international flights for foreign flag carriers under conditions of reduced visibility. The primary benefit would be in adverse weather.

19. Install doppler weather radar.

The new Terminal Doppler Weather Radar (TDWR) will detect microbursts, gust fronts, wind shifts, and precipitation. Microbursts are a weather phenomenon that consists of an intense downdraft that may occur in clear air or in precipitation areas. They are particularly dangerous to aircraft landing or departing. The TDWR scanning mode will be optimized for detection of microbursts and wind shear. TDWR will be used to provide alerts of hazardous weather conditions in the terminal area and to provide advanced notice of changing wind conditions to permit timely change of active runways.

20. End-fire glide slope for Runways 23R (new) and 14.

Use of a conventional glide slope at the approach ends of Runways 23R (new) and 14 would restrict portions of the adjoining taxiway because of the size of the critical area associated with glide slope antennas. Use of end-fire glide slopes at these two locations would eliminate these restrictions.

Operational Improvements

21. Reduce in-trail separations to 2.5 nm.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	100	240	1,710	12,870
$M	$0.15	$0.37	$2.62	$19.77

Existing procedures for IFR require that arriving aircraft be separated by 3 nautical miles (nm) or more. Reducing separation minimums to 2.5 nm for aircraft of similar class and less than 300,000 pounds would increase arrival rates and runway capacity; however, if the runway exits are not visible from the tower, the 2.5 nm separation cannot be applied. Most of the savings occur at the highest demand levels during operations under IFR.

Annual savings at the Baseline activity level would be 100 hours or $0.15 million, and, at Future 2 activity levels, 1,710 hours or $2.62 million.

22. Develop dependent converging approaches.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	90	450	2,380
$M	—	$0.14	$0.70	$3.65

Under VFR, it is common to use non-intersecting converging runways for independent streams of arriving aircraft. Because of the reduced visibility and ceilings associated with IFR, simultaneous (independent) use of runways is currently permitted for aircraft arrivals only during relatively high weather minimums. However, a program is under development that would allow dependent (alternating) arrivals on non-parallel runways through the use of a Converging Runway Display Aid (CRDA) for air traffic controllers.

Annual savings at the Future 1 activity level would be 90 hours or $0.14 million, and, at Future 2 activity levels, 450 hours or $0.70 million.

23. Effect of removing noise restrictions.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	330	660	3,510	54,030
$M	$0.50	$1.02	$5.39	$83.02

An approved Federal Aviation Regulation (FAR) Part 150 Noise Study identified a noise sensitive area southwest of the Airport. As a result, Air Traffic Control modified departure turn procedures, runway assignments, and nighttime jet approaches. These noise restrictions include: noise abatement takeoff profiles, preferential runway use and runway assignment, prohibition of certain intersection departures, departure turn procedures, nighttime jet approach procedures, and designated helicopter routing.

Under the departure turn procedures, turbojet aircraft avoid the residential area at altitudes below 2,500 feet for daytime departures and 3,000 feet for nighttime departures. The departures are taxied to a potentially less efficient runway and kept on a non-impacting heading until above the protected altitude. Some of these avoidance and abatement measures restrict optimum airspace utilization, increase delays, and increase user expenses.

At the Baseline activity level, the annual cost penalty of these noise restrictions is 330 hours or $0.5 million, and, at Future 2 activity levels, 3,510 hours or $5.39 million.

24. Reduce runway occupancy times.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	270	2,330	18,680
$M	—	$0.42	$3.57	$28.70

The addition of new and improved exits will facilitate a reduction in runway occupancy times permitting a reduction of the in-trail spacing required for arriving aircraft. This would increase arrival acceptance rates and decrease arrival delays. Once the new exits are in place and the proposed midfield terminal has been developed, this alternative will have a significant effect in reducing the expected delays associated with the current taxiway/exit configuration and the increases in the level of traffic expected at IND in the future. In modeling this alternative, a 15 percent reduction in runway occupancy time was assumed using the baseline airport configuration. Further studies are needed to optimize the locations of high-speed taxiway exits.

Annual savings at the Future 1 activity level would be 270 hours or $0.42 million, and, at Future 2 activity levels, 2,330 hours or $3.57 million.

25. Continue enhancement of the reliever airport system in order to accommodate a reduction in small/slow aircraft operations at IND.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	690	4,160	25,400
$M	—	$1.06	$6.39	$39.03

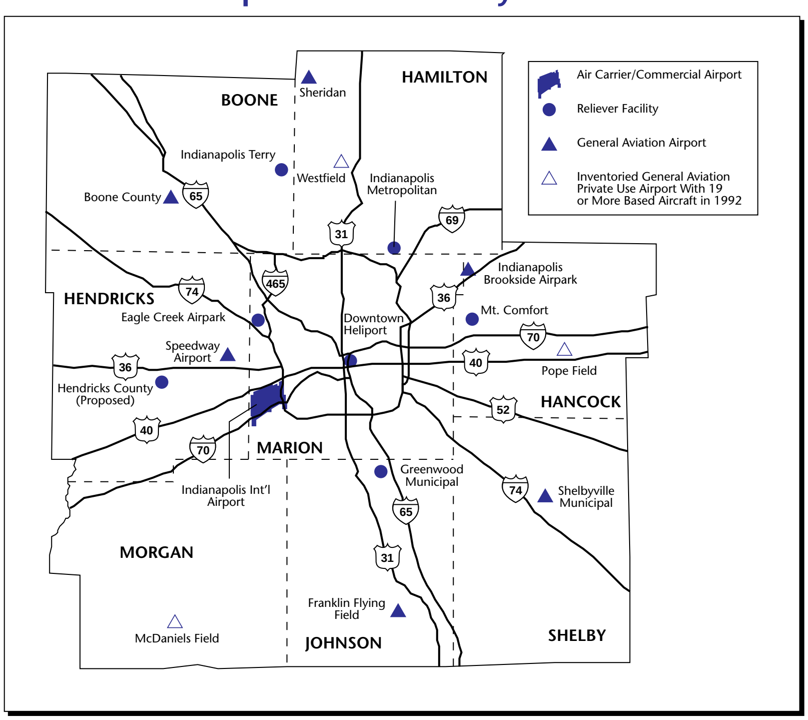
Reliever airports can ease capacity constraints by attracting small/slow aircraft away from primary airports, especially where small/slow aircraft constitute a significant portion of operations. The segregation of aircraft operations by size and speed increases effective capacity because required time and distance separations are reduced between planes of similar size and speed. A 25 percent reduction in small/slow aircraft activity at IND would result in annual savings at the Future 1 activity level of 690 hours or $1.06 million, and, at Future 2 activity levels, 4,160 hours or $6.39 million.

Every effort should be made to accommodate these aircraft at enhanced "reliever airports" with easy access to various locations within the metropolitan area. The reliever airports would need to provide services similar to those available at IND. "Similar services" would include longer and wider runways with associated lighting and increased pavement strength, all-weather approach capability, parallel taxiways, larger aprons, and such ancillary services as rental cars and easy access to public and private transportation.

The instrument systems needed to provide approach capability under instrument meteorological conditions (IMC) are limited in their availability. The FAA has reinstated the use of a localizer only/outer marker (LOC/OM) approach including a light lane (medium intensity approach light system (MALS)). This provides for approach minimums of a 400 foot ceiling and 3/4 mile visibility. These lower approach minimums would allow the existing facilities, without precision instrument approach procedures, to be available for a larger percent of the time under IMC. There is such an approach at the Eagle Creek Airpark.

In order to increase utilization of reliever airports, the FAA provides assistance under the Airport Improvement Program and the Facilities and Equipment Program to construct new reliever airports, improve the facilities, and provide for navigational aids at existing relievers, and minimize the adverse environmental impact of these airports on neighboring communities.

Airports in the vicinity of IND



Section 3 Summary of Technical Studies

Overview

The Indianapolis International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future airfield configuration. A brief description of the computer models and methodology employed can be found in Appendix B. Certain standard inputs were used to reflect the operating environment at Indianapolis International Airport (IND). Details may be found in the data packages and technical summary produced by the FAA Technical Center during the course of the study. Figure 9 shows the characteristics of the aircraft fleet operating at IND; Figure 10, the airfield weather conditions; and Figure 11, the runway utilization for various runway configurations. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

The fleet mix at IND has an average direct operating cost of $1,537 per hour ($25.61 per minute). This figure represents the costs for operating the aircraft and includes such items as fuel, maintenance, and crew costs, but it does not consider lost passenger time, disruption to airline schedules, or any other intangible factors.

Daily operations corresponding to an average day in the peak month were used for each of the demand levels. The Runway Delay Simulation Model (RDSIM) and the Airport and Airspace Simulation Model (SIMMOD) were used to determine aircraft delays during peak periods. Delays were calculated for current and future conditions. Daily delays were annualized to measure the potential economic benefits of the proposed improvements. The annualized delays provided a basis for comparing the benefits of the proposed alternatives. The benefits associated with various runway use strategies were also identified. The cost of a particular improvement can be compared to its annual delay savings benefits.

For expected increases in demand, a combination of improvements can be implemented to allow airfield capacity to increase while aircraft delays are minimized.

Figure 9. Aircraft Fleet Characteristics

Aircraft Class	Aircraft Types	Peak Hour		Departure Runway Occupancy Times	Approach Speeds
		Airfield Mix	Annual Fleet Mix		
Class 4	Single-engine props under 12,500 lbs.	18%	19%	34 seconds	90 knots
Class 3	Twin-engine props under 12,500 lbs.	23%	22%	34 seconds	120 knots
Class 2	Large aircraft <300,000 lbs. and small jets.	58%	59%	39 seconds	130 knots
Class 1	Heavy aircraft >300,000 lbs.	0%	0%	39 seconds	140 knots

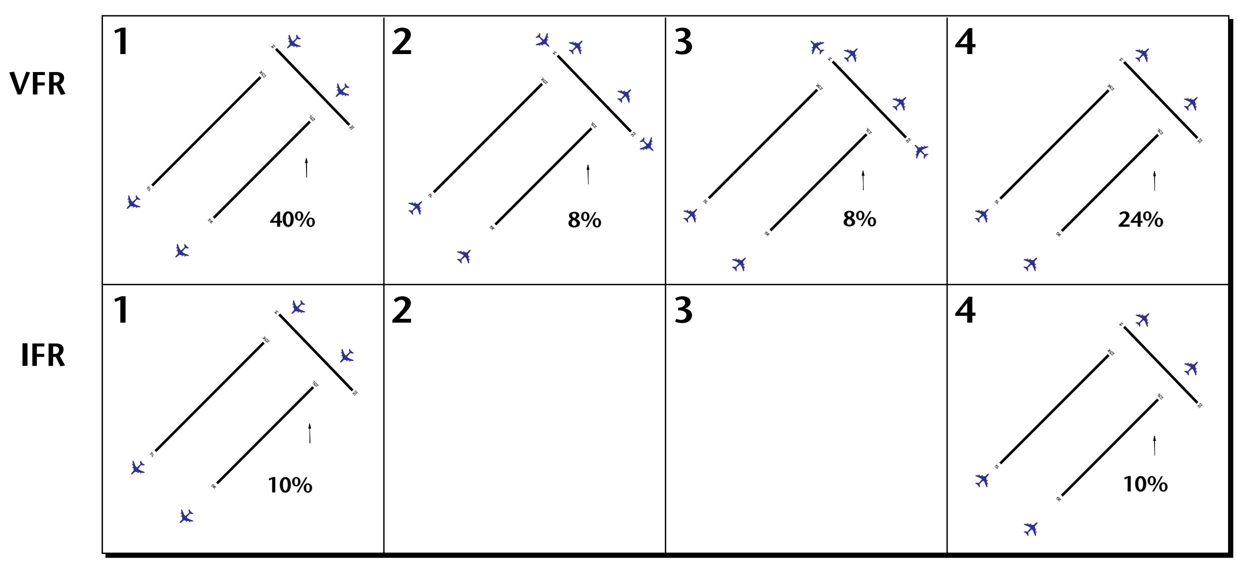
Figure 10. Airfield Weather

	Ceiling/Visibility	Occurrence (%)
VFR	3,000 feet and above/5 mi and above	80
IFR	below 3,000 feet/below 5 mi	20
	Total	100

VFR – visual flight rules
IFR – instrument flight rules
mi – miles

Note: Airfield weather specific according to minimum vectoring altitude.

Figure 11. Runway Configurations



Note: Daytime configurations and percentages only.

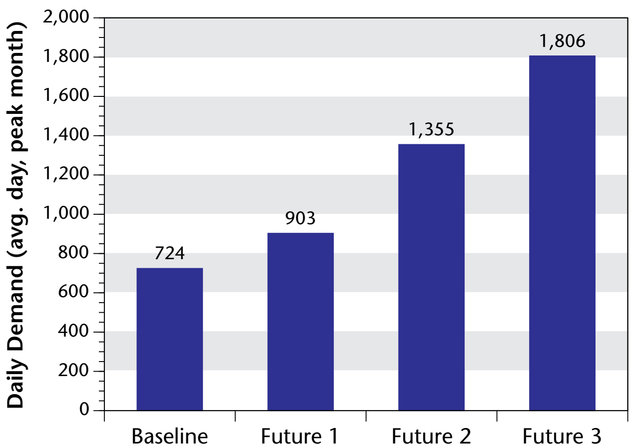
Airfield Capacity

The IND Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings and takeoffs) that can take place in a given time. The following conditions were considered:

- Level of delay
- Airspace constraints
- Ceiling and visibility
- Runway layout and use
- Noise constraints
- Aircraft mix
- Percent arrival demand

Figure 12 illustrates the average-day, peak-month arrival and departure demand levels for IND for each of the four annual activity levels used in the study, Baseline, Future 1, Future 2, and Future 3.

Figure 12. Airfield Demand Levels



	Annual	24-Hour Day*	Peak Hour
Baseline	252,000	724	58
Future 1	314,000	903	73
Future 2	472,000	1,355	111
Future 3	628,000	1,806	146

* Average Day, Peak Month

Figure 13 presents the airport capacity curves for IND. The curves were developed for the depicted runway configuration, under IFR, with an 80/20, 50/50, and 20/80 split of arrivals and departures, with the replacement of Runway 5L/23R completed. These curves are based on the assumption that arrival and departure demand is randomly distributed within the hour. Other patterns of demand can alter the demand/delay relationship.

The curves in Figure 13 illustrate the relationship between airfield capacity, stated in the number of operations per hour, and the average delay per aircraft. They show that, as the number of aircraft operations per hour approaches practical capacity, the average delay per operation increases exponentially.

Figure 14 illustrates the hourly profile of daily demand for the Baseline activity level of 252,000 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 472,000 aircraft operations per year.

Comparing the information in Figures 13 and 14 shows that:

- aircraft delays will begin to escalate rapidly as hourly demand exceeds 90 operations per hour (50/50 arrival/departure ratio at 4 minutes average delay), and,
- although hourly demand does not exceed 90 operations at Baseline demand levels, 90 operations per hour is exceeded at the demand levels forecast for Future 2.

Figure 13. Airport Capacity Curve — Hourly Flow Rate Versus Average Delay — Under IFR

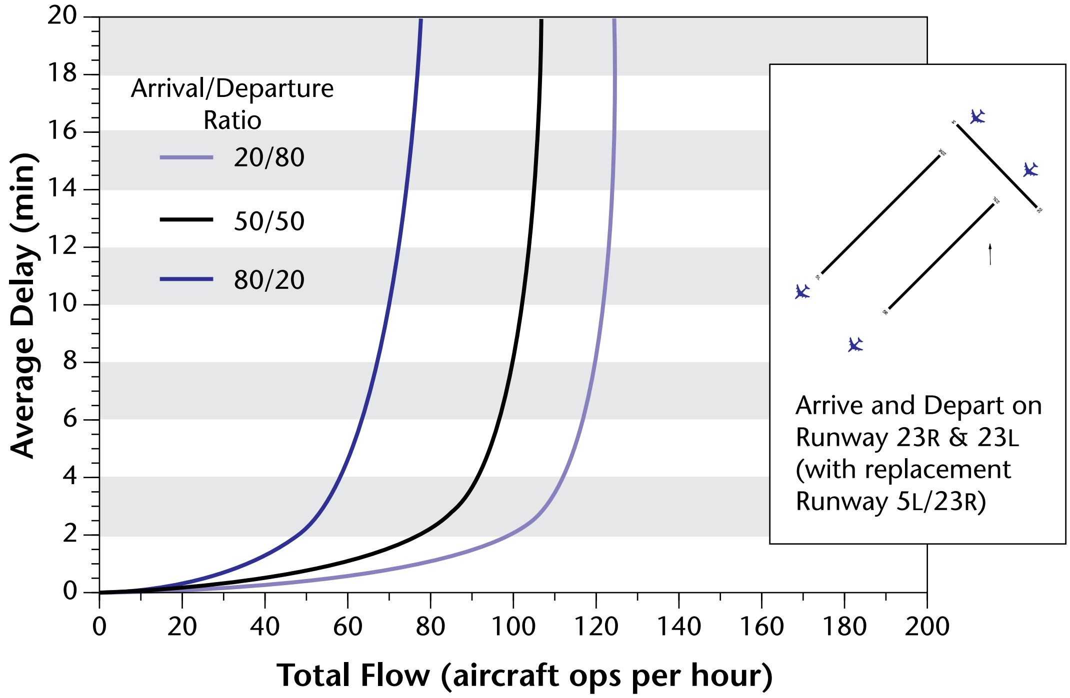
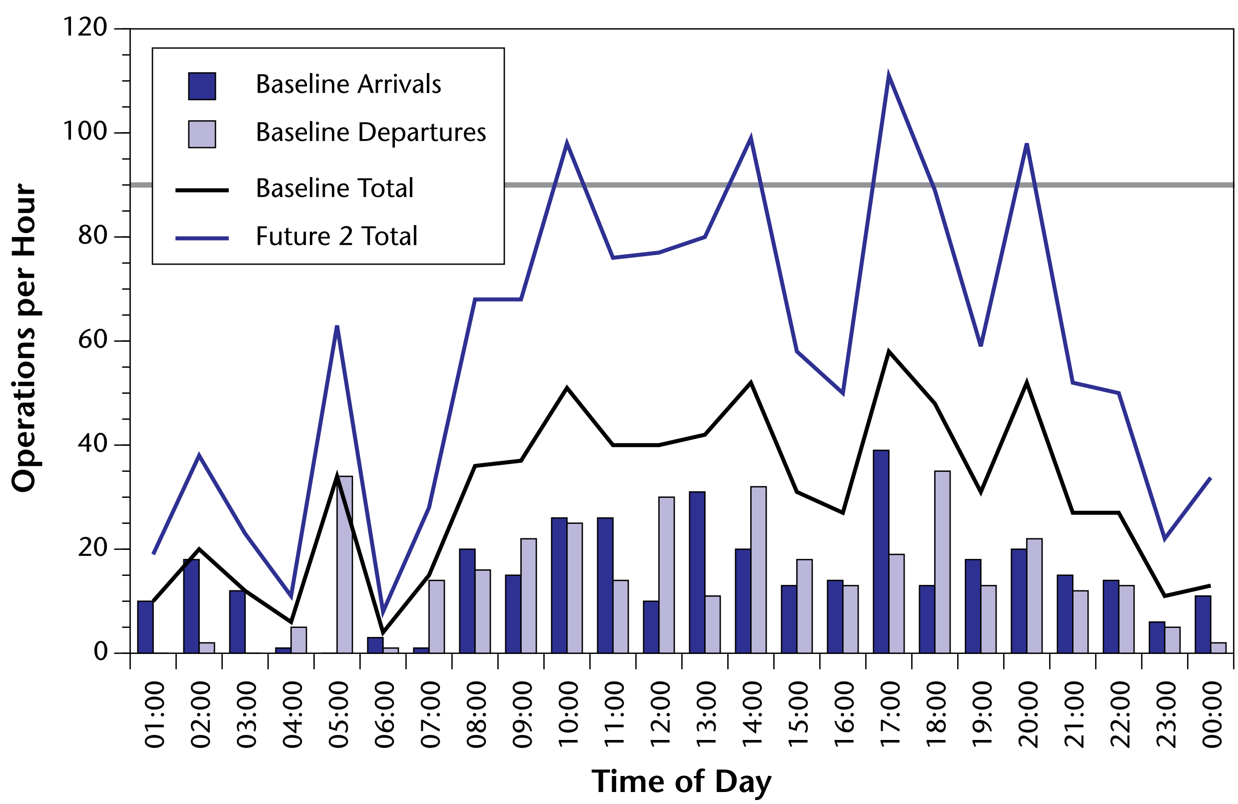


Figure 14. Profile of Daily Demand — Hourly Distribution



Aircraft Delays

Aircraft delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination. Aircraft delay results from interference from other aircraft competing for the use of the same facilities.

The major factors influencing aircraft delays are:

- Weather
- Airfield and ATC system demand
- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics

Average delay in minutes per operation was generated by the Runway Delay Simulation Model (RDSIM). A description of this model is included in Appendix B. Under the Do Nothing scenario, if there are no improvements made in airfield capacity, the annual delay cost could increase as follows:

	Annual Delay Costs Hours	Millions of 1992 $
Baseline	3,240	$4.98
Future 1	5,830	$8.96
Future 2	25,450	$39.11
Future 3	113,300	$174.10

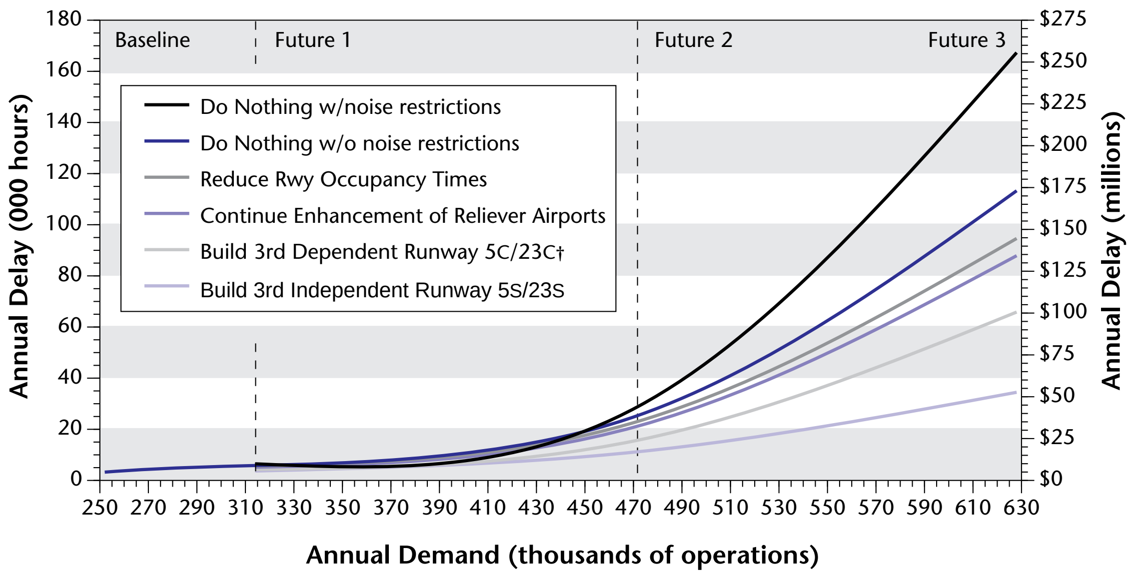
Conclusions

Figure 15 demonstrates the impact of delays at Indianapolis International Airport. The chart shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. The graphs also show that the greatest savings in delay costs would be provided by:

- Building a third independent Runway 5S/23S
- Building a third dependent Runway 5C/23C (as an alternate to independent Runway 5S/23S)
- Continuing enhancement of reliever airports
- Removing noise restrictions
- Reducing runway occupancy times

Figure 16 illustrates the average delay in minutes per aircraft operation for these same alternatives. Under the Do Nothing alternative with noise restrictions, if there are no improvements made in airfield capacity, the average delay per operation of 0.8 minutes in Baseline will increase to 3.7 minutes per operation by Future 2 and 16 minutes per operation by Future 3.

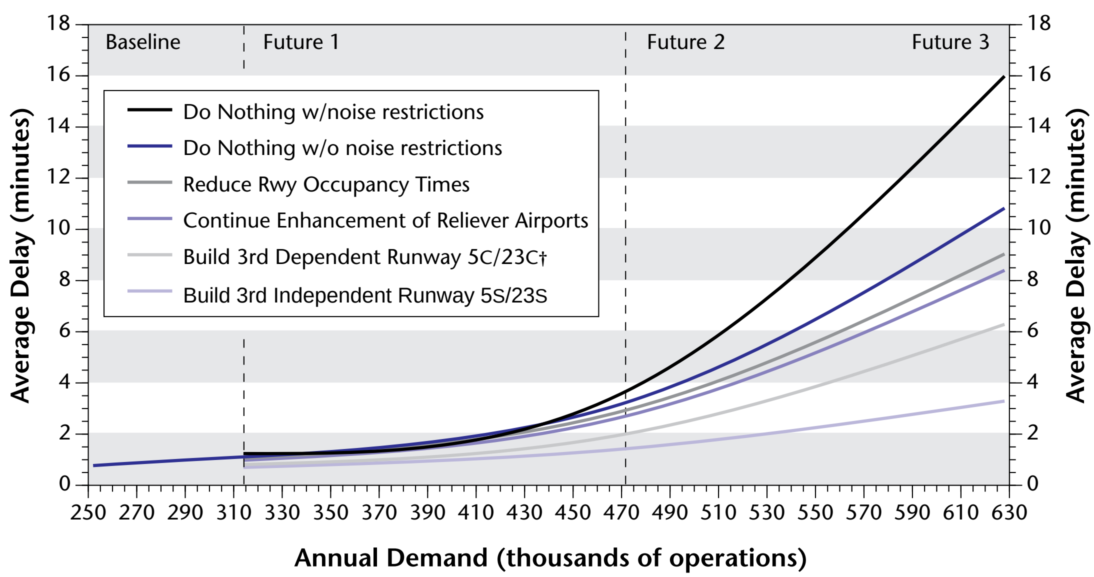
Figure 15. Annual Delay Costs — Capacity Enhancement Alternatives



Note: All alternatives include replacement Runway 5L/23R as part of the Baseline airport configuration for modeling purposes.

† = As an alternate to independent Runway 5S/23S.

Figure 16. Average Delays — Capacity Enhancement Alternatives



Note: All alternatives include replacement Runway 5L/23R as part of the Baseline airport configuration for modeling purposes.

† = As an alternate to independent Runway 5S/23S.

Figure 17. Annual Delay-Savings Benefits — Capacity Enhancement Alternatives

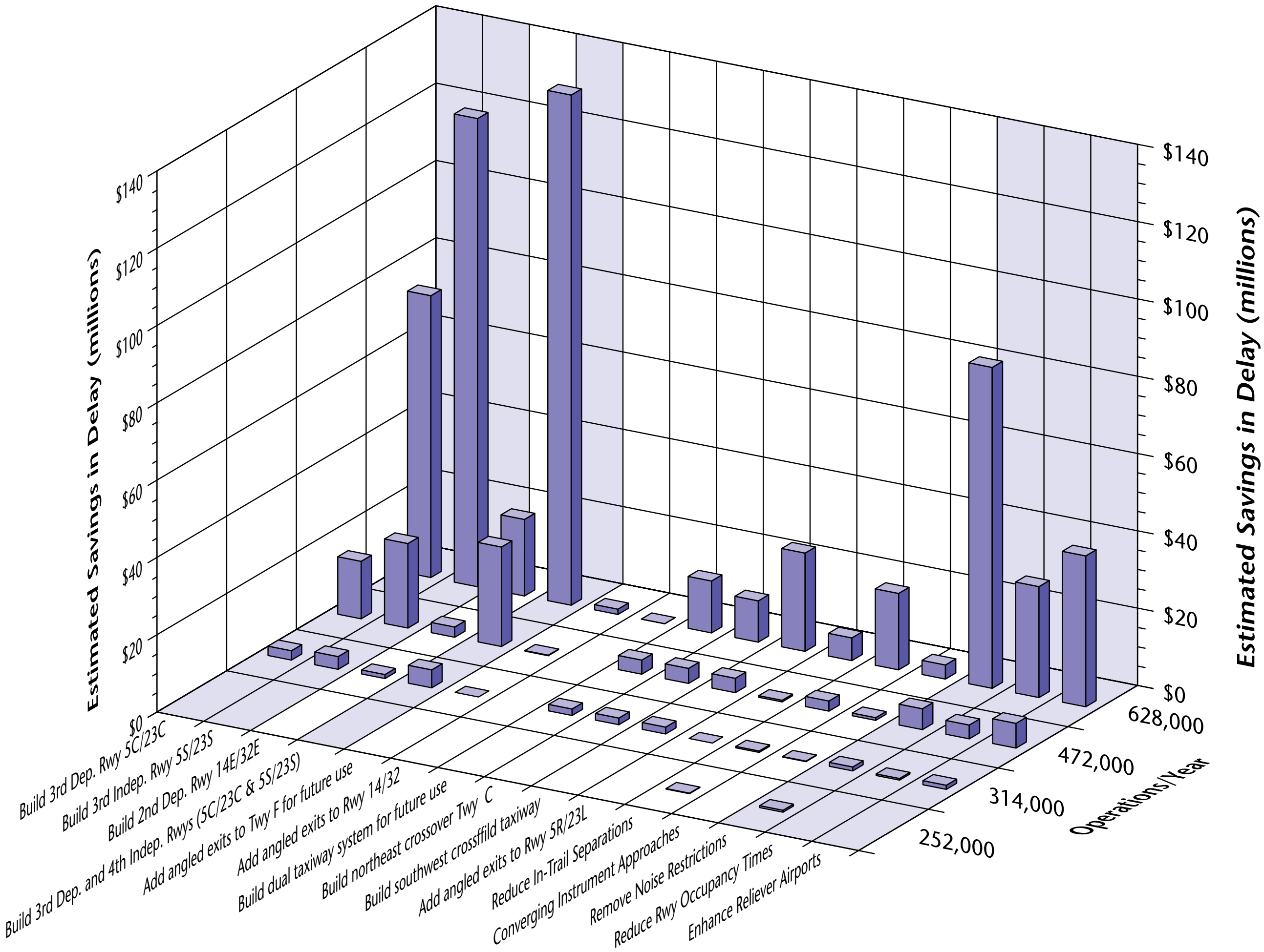


Figure 17 illustrates the annual delay-savings benefits for each alternative and for each of the four annual activity levels (operations per year). It serves to highlight the alternatives that will provide the greatest savings in delay costs:

- Building both a third dependent and a fourth independent runway
- Building a third independent northeast/southwest runway
- Removing noise restrictions
- Continuing enhancement of reliever airports
- Reducing runway occupancy times

Appendix A — Participants

Federal Aviation Administration

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Aircraft Owners and Pilots Association
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Richard Hetzel
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HNTB
Evan Futterman
Jeff Mishler

Appendix B Computer Models and Methodology

The IND Capacity Team studied the effects of various improvements proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using several computer modeling techniques. A brief description of the models and the methodology employed follows.

Computer Models

Runway Delay Simulation Model (RDSIM)

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

RDSIM, on the other hand, simulates only the runways and runway exits. There are two versions of the model. The first version ignores the taxiway and gate complexes for a user-specified daily traffic demand and is used to calculate daily demand statistics. In this mode, the model replicated each experiment 100 times, using Monte Carlo sampling techniques to introduce daily variability of results, which were averaged to produce output statistics. The second version also simulates the runway and runway exits only, but it creates its own demand using randomly assigned arrival and departure times. The demand created is based upon user-specified parameters. This form of the model is suitable for capacity analysis.

For this study, RDSIM was calibrated against field data collected at IND to insure that the model was site specific. For a given demand, the model calculated the hourly flow rate and average delay per aircraft during the full period of airport operations. Using the same aircraft mix, computer specialists simulated different demand levels for each run to generate demand versus delay relationships.

Airport and Airspace Simulation Model (SIMMOD)

SIMMOD is a fast-time, event-step model that simulates the real-world process by which aircraft fly through positive controlled en route and terminal airspace. SIMMOD traces the movement of individual aircraft as they travel through the gate, taxiway, runway, and airspace system and detects potential violations of separations and operational procedures. It simulates the air traffic control actions required to resolve potential conflicts and insures that aircraft operate within procedural rules. Aircraft travel time, delay, and traffic statistics are computed and provided as model outputs. To ensure the model was site specific, it was calibrated for this study against field data collected at IND. The model replicated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability. The results were then averaged to produce the output statistics.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands. To assess the benefits of proposed airfield improvements, the FAA used different airfield configurations derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for IFR and VFR simulations.

For the delay analysis, agency specialists developed traffic demands based on the *Official Airline Guide,* historical data, and various forecasts. Aircraft volume, mix and peaking characteristics were developed for four demand periods (Baseline, Future 1, Future 2, and Future 3). The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reductions for each improvement were assessed by comparing the annual delay estimates.

RDSIM, in its capacity mode, was used to perform the capacity analysis for IND.

Appendix C — List of Abbreviations

ADSIM .... Airfield Delay Simulation Model
ASTA .... Airport Surface Traffic Automation
ALS .... Approach Light System
ALSF-2 .... Standard Approach Light System With Sequenced Flashers and CAT II Modification
ASD .... Aircraft Situation Display
ASDE .... Airport Surface Detection Equipment
ATC .... Air Traffic Control
CAT .... Category of instrument approach
CRDA .... Converging Runway Display Aid
FAA .... Federal Aviation Administration
FAR .... Federal Aviation Regulation
GA .... General Aviation
IAA .... Indianapolis Airport Authority
ICAO .... International Civil Aviation Organization
IFR .... Instrument Flight Rules
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions
IND .... Indianapolis International Airport
LLWAS .... Low-Level Wind Shear Alert System
LOC .... Localizer
MALS .... Medium Intensity Approach Light System
MI .... Miles
NAVAID........ Navigation Aid — air navigation facility
NM .... Nautical Miles
OM .... Outer Marker
PRM .... Precision Runway Monitor
RDSIM .... Runway Delay Simulation Model
RVR .... Runway Visual Range
SIMMOD ...... Airport and Airspace Simulation Model
TDWR .... Terminal Doppler Weather Radar
USPS .... U.S. Postal Service
VFR .... Visual Flight Rules
VMC .... Visual Meteorological Conditions

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