Cleveland-Hopkins International Airport

Airport Capacity Enhancement Plan

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Capacity Enhancement Plan

August 1994

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the City of Cleveland, Department of Port Control, and the airlines and general aviation serving the Cleveland metropolitan area.

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Figure 1. Cleveland-Hopkins International Airport

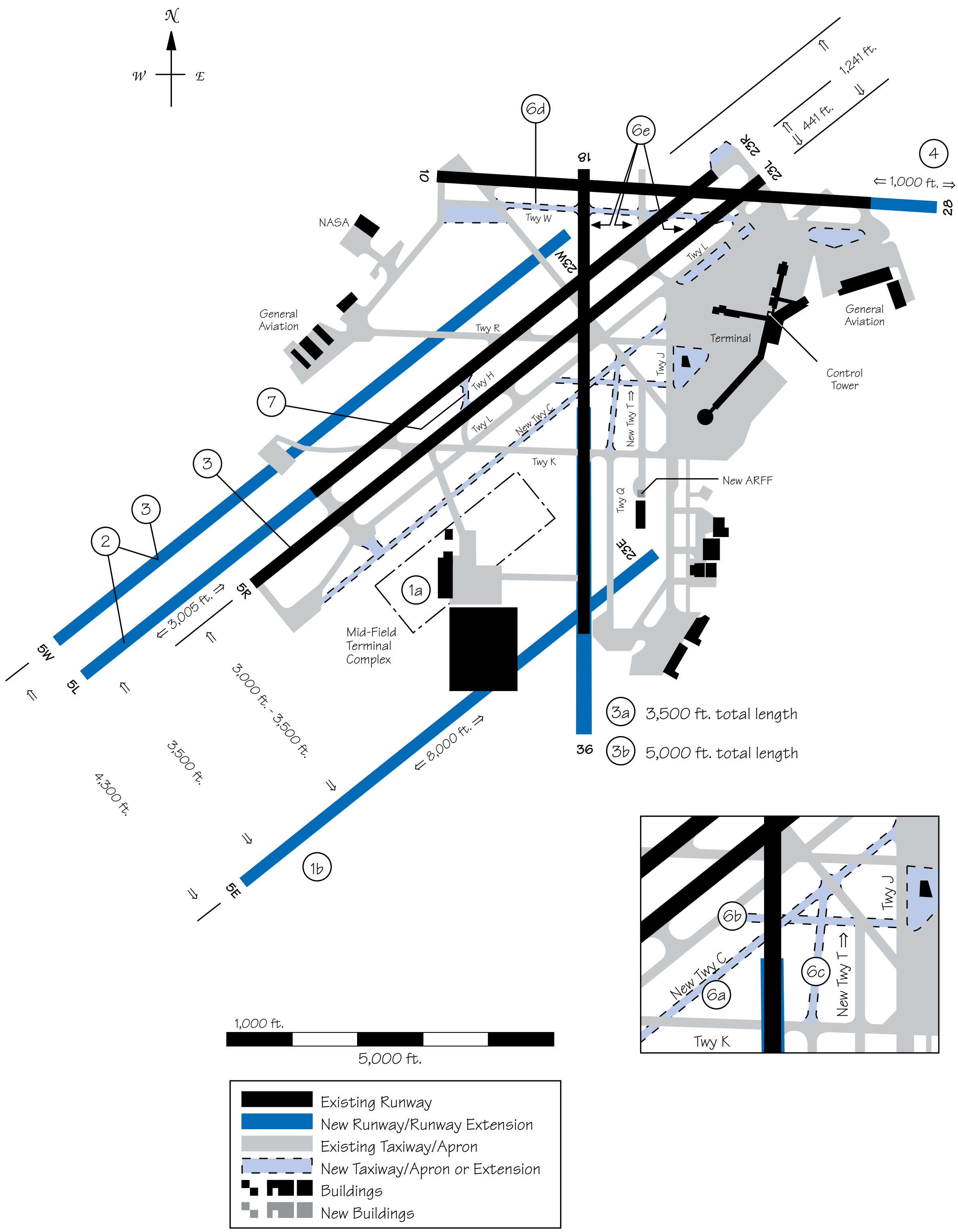


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives Airfield Improvements	Estimated Annual Delay Savings[1] (in hours and millions of 1991 dollars) Baseline (257,000)	Future 1 (300,000)	Future 2 (322,500)
1. Simultaneous (independent) runway improvements	5,232/$6.2	13,269/$15.6	25,142/$29.6
1a. Relocate terminal complex to midfield			
1b. Construct new Runway 5E/23E			
1c. Install PRM with Runway 5/23 parallels separated by 3,400 ft.			
2. Construct 8,000 foot Runway 5W/23W with parallel taxiways and high-speed exits, redesignate Runway 5L/23R as Runway 5R/23L and extend to southwest, and relocate Runway 23 thresholds to southwest.	3,027/$3.6	6,264/$7.4	8,534/$10.1
3. Dedicated runway use. Construct 8,000 ft. Runway 5W/23W and convert existing Runway 5L/23R to taxiway			
3a. Runway 18/36 becomes 3,500 ft. runway	2,938/$3.5	6,425/$7.6	9,755/$11.5
3b. Extend Runway 18/36 1,500 ft. to the south to 5,000 ft.	3,420/$4.0	7,261/$8.6	10,873/$12.8
4. Extend existing Runway 28 1,000 ft. to the east with associated parallel taxiway	513/$0.6	1,036/$1.2	2,209/$2.6
5. Lower approach minimums to Runway 23L by relocating, tunneling, or abandoning Brookpark Road		†	
6. Taxiway improvements	717/$0.8	951/$1.1	967/$1.1
6a. Construct new Taxiway C parallel to Taxiway L			
6b. Construct new Taxiway T parallel to Taxiway R			
6c. Extend Taxiway Q			
6d. Complete parallel Taxiway W to Runway 10/28			
6e. Displace Runway 23L, 23R, and 18 thresholds south of completed parallel Taxiway W			
7. Complete extension of high-speed Taxiway H to Runway 5L/23R		†	
8. Construct high-speed exits on all 5/23 runways[2]			
8a. For current airport	905/$1.1	2,996/$3.5	8,826/$10.4
8b. For current airport with taxiway improvements	928/$1.1	3,030/$3.6	8,829/$10.4
8c. For Master Plan airfield	914/$1.1	3,009/$3.5	8,926/$10.5
Facilities and Equipment Improvements			
9. Install CAT I ILS on Runway 23R[3]	128/$0.2	129/$0.2	142/$0.2
10. Install terminal VOR/DME		†	
11. Install full ILS on current Runway 10		†	

1 The savings benefits of these alternatives are not necessarily additive.
† 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.
2 Delay savings benefits for high-speed exits assume that procedures to reduce in-trail separations to 2.5 nm under IFR have been implemented.
3 Delay savings benefits reflect the case of landing on Runway 23R in southwest flow under IFR 2, which eliminates the ILS critical zone problem caused when aircraft land on Runway 23L under IFR 2.

Alternatives Operatinal Improvements	Estimated Annual Delay Savings[1] (in hours and millions of 1991 dollars) Baseline (257,000)	Future 1 (300,000)	Future 2 (322,500)
12. Dependent converging instrument approaches (DCIA)[4]			
12a. For current airport with taxiway improvements	402/$0.5	1,655/$1.9	5,027/$5.9
12b. For Master Plan airfield	314/$0.4	1,550/$1.8	4,901/$5.8
13. Reduce in-trail separations to 2.5 nm between similar class aircraft			
13a. For current airport	905/$1.1	2,996/$3.5	8,826/$10.4
13b. For current airport with taxiway improvements	928/$1.1	3,030/$3.6	8,829/$10.4
13c. For Master Plan airfield	914/$1.1	3,009/$3.5	8,926/$10.5
14. Continue enhancement of reliever airport system		†	
15. Eliminate departure route restrictions	1,086/$1.3	2,615/$3.1	4,120/$4.9
16. Redistribute traffic more uniformly within the hour	1,981/$2.3	2,369/$2.8	4,196/$4.9

1 The savings benefits of these alternatives are not necessarily additive.

† 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.

4 Delay savings benefits for DCIA are only for southwest flow with arrivals to Runways 23L and 28.

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 joint Airport Capacity Design Teams at various major air carrier airports throughout the country. 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.

Steady growth at Cleveland-Hopkins International Airport has made it one of the busier airports in the country. Activity at the airport has increased from 2,823,598 revenue passenger enplanements in 1983 to 4,266,092 in 1992, a 51 percent increase. In 1992, the airport handled 237,216 aircraft operations (takeoffs and landings).

An Airport Capacity Design Team for Cleveland-Hopkins International Airport (CLE) was formed in 1991. The CLE Capacity Team identified and assessed various actions which, if implemented, would increase CLE'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. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

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 — 257,000 operations per year
- Future 1 — 300,000 operations per year
- Future 2 — 322,500 operations per year

Figure 3 illustrates the capacity and delay curves for the current airfield configuration at CLE for a southwest flow under instrument flight rules (IFR). It shows that aircraft delays will begin to escalate rapidly as hourly demand exceeds 40 to 60 operations per hour. Figure 4 shows that, while hourly demand exceeds 40 to 60 operations during certain hours of the day at Baseline demand levels, 60 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Conclusions

Figure 5 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. Annual delay costs will increase from 8,042 hours or $9.5 million at the Baseline level of operations to 16,459 hours or $19.4 million by Future 1 and 27,884 hours or $32.8 million by Future 2.

Figure 5 also indicates the major delay-savings benefits from improvement alternatives recommended by the Capacity Team.

Figure 6 illustrates the annual delay-savings benefits for each of the improvement alternatives modeled at each of the three activity levels (operations per year). It serves to highlight the savings that would be provided by the alternatives recommended by the Capacity Team.

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

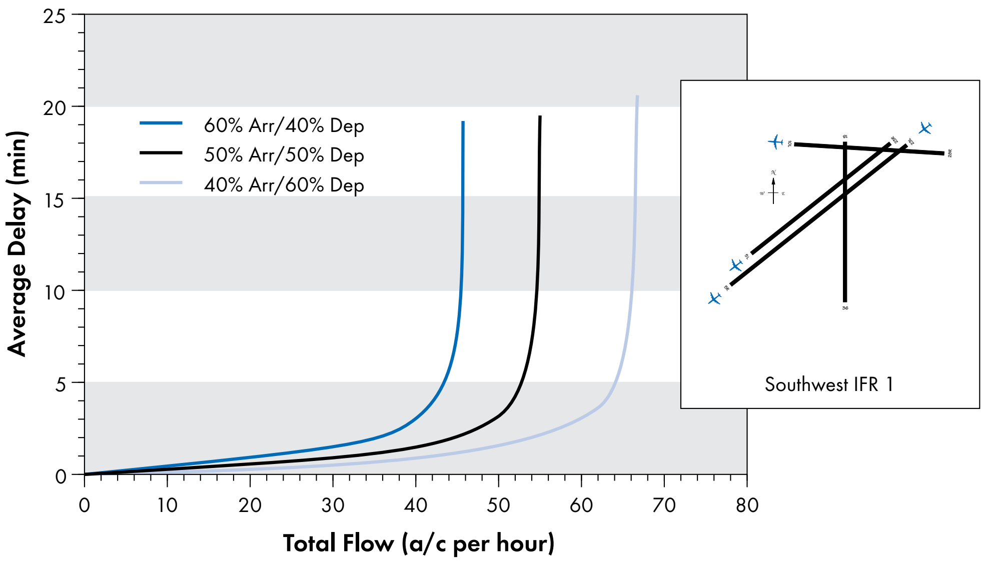


Figure 4. Profile of Daily Demand — Hourly Distribution

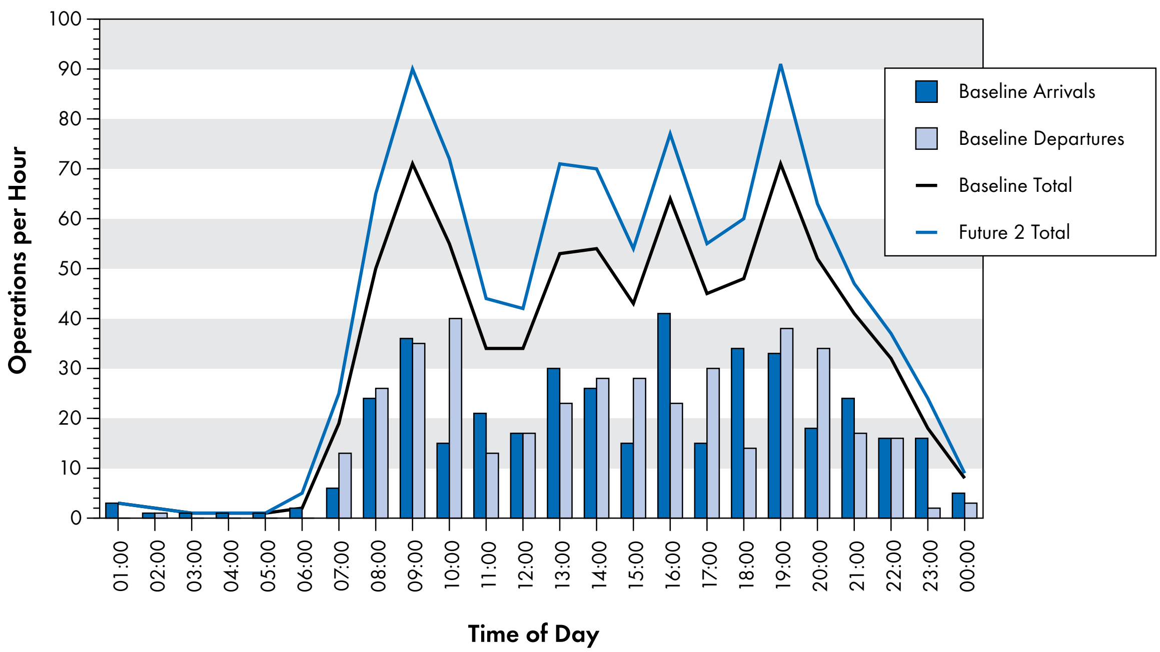
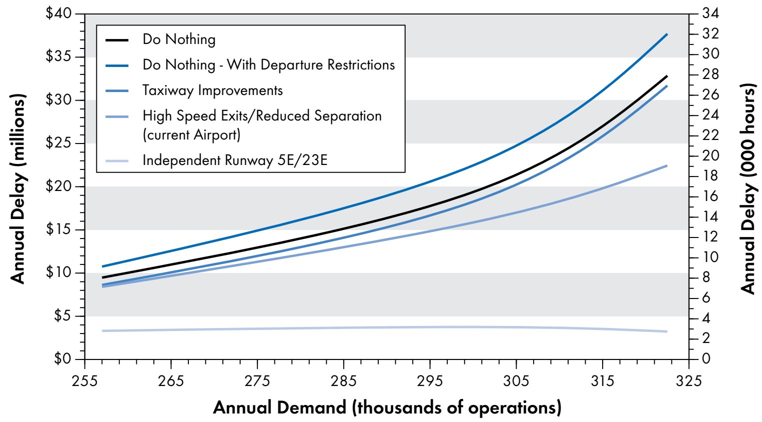
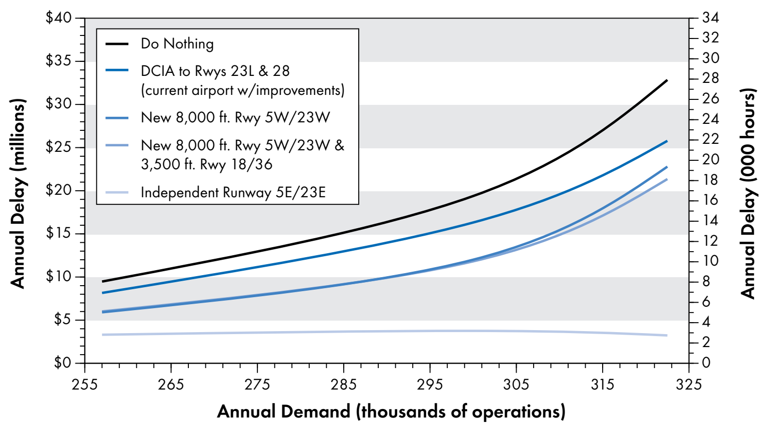


Figure 5. Annual Delay Costs — Capacity Enhancement Alternatives



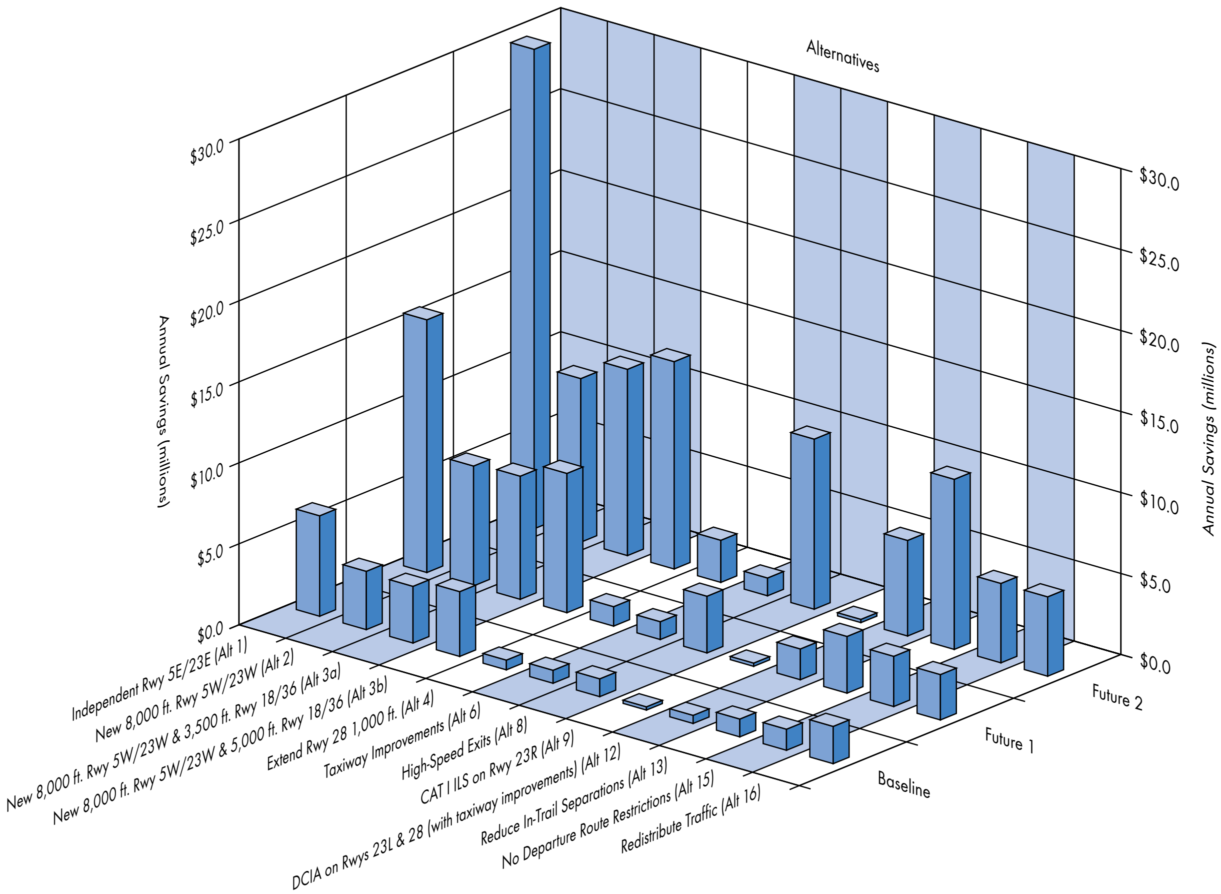


Major Capacity Enhancing Alternatives	Future 2 Annual Delay Savings Hours	Future 2 Annual Delay Savings Millions of 1991 $
• Simultaneous (independent) runway improvements — relocate terminal, new Runway 5E/23E, and install PRM	25,142	$29.6
• Dedicated runway use — new 8,000 foot Runway 5W/23W, convert existing Runway 5L/23R to taxiway, and Runway 18/36 3,500 feet in length	9,755	$11.5
• Construct high-speed exits on all runways; reduce in-trail separations to 2.5 nm[5]	8,826	$10.4
• Construct new 8,000 foot Runway 5W/23W with parallel taxiway and high-speed exits	8,534	$10.1
• Dependent converging instrument approaches (DCIA)[6] for current airport with taxiway improvements	5,027	$5.9
• Eliminate departure route restrictions	4,120	$4.9
• Taxiway improvements	967	$1.1

5 Delay savings benefits for high-speed exits assume that procedures to reduce in-trail separations to 2.5 nm under IFR have been implemented.

6 Delay savings benefits for DCIA are only for southwest flow with arrivals to Runways 23L and 28.

Figure 6. 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 Federal Aviation Administration (FAA) asked the aviation community to study the problem of airport congestion through the Industry Task Force 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 country. 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 1992, 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 32 by 2003. 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.

Cleveland-Hopkins International Airport

In the past decade, Cleveland-Hopkins International Airport (CLE) has been one of the nation's busier airports. Revenue passenger enplanements at CLE rose from 2,823,598 in 1983 to 4,266,092 in 1992, a 51 percent increase. CLE's total aircraft operations reached 237,216 in 1992.

Cleveland-Hopkins International Airport is owned by the City of Cleveland and operated by the Department of Port Control. The airport is situated on approximately 1,700 acres and is located about 12 miles southwest of the central business district of Cleveland. The Cleveland metropolitan area is also served by a network of general aviation reliever airports.

Cleveland-Hopkins Airport Capacity Design Team

An Airport Capacity Design Team for Cleveland-Hopkins International Airport was formed in 1991. The CLE 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, the report should retain its validity until the highest traffic level is attained regardless of the actual dates paralleling the development.

A Baseline benchmark of 257,000 aircraft operations (takeoffs or landings) was established based on the annual traffic level for 1990, the base year of the study. Two future traffic levels, Future 1 and Future 2, were established at 300,000 and 322,500 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Cleveland-Hopkins. If no improvements are made at CLE, annual delay levels and delay costs are expected to increase from 8,042 hours or $9.5 million at the Baseline level of operations to 16,459 hours or $19.4 million by Future 1 and 27,884 hours or $32.8 million by Future 2.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at CLE. The improvements evaluated by the Capacity Team are listed 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 technical and 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 Cleveland Department of Port Control, the State of Ohio Department of Transportation, and various aviation industry and citizen groups (see Appendix A), met periodically for review and coordination. The Capacity Team members considered suggested capacity improvement alternatives proposed by the FAA's Office of System Capacity and Requirements, Technical Center, and Regional Aviation Capacity Program Manager, and by other members of the Team. 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 analyses 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.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analyses and modeling. Where possible, assumptions were based on actual field observations at CLE. Proposed improvements were analyzed in relation to current and future demands with the help of FAA computer models, the Airfield Delay Simulation Model (ADSIM) and the Runway Delay Simulation Model (RDSIM). Appendix B briefly explains these models.

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 visual flight rules (VFR) and instrument flight rules (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 three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual delay estimates were determined based on implementing various improvements. These estimates took into account historic variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the improvements.

Following the evaluation, the Capacity Team developed a plan of recommended alternatives for consideration.

Section 2

Capacity Enhancement Alternatives

Background

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

- Airfield Improvements.
- Facilities and Equipment Improvements.
- Operational Improvements.

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, and Future 2, which correspond to annual aircraft operations of 257,000, 300,000, and 322,500 respectively. The delay savings benefits of the improvements are not necessarily additive.

Figure 7 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

In the process of conducting the study, the Airport Capacity Design Team also grouped the proposed capacity enhancement alternatives into various combinations, or improvement packages, in order to examine which general strategy might be the most effective in reducing delay. These improvement packages and the annual delay savings for each package are described in Appendix C.

Figure 7. Capacity Enhancement Alternatives and Recommended Actions

Airfield Improvements	Action	Time Frame
1. Simultaneous (independent) runway improvements 1a. Relocate terminal complex to midfield 1b. Construct new Runway 5E/23E 1c. Install PRM with Runway 5/23 parallels separated by 3,400 ft.	Recommended	Future 2
2. Construct 8,000 foot Runway 5W23W with parallel taxiways and high-speed exits, redesignate Runway 5L/23R as Runway 5R/23L and extend to southwest, and relocate Runway 23 thresholds to southwest.	Recommended	Baseline/Future 1
3. Dedicated runway use. Construct new 8,000 ft. Runway 5W/23W and convert Runway 5L/23R to a taxiway		
3a. Runway 18/36 becomes 3,500 ft. runway	Recommended	Baseline/Future 1
3b. Extend Runway 18/36 1,500 ft. to the south to 5,000 ft. runway	Not Recommended	—
4. Extend existing Runway 28 1,000 feet to the east with associated parallel taxiway	Not Recommended	—
5. Lower approach minimums to Runway 23L by relocating, tunneling, or abandoning Brookpark Road	Not Recommended	—
6. Taxiway improvements 6a. Construct new Taxiway C parallel to Taxiway L 6b. Construct new Taxiway T parallel to Taxiway R 6c. Extend Taxiway Q 6d. Complete parallel Taxiway W to Runway 10/28 6e. Displace Runway 23L, 23R, and 18 thresholds south of completed parallel Taxiway W	Recommended	Baseline
7. Complete extension of high-speed Taxiway H to Runway 5L/23R	Recommended	Baseline
8. Construct high-speed exits on all 5/23 runways 8a. For current airport 8b. For current airport with taxiway improvements 8c. For Master Plan airfield	Recommended	Baseline

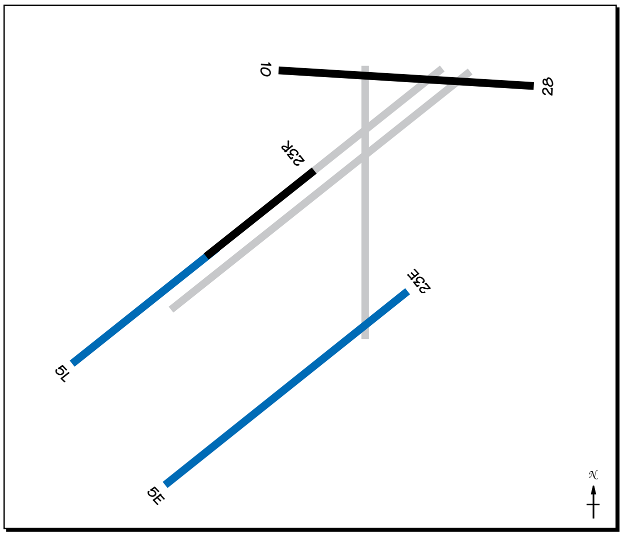
Facilities and Equipment Improvements	Action	Time Frame
9. Install CAT I ILS on Runway 23R	Recommended	Baseline
10. Install terminal VOR/DME	Recommended	Baseline
11. Install full ILS on current Runway 10	Not Feasible	—

Operational Improvements	Action	Time Frame
12. Dependent converging instrument approaches (DCIA) 12a. For current airport with taxiway improvements 12b. For Master Plan airfield	Recommended 23L & 28 Only	Baseline
13. Reduce in-trail separations to 2.5 nm between similar class aircraft 13a. For current airport 13b. For current airport with taxiway improvements 13c. For Master Plan airfield	Recommended	Baseline
14. Continue enhancement of reliever airport system	Recommended	Baseline
15. Eliminate departure route restrictions	Recommended	Baseline
16. Redistribute traffic more uniformly within the hour	Not Recommended	—

Airfield Improvements

1. Simultaneous (independent) runway improvements.

Recommended



Under this concept, Runway 18/36 would be closed and a new 8,000 foot Runway 5E/23E would be opened 3,500 feet southeast of the current Runway 5L/23R. A 60 gate midfield terminal would replace current airside facilities at an optimal location relative to the arrival runway exits and departure runway thresholds. A Precision Runway Monitor (PRM) would be installed in order to support simultaneous (independent) parallel arrivals to the new runway and the existing Runway 5L/23R.

Annual delay savings at the Baseline activity level would be 5,232 hours or $6.2 million, at Future 1 activity levels, 13,269 hours or $15.6 million, and, at Future 2 activity levels, 25,142 hours or $29.6 million. These savings do not consider ground travel times.

A special study compared the travel times of aircraft on the midfield terminal's taxiway system against the travel times of aircraft on the existing airport with taxiway improvements. The study concluded that the reduced travel times of the midfield terminal's taxiway system will save an additional $4.5 million per year at the Future 2 activity level.

This project is recommended for implementation at the Future 2 level of activity.

1a. Relocate terminal complex to midfield.

Construction of a new midfield passenger terminal complex would provide the additional gates needed to accommodate the expected increase in aircraft operations at CLE.

Estimated 1993 project cost is $300 million.

1b. Construct new Runway 5E/23E.

Estimated 1993 project cost is $230 million.

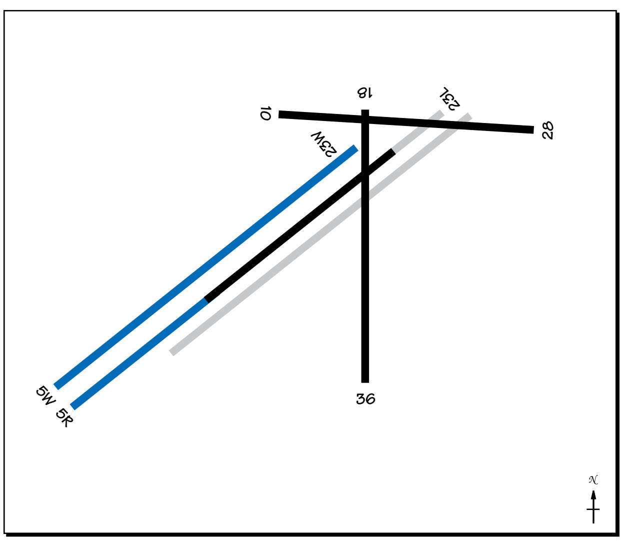
1c. Install Precision Runway Monitor with Runway 5/23 parallels separated by 3,400 feet.

The capacity of CLE would be significantly increased by the ability to conduct simultaneous (independent) parallel approaches in all weather conditions. With existing radar equipment, current FAA criteria require 4,300 feet between parallel runway centerlines. CLE's parallel runways (Runways 5R/23L and 5L/23R) are now only 441 feet apart).

The Precision Runway Monitor has demonstrated the potential to reduce the spacing required between runways for simultaneous independent parallel approaches in all weather conditions. The PRM relies on improved radar surveillance with higher update rates of aircraft positions and a new air traffic controller display system. In fact, procedures have recently been published for simultaneous parallel approaches to runways that have centerlines separated by 3,400 to 4,300 feet with the use of PRM. When PRM equipment becomes available, installing it at CLE would allow simultaneous independent parallel ILS approaches to the existing Runway 5L/23R and the new Runway 5E/23E.

2. Construct 8,000 foot Runway 5W/23W with parallel taxiways and high-speed exits, redesignate Runway 5L/23R as Runway 5R/23L and extend to the southwest, relocate Runway 23 thresholds to southwest.

Recommended



Under this improvement project, the existing Runway 5L/23R would become the relocated Runway 5R/23L. This new Runway 5R/23L would be extended 3,005 feet on the southwest end, and the northeast threshold would be relocated 1,100 feet to the southwest. The length of the new Runway 5R/23L would be 9,000 feet. Also as a part of this project, the existing Runway 5R/23L would be converted into a taxiway and extended to become a full-length parallel taxiway for the new Runway 5R/23L. A new 8,000 foot Runway 5W/23W would be constructed 800 feet northwest of the new Runway 5R/23L.

These new runways would provide a two-runway system that would allow simultaneous arrivals, simultaneous departures, or simultaneous arrivals and departures during visual meteorological conditions (VMC). In addition, the runways would be sufficiently separated to allow the taxiing of aircraft between the runways, and the project includes a new parallel taxiway between the new Runway 5W/23W and the new Runway 5R/23L. The Runway 23 thresholds would also be relocated to the southwest so as not to intersect with Runway 10/28, and the Runway 23W threshold would be located west of Runway 18/36. Taxiway W would be completed parallel to Runway 10/28. Runways 18/36 and 10/28 would remain unchanged from the existing airfield. However, in order to maintain the operational flexibility that the current airfield has with a full-length Runway 18/36, an informal runway use program should be developed.

Estimated 1993 project cost to construct the new Runway 5W/23W is $221 million.

Annual delay savings at the Baseline activity level would be 3,027 hours or $3.6 million, at Future 1 activity levels, 6,264 hours or $7.4 million, and, at Future 2 activity levels, 8,534 hours or $10.1 million.

This project is recommended for implementation between the Baseline and Future 1 levels of activity.

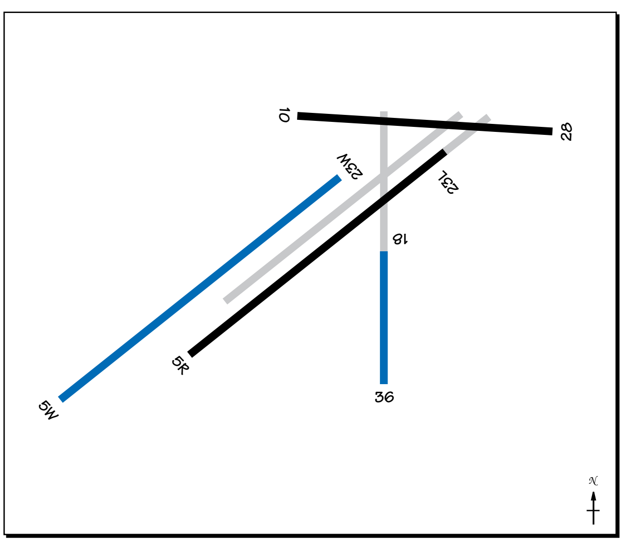
3. Dedicated runway use. Construct 8,000 foot Runway 5W/23W and convert Runway 5L/23R to a taxiway.

Construction of a 8,000 foot Runway 5W/23W located 800 feet northwest of existing Runway 5L/23R would provide a two runway system (the new 5W/23W and the existing 5R/23L) that would allow simultaneous arrivals, simultaneous departures, or simultaneous arrivals and departures during VMC. In addition, the runways would be sufficiently separated (1,241 feet) to allow the taxiing of aircraft between the runways with the conversion of the existing Runway 5L/23R to a parallel taxiway. The Runways 23 thresholds would also be relocated to the southwest so as not to intersect with Runway 10/28.

Estimated 1993 project cost to construct Runway 5W/23W is $221 million. The cost of converting Runway 5L/23R to a taxiway is $3 million.

3a. Runway 18/36 becomes a 3,500 foot runway.

Recommended



As currently configured, Runway 18/36 intersects Runways 10/28, 5L/23R, and 5R/23L. Air traffic control procedures for operations conducted on intersecting runways are, by necessity, more restrictive than for operations conducted on non-intersecting or parallel runways. Shortening Runway 18/36 on the north, below Taxiway L, would reduce the coordination necessary to conduct simultaneous operations on Runways 5/23 and 18/36.

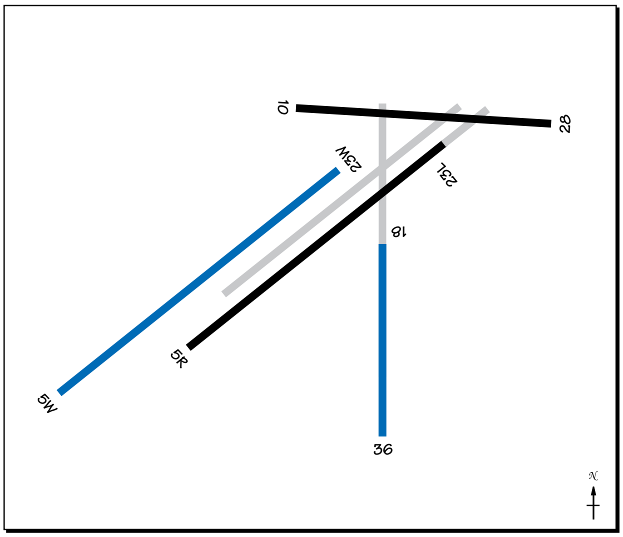
Runway 18/36 can be shortened on the north at virtually no cost to provide a 3,500 foot runway to serve general aviation and commuter aircraft.

Annual delay savings at the Baseline activity level would be 2,938 hours or $3.5 million, at Future 1 activity levels, 6,425 hours or $7.6 million, and, at Future 2 activity levels, 9,755 hours or $11.5 million.

This project is recommended because it results in increased delay savings over those achieved in Alternative 2 without increasing program costs. However, in order to maintain the operational flexibility that the current airfield has with a full-length Runway 18/36, an informal runway use program should be developed. Such a program would achieve the same capacity gains without actually shortening the runway. Establishing an informal runway use program emphasizes how the runway would normally be used with the existing airfield and may provide further incentive to make better use of operational techniques to maximize airfield capacity with a new parallel runway.

3b. Extend Runway 18/36 to the south to make it a 5,000 foot runway.

Not Recommended



This alternative is identical to Alternative 3a except that Runway 18/36 is extended south by 1,500 feet. Adding 1,500 feet of pavement to the south end of the runway would keep Runway 18/36 a non-intersecting runway but allow it to serve larger aircraft.

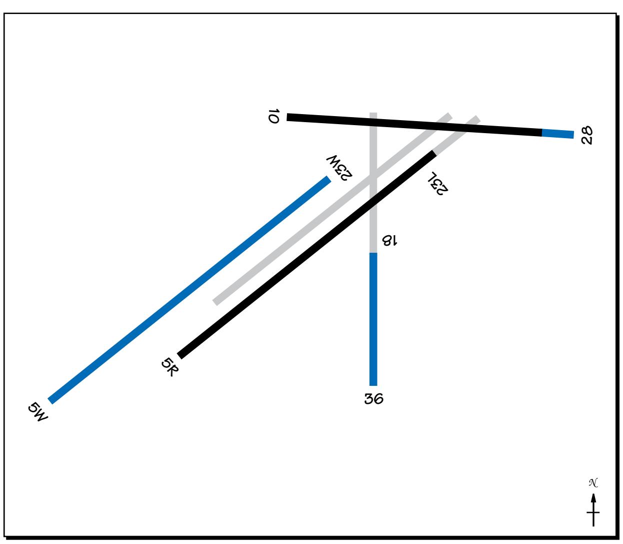
The estimated 1993 project cost to extend Runway 18/36 to the south is about $35 million, since it requires reconfiguring the interchange of Kolthoff Road and the Berea Freeway and relocating a rail line.

Annual delay savings at the Baseline activity level would be 3,420 hours or $4.0 million, at Future 1 activity levels, 7,261 hours or $8.6 million, and, at Future 2 activity levels, 10,873 hours or $12.8 million.

This project is not recommended because the incremental delay savings over the delay savings for Alternative 2 do not justify the $35 million cost of extending Runway 18/36 to the south.

4. Extend existing Runway 10/28 1,000 feet to the east with associated parallel taxiway.

Not Recommended



Extending Runway 10/28 1,000 feet eastward for a total length of 7,015 feet allows larger aircraft to use this runway for arrivals and departures. Extending the runway offers a delay reduction benefit in the northeast configuration. However, in the southwest configuration, the extension allows GA aircraft departing from Runway 28 to become airborne by the time they reach Runway 23L; and it allows air carrier aircraft departing from Runway 28 to become airborne by the time they reach Runway 23W. This results in a two minute arrival/departure wake vortex dependency between arrivals on Runways 23L and 23W and departures on Runway 28.

Estimated 1993 project cost is $110 million since it requires relocation of the Berea Freeway and reconfiguration of an interchange on Interstate 480.

Annual delay savings at the Baseline activity level would be 513 hours or $0.6 million, at Future 1 activity levels, 1,036 hours or $1.2 million, and, at Future 2 activity levels, 2,209 hours or $2.6 million.

This improvement is not recommended because the annual delay savings do not justify the cost of the project.

5. Lower approach minimums to Runway 23L by relocating, tunneling, or abandoning Brookpark Road.

Not Recommended

Relocating Brookpark Road to the north of Interstate 480 and reconfiguring the Grayton Road Interchange with Interstate 480 removes the critical obstruction that now raises approach minimums to Runway 23L.

Estimated 1993 project cost is $37 million.

This project is not recommended since the delay savings would not justify the cost of the project.

6. Taxiway improvements.

Recommended

Construction of a series of taxiways would improve the circulation of aircraft around the terminal area, provide area to stage departures, and improve the segregation of inbound and outbound aircraft. The following taxiway improvements were evaluated as a single package.

Estimated 1993 project cost of all taxiway improvements is $12 million.

Annual delay savings at the Baseline activity level would be 717 hours or $0.8 million, , at Future 1 activity levels, 951 hours or $1.1 million, and, at Future 2 activity levels, 967 hours or $1.1 million.

This project is recommended for implementation at the Baseline activity level.

6a. Construct new Taxiway C parallel to Taxiway L.

By providing a dual taxiway and two-way flow, a new taxiway parallel to Taxiway L would facilitate movement of arriving and departing aircraft to and from the terminal area. The Capacity Team directed the FAA Technical Center to include this taxiway project in the Baseline activity level.

6b. Construct new Taxiway T parallel to Taxiway R.

By providing a dual taxiway and two-way flow, a new taxiway parallel to Taxiway R would facilitate movement of arriving and departing aircraft to and from the terminal area.

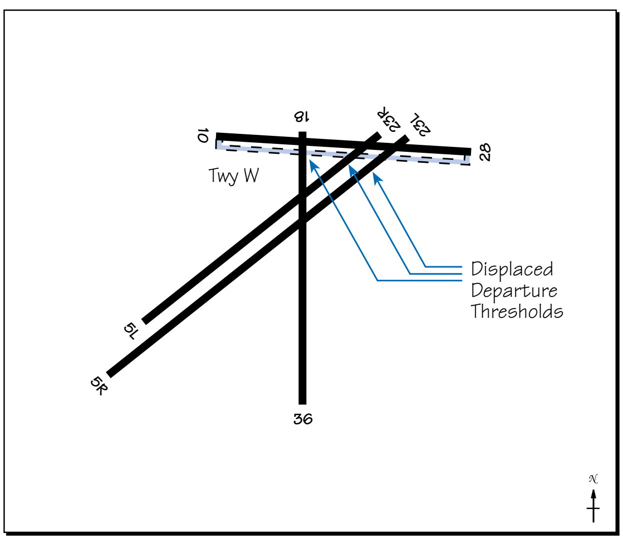
6c. Extend Taxiway Q.

Extending Taxiway Q would improve the flow of ground traffic and reduce taxi interference and delays. The Capacity Team directed the FAA Technical Center to include this taxiway project in the Baseline activity level.

6d. Complete parallel Taxiway W to Runway 10/28.

Completing Taxiway W so that it serves as a full length parallel taxiway to Runway 10/28 would provide an additional taxiway for arriving and departing aircraft to taxi to and from the terminal area. It would reduce taxi interference, expedite ground movement, and reduce delays. Combined with Alternative 6e, the completed Taxiway W would accommodate departures to Runways 23L, 23R, and 18 in the southwest configuration.

6e. Displace Runway 23L, 23R, and 18 thresholds south of completed parallel Taxiway W.



Displacing these runway thresholds would make Runway 10/28 a non-intersecting runway, reducing the level of air traffic coordination required to operate simultaneously on Runways 5/23 and 10/28. In the southwest configuration, the threshold displacement would enable Runway 28 to operate independent of departures on Runways 23L, 23R, and 18. This alternative would reduce the length of Runway 18/36 500 to 1,500 feet, and the length of the runway could be further reduced to provide for clear and overrun areas and jet-blast protection.

This proposal requires extensions to the southwest ends of Runways 5R/23L and 5L/23R to maintain equivalent aircraft operating capability. Extending the runways would increase taxi times for arriving and departing aircraft taxiing to and from the terminal area and the southwest runway ends.

7. Complete extension of high-speed Taxiway H to Runway 5L/23R.

Recommended

This project would provide for a high-speed exit on Runway 23R well-placed for commuter and some jet aircraft. This would reduce runway occupancy times and enhance runway capacity.

Estimated 1993 project cost is $1 million.

This project is recommended for implementation at the Baseline activity level if Alternative 2 or Alternative 3a is not implemented in the near term.

8. Construct high-speed exits on all 5/23 runways.

Recommended

This project would minimize runway occupancy times (ROTs) and enhance runway capacity for the Airport's most heavily used runways. With an ROT of less than 50 seconds, CLE could operate (with FAA approval) with in-trail separations between aircraft reduced to 2.5 nm on the final approach course under IFR. When computing the delay savings benefits for high-speed exits, it was assumed that procedures to reduce in-trail separations to 2.5 nm had been implemented.

Estimated 1993 project cost is $8 million.

This project is recommended for implementation at the Baseline activity level if Alternative 2 or Alternative 3a is not implemented in the near term.

8a. For current airport.

For the current airport, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 905 hours or $1.1 million, at Future 1 activity levels, 2,996 hours or $3.5 million, and, at Future 2 activity levels, 8,826 hours or $10.4 million.

With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 331 hours or $0.4 million, at Future 1 activity levels, 1,119 hours or $1.3 million, and, at Future 2 activity levels, 3,400 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 574 hours or $0.7 million, at Future 1 activity levels, 1,876 hours or $2.2 million, and, at Future 2 activity levels, 5,427 hours or $6.4 million.

8b. For current airport with taxiway improvements.

For the current airport with taxiway improvements, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 928 hours or $1.1 million, at Future 1 activity levels, 3,030 hours or $3.6 million, and, at Future 2 activity levels, 8,829 hours or $10.4 million.

With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 339 hours or $0.4

million, at Future 1 activity levels, 1,142 hours or $1.3 million, and, at Future 2 activity levels, 3,399 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 589 hours or $0.7 million, at Future 1 activity levels, 1,888 hours or $2.2 million, and, at Future 2 activity levels, 5,430 hours or $6.4 million.

8c. For Master Plan airfield.

For the Master Plan airfield, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 914 hours or $1.1 million, at Future 1 activity levels, 3,009 hours or $3.5 million, and, at Future 2 activity levels, 8,926 hours or $10.5 million.

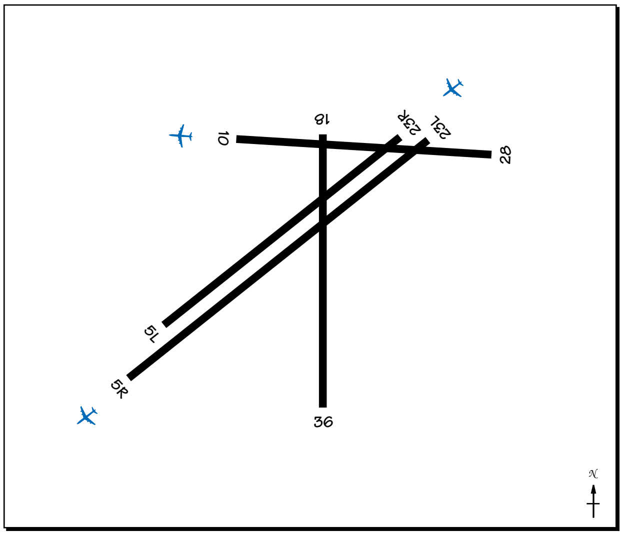
With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 341 hours or $0.4 million, at Future 1 activity levels, 1,124 hours or $1.3 million, and, at Future 2 activity levels, 3,405 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 574 hours or $0.7 million, at Future 1 activity levels, 1,885 hours or $2.2 million, and, at Future 2 activity levels, 5,521 hours or $6.5 million.

Facilities and Equipment Improvements

9. Install Category I ILS on Runway 23R.

Recommended



IFR that restrict operations (IFR 1/IFR 2) occur about 13.2 percent of the time, and the impact of the associated delays can be significant. Installing an ILS on Runway 23R would provide an instrument approach to the Airport's most frequently used arrival runway. It would reduce visibility minimums, enhance operational flexibility, and thereby help to maintain capacity during instrument meteorological conditions (IMC). An ILS on Runway 23R would also allow aircraft to land on Runway 23R and depart on Runway 23L under IFR 2, thus eliminating the current ILS critical zone problem that exists when aircraft land on Runway 23L under IFR 2. IFR 2 occurs about 5.7 percent of the time.

Estimated 1993 project cost is $1.75 million.

Eliminating the ILS critical zone problem by landing aircraft on Runway 23R under IFR 2 rather than on Runway 23L would result in an annual delay savings at the Baseline activity level of 128 hours or $0.2 million, at Future 1 activity levels, 129 hours or $0.2 million, and, at Future 2 activity levels, 142 hours or $0.2 million.

This project is recommended for implementation at the Baseline activity level if Alternative 2 or Alternative 3a is not implemented in the near term.

10. Install terminal Very High Frequency Omnidirectional Range/Distance Measuring Equipment (VOR/DME).

Recommended

The installation of a terminal VOR/DME at Cleveland would provide an additional source of accurate fix information to pilots performing instrument approaches to CLE. A VOR/DME would provide for improved instrument approaches, enhance safety, decrease approach minimums, increase airport capacity, and better serve the needs of the users.

Estimated 1993 project cost is $600,000.

This project is recommended for implementation at the Baseline activity level.

11. Install full ILS on current Runway 10.

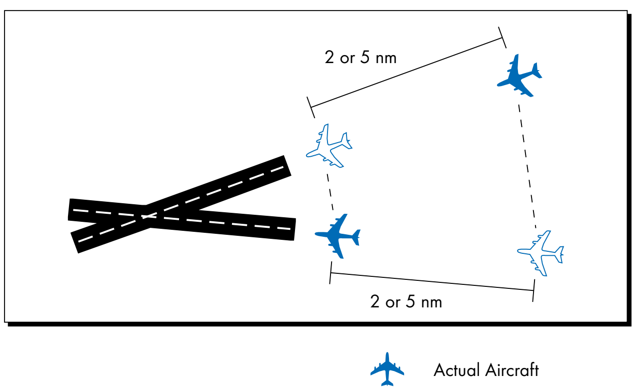
Not Feasible

The impact of delays associated with IFR can be significant. Installing ILS equipment on Runway 10 would reduce visibility minimums and enhance operational flexibility and thereby help to maintain capacity during IMC.

This project is not recommended, because the installation of an ILS on Runway 10 is not feasible now, due to the existing terrain and the short runway safety area.

Operational Improvements

12. Dependent converging instrument approaches (DCIA).



Because of the reduced visibility and ceiling associated with IFR, simultaneous (independent) use of converging runways is normally permitted for aircraft arrivals only during relatively high weather minimums to non-intersecting runways. However, a program has been developed that allows dependent (alternating) arrivals to both intersecting and non-intersecting converging runways through the use of a Converging Runway Display Aid (CRDA) for air traffic controllers.

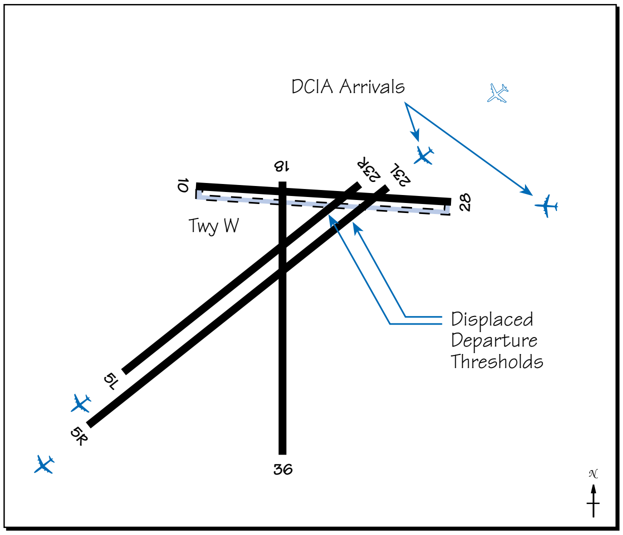
The CRDA update to the Automated Radar Terminal System (ARTS) IIIa software projects an electronic "ghost" image of aircraft on converging arrival paths so that separation between aircraft can be verified by the controller during arrival spacing. A demonstration at Lambert St. Louis International Airport validated the use of CRDA under actual operational conditions. National standards that incorporate these approach procedures were published November 1992.

12a. For current airport with taxiway improvements.

Recommended for Runways 23L and 28
Not Recommended for Runways 5R and 36

For the current airport with taxiway improvements, DCIA have been recommended only in the southwest flow with approaches to Runways 23L and 28. Annual delay savings at the Baseline activity level would be 402 hours or $0.5 million, at Future 1 activity levels, 1,655 hours or $1.9 million, and, at Future 2 activity levels, 5,027 hours or $5.9 million.

DCIA procedures result in a measurable increase in workload for air traffic controllers. They are normally recommended only when additional airport capacity is

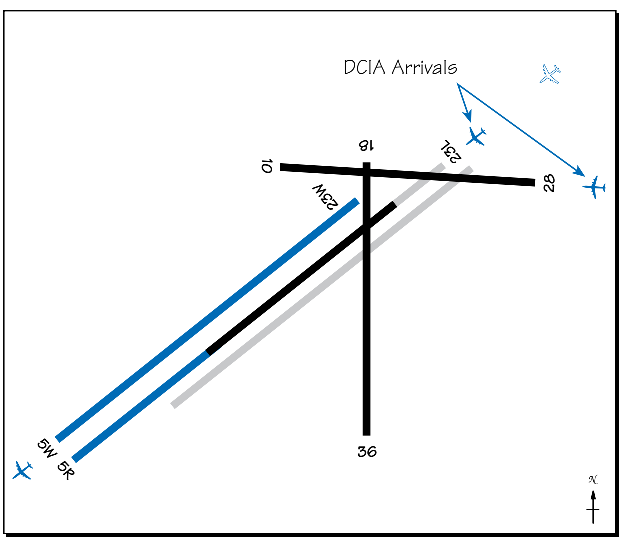


required that cannot be achieved by other less demanding or less complex procedural alternatives. The use of DCIA for Runways 23L and 28 meets these criteria by enabling an equivalent 2.0 nm longitudinal spacing.

The use of DCIA for Runways 5R and 36, however, only results in an equivalent 2.5 nm longitudinal spacing. This result can be achieved more easily by demonstrating reduced runway occupancy times and operating with 2.5 nm arrival spacing to a single runway. In addition, in order to employ DCIA effectively in the northeast configuration, all arrivals to Runway 36 must exit at Taxiway R. If any Runway 36 arrival was to overshoot Taxiway R, the established arrival and departure sequencing would have to be interrupted, and subsequent runway operations delayed, until that arrival cleared the runway/ taxiway system. It cannot be guaranteed that all arrivals to Runway 36 will exit at Taxiway R, and land-and-hold-short procedures are not authorized for DCIA operations. For these reasons, DCIA are not recommended for use on Runways 5R and 36.

12b. For Master Plan airfield.

Recommended for Runways 23L and 28
Not Recommended for Runways 5L and 36



For the Master Plan airfield, DCIA have also been recommended only in the southwest flow with approaches to Runways 23L and 28. Annual delay savings at the Baseline activity level would be 314 hours or $0.4 million, at Future 1 activity levels, 1,550 hours or $1.8 million, and, at Future 2 activity levels, 4,901 hours or $5.8 million.

DCIA procedures result in a measurable increase in workload for air traffic controllers. They are normally recommended only when additional airport capacity is required that cannot be achieved by other less demanding or less complex procedural alternatives. The use of DCIA for Runways 23L and 28 meets these criteria by enabling an equivalent 2.0 nm longitudinal spacing.

The use of DCIA for Runways 5L and 36, however, only results in an equivalent 2.5 nm longitudinal spacing. Again, this result can be more easily achieved by demonstrating reduced runway occupancy times. In addition, it cannot be guaranteed that all arrivals to Runway 36 will exit at Taxiway R, and land-and-hold-short procedures are not authorized for DCIA operations. For these reasons, DCIA are not recommended for use on Runways 5L and 36.

13. Reduce in-trail separations to 2.5 nm between similar class aircraft.

Recommended

Existing procedures for IFR require that arriving aircraft be separated by 3 nm or more. Reducing separation minimums to 2.5 nm for aircraft of similar class would increase arrival rates and runway capacity. Most of the delay savings occurs at the highest demand levels during IFR operations.

This project is recommended for implementation at the Baseline activity level.

13a. For current airport.

For the current airport, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 905 hours or $1.1 million, at Future 1 activity levels, 2,996 hours or $3.5 million, and, at Future 2 activity levels, 8,826 hours or $10.4 million.

With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 331 hours or $0.4 million, at Future 1 activity levels, 1,119 hours or $1.3 million, and, at Future 2 activity levels, 3,400 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 574 hours or $0.7 million, at Future 1 activity levels, 1,876 hours or $2.2 million, and, at Future 2 activity levels, 5,427 hours or $6.4 million.

13b. For current airport with taxiway improvements.

For the current airport with taxiway improvements, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 928 hours or $1.1 million, at Future 1 activity levels, 3,030 hours or $3.6 million, and, at Future 2 activity levels, 8,829 hours or $10.4 million.

With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 339 hours or $0.4 million, at Future 1 activity levels, 1,142 hours or $1.3 million, and, at Future 2 activity levels, 3,399 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 589 hours or $0.7 million, at Future 1 activity levels, 1,888 hours or $2.2 million, and, at Future 2 activity levels, 5,430 hours or $6.4 million.

13c. For Master Plan airfield.

For the Master Plan airfield, with in-trail separations reduced to 2.5 nm in both the northeast and southwest flows during the year, annual delay savings at the Baseline activity level would be 914 hours or $1.1 million, at Future 1 activity levels, 3,009 hours or $3.5 million, and, at Future 2 activity levels, 8,926 hours or $10.5 million.

With reduced separations employed only in the northeast flow during the year, annual delay savings at the Baseline activity level would be 341 hours or $0.4 million, at Future 1 activity levels, 1,124 hours or $1.3 million, and, at Future 2 activity levels, 3,405 hours or $4.0 million.

With reduced separations employed only in the southwest flow during the year, annual delay savings at the Baseline activity level would be 574 hours or $0.7 million, at Future 1 activity levels, 1,885 hours or $2.2 million, and, at Future 2 activity levels, 5,521 hours or $6.5 million.

14. Continue enhancement of the reliever airport system.

Recommended

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.

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 CLE. "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 (formerly known as a partial ILS). 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.

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 navigational aids at existing relievers, and minimize the adverse environmental impact of these airports on neighboring communities.

15. Eliminate departure route restrictions.

Recommended

Air traffic control often dictates that aircraft hold at the runway thresholds before takeoff because of departure route restrictions. At CLE, departures are currently restricted to 10 nm in trail for like-type aircraft on the same route.

Preliminary analyses at CLE indicate that, if the departure route restrictions could be eliminated, annual delay savings at the Baseline activity level would be 1,086 hours or $1.3 million, at Future 1 activity levels, 2,615 hours or $3.1 million, and, at Future 2 activity levels, 4,120 hours or $4.9 million.

16. Redistribute traffic more uniformly within the hour.

Not Recommended

A more uniform distribution of airline flights during peak periods would promote a more orderly flow of traffic, reduce arrival and departure delays, and reduce ground congestion near the terminal and on the taxiway system.

However, CLE is a part of the hub-and-spoke operation, and uniform distribution of traffic is not consistent with such an operation. Hubbing creates efficiencies that cannot be measured in a delay study of this type. This system of operations provides frequent service between city-pairs that could not support frequent direct service. Frequent flights provide an economic benefit to consumers, in particular the business flyer. Although annual delay savings at the Baseline activity level would be 1,981 hours or $2.3 million, at Future 1 activity levels, 2,369 hours or $2.8 million, and, at Future 2 activity levels, 4,196 hours or $4.9 million, in order to properly evaluate the overall impact of hubbing and the redistribution of scheduled operations, the entire system must be studied, not any one individual airport.

Section 3

Summary of Technical Studies

Overview

The Cleveland-Hopkins International Airport (CLE) Capacity Team evaluated the efficiency of the existing airfield and the proposed future configuration. A brief description of the computer models and methodology used can be found in Appendix B. Certain standard inputs were used to reflect the operating environment at CLE. Details can be found in the data packages produced by the FAA Technical Center during the course of the study. Figure 8 shows the characteristics of the aircraft fleet, Figure 9, airfield weather conditions, and Figure 10, runway utilization for various runway configurations used in the computer simulation modeling. Figure 11 illustrates these runway configurations. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

The fleet mix at CLE has a weighted-average direct operating cost of $1,178 per hour. 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 forecast periods. The Capacity Team used the Airport Delay Simulation Model (ADSIM) and the Runway Delay Simulation Model (RDSIM) 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 provide a basis for comparing the benefits of the proposed changes. The benefits associated with various runway use strategies were also identified. The cost of a particular improvement was measured against its annual delay savings. This comparison indicates which improvement will be the most effective.

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

Figure 8. Aircraft Fleet Characteristics

Aircraft Class	Aircraft Types	Baseline Demand	Departure Runway Occupancy Time (seconds)	Approach Speeds (knots) VFR	IFR
Class 4	Single-engine props under 12,500 lbs.	4%	34	90	90
Class 3	Twin-engine props under 12,500 lbs.	8%	34	120	120
Class 2	Large aircraft under 300,000 lbs. and small jets	87%	39	130	130
Class 1	Heavy aircraft over 300,000 lbs.	1%	39	140	140

Figure 9. Airfield Weather

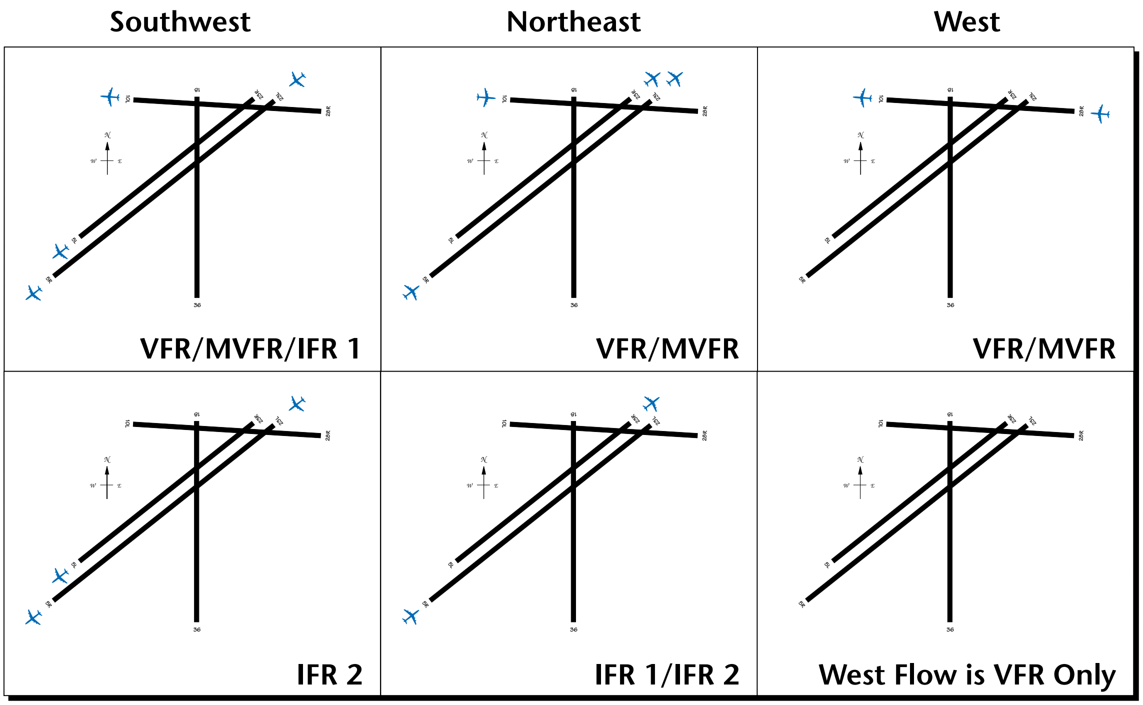
	Ceiling/Visibility	Occurrence (%)
VFR	3,000 feet and above / 5 sm and above	70.8
MVFR	1,000 to 3,000 feet / 3 to 5 sm	16.0
IFR 1	800 to 1,000 feet / 2 to 3 sm	7.5
IFR 2	below 800 feet / below 2 sm	5.7
	Total	100.0

VFR – Visual Flight Rules
IFR – Instrument Flight Rules
MVFR – Marginal VFR
sm – statute miles

Figure 10. Runway Utilization (percentage use)

	VFR	MVFR	IFR 1	IFR 2	Total
Southwest Flow	49.0	10.8	4.7	3.6	68.2
Northeast Flow	20.5	4.5	2.7	2.1	29.8
West Flow	1.3	0.7	0.0	0.0	2.0
Total	70.8	16.0	7.5	5.7	100.0

Figure 11. Runway Configurations — Current Airport



Airfield Capacity

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

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

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

Figure 12. Airfield Demand Levels

	Annual	24-Hour Day (Average Day, Peak Month)	Peak Hour
Baseline	257,000	802	71
Future 1	300,000	938	84
Future 2	322,500	1,009	91

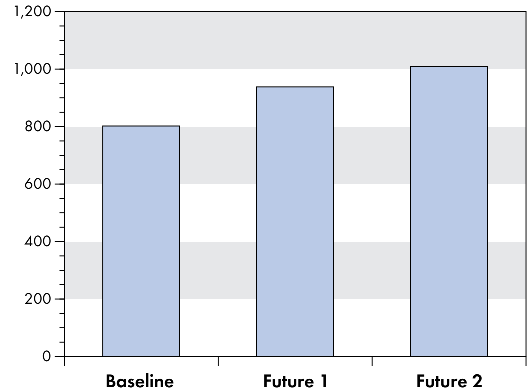


Figure 13 presents the airport capacity curves for CLE. The curves were developed for the southwest flow runway configuration, under instrument flight rules (IFR) conditions, with a 60/40, 50/50, and 40/60 percent split of arrivals and departures. These curves are based on the assumption that arrival 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 increases, the average delay per operation increases exponentially.

Figure 14 illustrates the hourly profile of daily demand for the Baseline activity level of 257,000 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 322,500 aircraft operations per year.

Comparing the information in Figures 13 and 14 shows that:

- Aircraft delays will begin to rapidly escalate as hourly demand exceeds 40 to 60 operations per hour;
- While hourly demand exceeds 40 to 60 operations during certain hours of the day at Baseline demand levels, 60 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

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

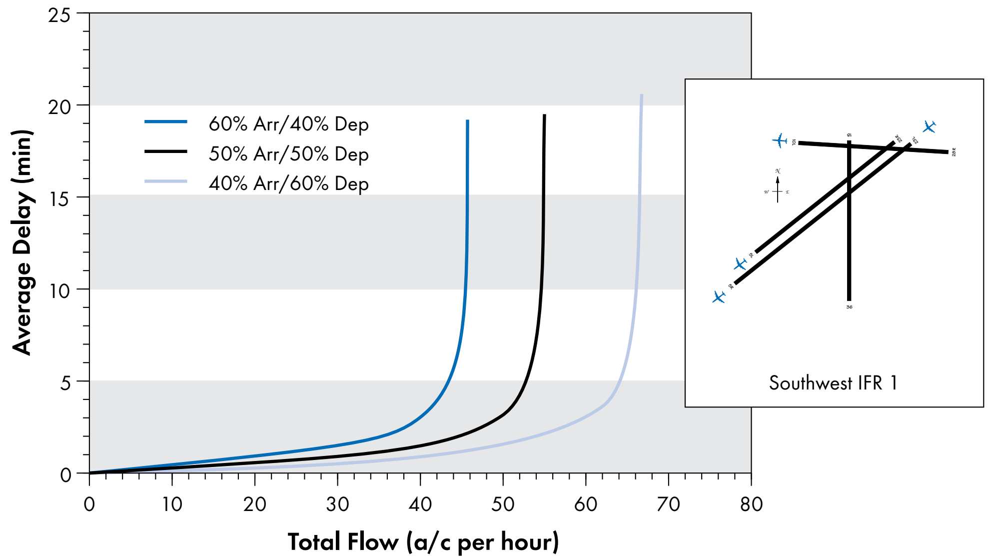
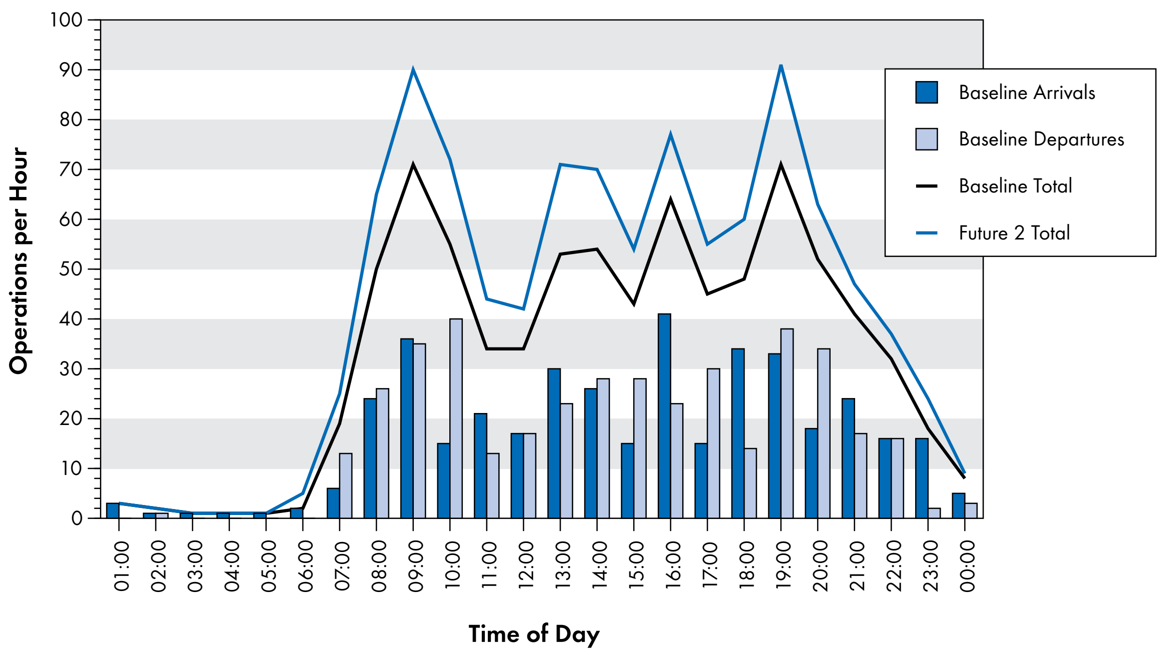


Figure 14. Profile of Daily Demand — Hourly Distribution



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.

Do Nothing Scenario	Annual Delay Costs Hours	Millions of 1991 $
Baseline	8,042	$9.5
Future 1	16,459	$19.4
Future 2	27,884	$32.8

Average delay in minutes per operation was generated by the Airfield Delay Simulation Model (ADSIM). A description of this model is included in Appendix B. If no improvements are made in airport capacity, the average delay per operation of 1.9 minutes in Baseline will increase to 3.3 minutes per operation by Future 1 and 5.2 minutes per operation by Future 2.

Under the Do Nothing scenario, if there are no improvements in airfield capacity, the annual delay cost could increase to $32.8 million at the Future 2 activity level, as shown at left.

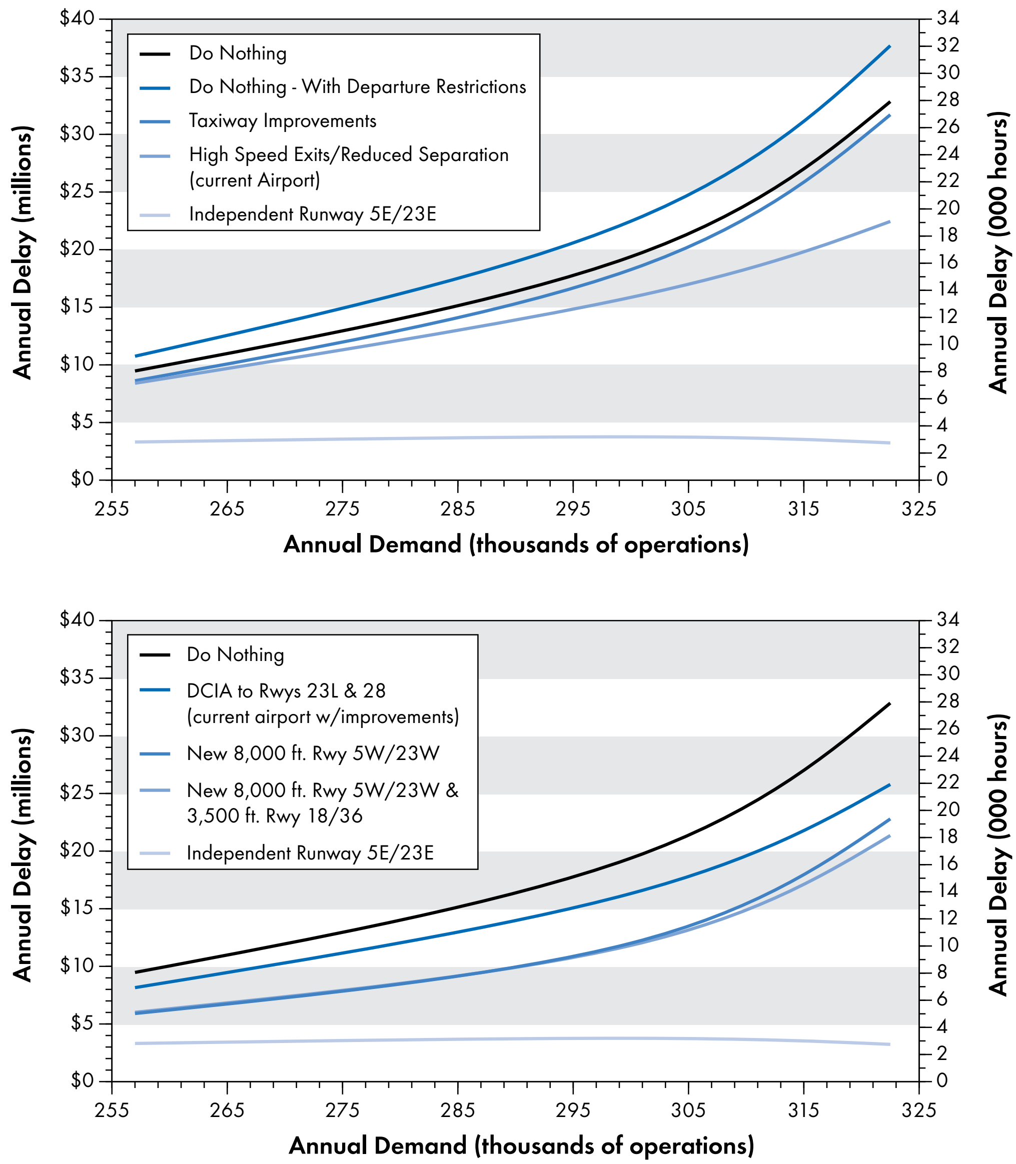
Conclusions

Figure 15 demonstrates the impact of delays at Cleveland-Hopkins 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.

Figure 15 also shows the savings in delay costs that would be provided by improvement alternatives recommended by the Capacity Team:

- Simultaneous (independent) runway improvements — relocate terminal, new Runway 5E/23E, and install PRM.
- Construct new 8,000 foot Runway 5W/23W with parallel taxiway and high-speed exits.
- Taxiway improvements.
- Dedicated runway use — new 8,000 foot Runway 5W/23W, convert existing Runway 5L/23R to taxiway, and Runway 18/36 3,500 feet in length.
- Construct high-speed exits on all runways; reduce in-trail separations to 2.5 nm.[7]
- Dependent converging instrument approaches (DCIA) for current airport with taxiway improvements.[8]
- Eliminate departure route restrictions.

Figure 15. Annual Delay Costs — Capacity Enhancement Alternatives



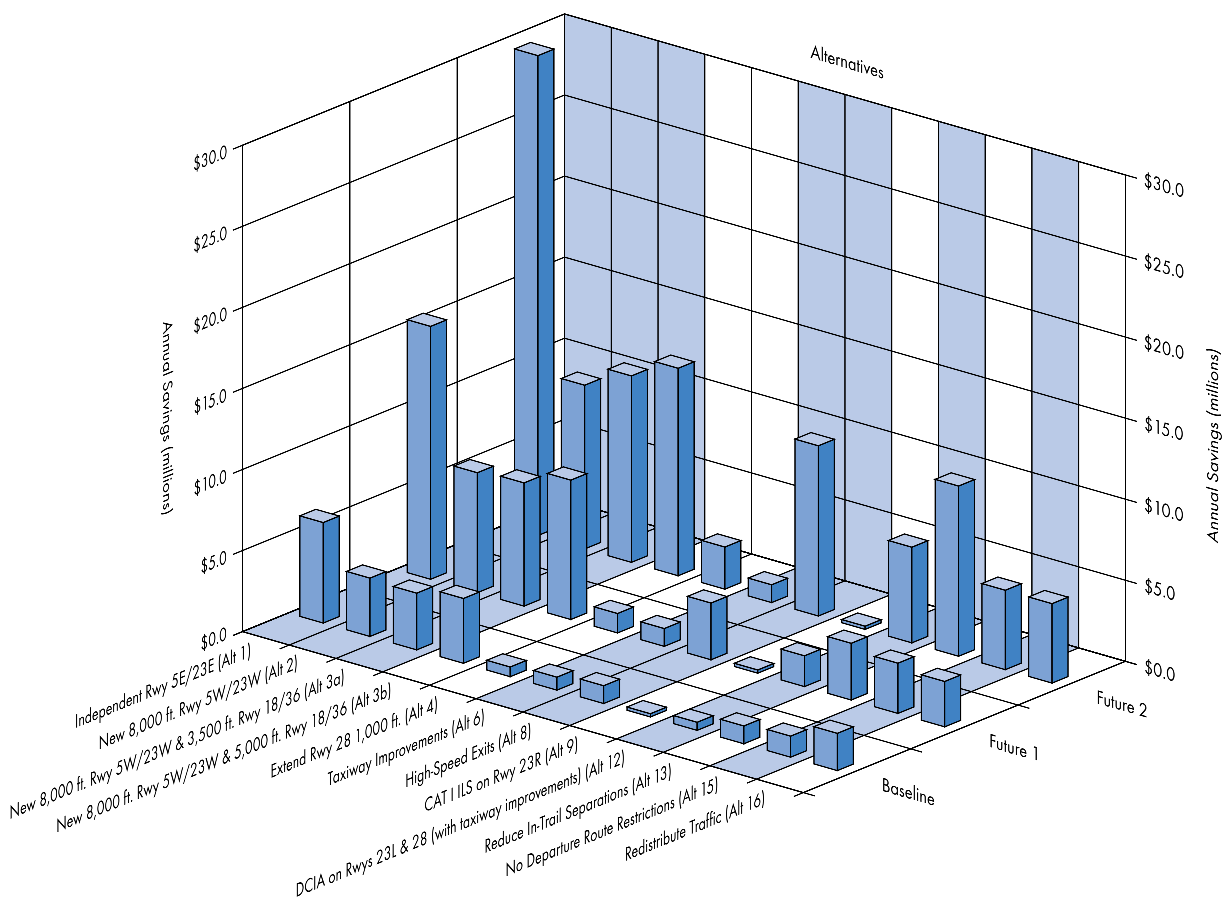
7 Delay savings benefits for high-speed exits assume that procedures to reduce in-trail separations to 2.5 nm under IFR have been implemented.

8 Delay savings benefits for DCIA are only for southwest flow with arrivals to Runways 23L and 28.

Figure 16 illustrates the annual delay-savings benefits for each alternative and for each of the three annual activity levels (operations per year). It serves to highlight the savings that would be provided by the alternatives recommended by the Capacity Team.

- Simultaneous (independent) runway improvements — relocate terminal, new Runway 5E/23E, and install PRM.
- Construct new 8,000 foot Runway 5W/23W with parallel taxiway and high-speed exits
- Taxiway improvements.
- Dedicated runway use — new 8,000 foot Runway 5W/23W, convert existing Runway 5L/23R to taxiway, and Runway 18/36 3,500 feet in length
- Construct high-speed exits on all runways; reduce in-trail separations to 2.5 nm.
- Dependent converging instrument approaches (DCIA) for current airport with taxiway improvements.
- Eliminate departure route restrictions.

Figure 16. Annual Delay-Savings Benefits — Capacity Enhancement Alternatives



APPENDIX A

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Appendix B

Computer Models and Methodology

Computer Models

The CLE 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.

Airfield Delay Simulation Model (ADSIM)

ADSIM is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques. It describes significant movements of aircraft on the airport and the effects of delay in the adjacent airspace. The model was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data. It was calibrated for this study against field data collected at CLE to insure that the model was site specific.

Inputs for the simulation model were derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability, which occurs on a daily basis in actual airport operations. The results were averaged to produce output statistics. Total and hourly aircraft delays, travel times, and flow rates for the airport and for the individual runways were calculated.

Runway Delay Simulation Model (RDSIM)

RDSIM is a short version of the ADSIM model that 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 forty 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.

RDSIM was calibrated for this study against field data collected at CLE 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.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. 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 weather 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 three demand periods (Baseline, Future 1, and Future 2). 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 with the Do Nothing case.

The RDSIM model, in its capacity mode, was used to perform the capacity analysis for CLE.

Appendix C

Improvement Packages:

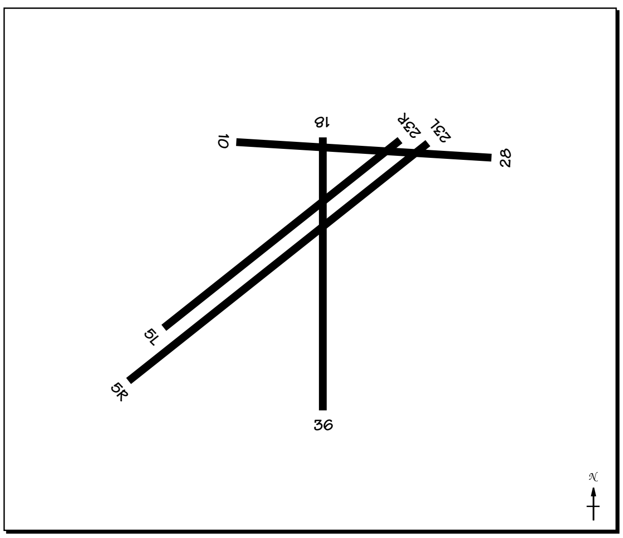
Capacity Enhancement Alternatives

Background

In the process of conducting the study, the Airport Capacity Design Team grouped the proposed capacity enhancement alternatives into various improvement packages in order to examine which general strategy might be the most effective in reducing delay.

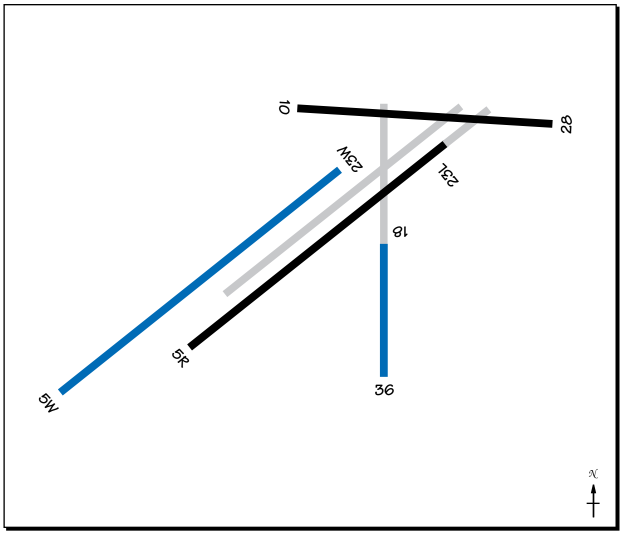
The listing below describes each improvement package and lays out the annual delay savings for each package. Annual savings are given for three activity levels, Baseline, Future 1, and Future 2, which correspond to annual aircraft operations of 257,000, 300,000, and 322,500 respectively.

	Estimated Annual Delay Savings (in hours and millions of 1991 dollars)		
Package 1 — Baseline	**Baseline**	**Future 1**	**Future 2**
(Existing airport)	—	—	—



1. Runways 5L/23R (7,095 ft.) and 5R/23L (8,998 ft.) have a centerline spacing of 441 ft.
2. Runway 23 thresholds intersect Runway 10/28.
3. Runway 10/28 6,015 ft. in length.
4. Runway 18/36 6,411 ft. in length and intersects Runways 10/28, 5L/23R, & 5R/23L.
5. Terminal Building complex located in the east quadrant.

	Estimated Annual Delay Savings (in hours and millions of 1991 dollars)		
Package 1A	**Baseline**	**Future 1**	**Future 2**
(Airfield improvement 3a)	**2,938/$3.5**	**6,425/$7.6**	**9,755/$11.5**

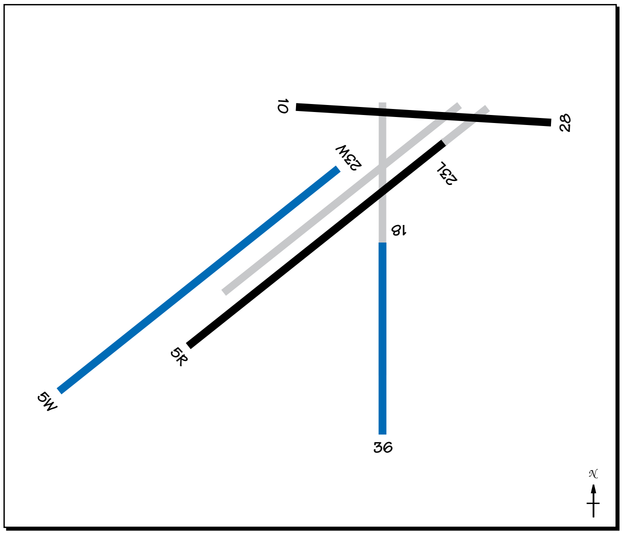


1. Construct new Runway 5W/23W 800 ft. from Runway 5L/23R and 8,000 ft. in length
2. Runway 23 thresholds to be relocated to SW so as not to intersect with Runway 10/28
3. Runway 23W threshold to be staggered 3,500 ft. SW of Runway 23L threshold
4. Existing Runway 5L/23R converted to parallel taxiway and extended to the full length of new Runway 5W/23W.
5. Runway 18/36 converted to non-intersecting 3,500 ft. runway by shortening on north end
6. Runway 10/28 remains unchanged at 6,015 ft. in length.
7. Complete Taxiway W parallel to Runway 10/28.

Package 1A represents the airport with two Runway 5/23 parallel runways spaced 1,241 feet apart.

- *Runway 5W/23W is a new 8,000 foot runway; the existing Runway 5R/23L is 8,998 feet in length. The arrival threshold of Runway 23W is staggered by about 3,500 feet from the arrival threshold of Runway 23L. Displaced thresholds offer an operational advantage that was not modeled in the simulations. In this configuration, the airfield can accommodate simultaneous ILS and LDA approaches if the LDA on Runway 23R is offset. The procedure has been used at St. Louis for several years with a minimum ceiling of 1,200 feet and a visibility of 4 miles.*
- *The existing Runway 5L/23R has been converted to a taxiway.*
- *The south end of Runway 18/36 has been converted to a 3,500 foot runway to serve general aviation and commuter aircraft. Starting below Taxiway L, Runway 18/36 would not intersect with Runway 5R/23L on the north end, thus making Runway 18 an independent departure runway (and an independent arrival runway under VFR).*
- *Northeast ends of Runways 5R/23L and 5W/23W do not intersect with Runway 10/28.*
- *Existing Runway 10/28 remains at 6,015 feet in length.*

	Estimated Annual Delay Savings (in hours and millions of 1991 dollars)		
Package 1A-Commuter (COM)	**Baseline**	**Future 1**	**Future 2**
(Airfield improvement 3b)	**3,420/$4.0**	**7,261/$8.6**	**10,873/$12.8**

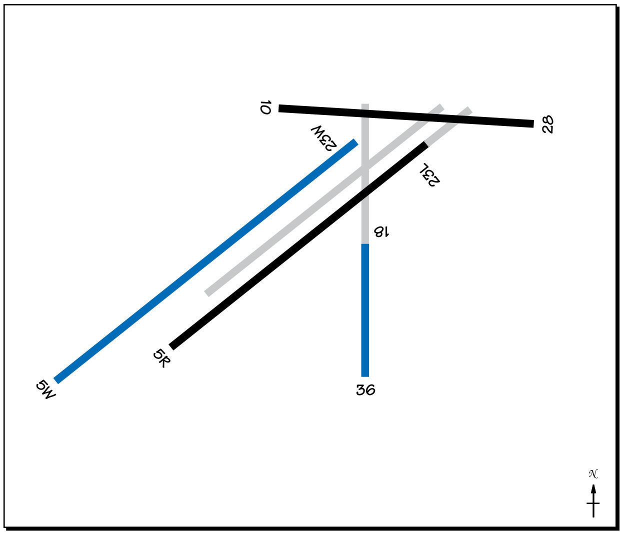


1. Construct new Runway 5W/23W 800 ft. from Runway 5L/23R and 8,000 ft. in length.
2. Runway 23 thresholds to be relocated to SW so as not to intersect with Runway 10/28.
3. Runway 23W threshold to be staggered 3,500 ft. SW of Runway 23L threshold.
4. Existing Runway 5L/23R converted to parallel taxiway and extended to the full length of new Runway 5W/23W.
5. Runway 18/36 converted to non-intersecting 5,000 ft. runway by shortening it on the north end and extending it on the south end.
6. Runway 10/28 remains unchanged at 6,015 ft. in length.
7. Complete Taxiway W parallel to Runway 10/28.

Package 1A-Commuter represents an airport layout with two Runway 5/23 parallel runways spaced 1,241 feet apart.

- *Runway 5W/23W is a new 8,000 foot runway; the existing Runway 5R/23L is 8,998 feet in length. The arrival threshold of Runway 23W is staggered by about 3,500 feet from the arrival threshold of Runway 23L.*
- *The existing Runway 5L/23R has been converted to a taxiway.*
- *The south end of Runway 18/36 has been converted to a 5,000 foot runway. Starting below Taxiway L, Runway 18/36 would not intersect with Runway 5R/23L on the north end, thus making Runway 18 an independent departure runway (and an independent arrival runway under VFR).*
- *Northeast ends of Runways 5R/23L and 5W/23W do not intersect with Runway 10/28.*
- *Existing Runway 10/28 remains at 6,015 feet in length.*

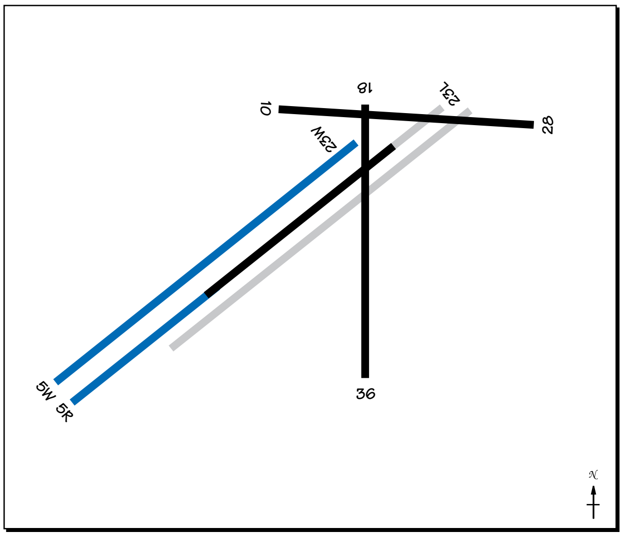
	Estimated Annual Delay Savings (in hours and millions of 1991 dollars)		
Package 1B	**Baseline**	**Future 1**	**Future 2**
(Alternative to airfield improvement 3a)	**2,938/$3.5**	**6,425/$7.6**	**9,755/$11.5**



1. Construct new Runway 5W/23W 800 ft. from Runway 5L/23R and 8,000 ft. in length.
2. Runway 23 thresholds to be relocated to SW so as not to intersect with Runway 10/28.
3. Northeast ends of Runways 23L and 23W would intersect the completed Taxiway W.
4. Existing Runway 5L/23R converted to parallel taxiway and extended the full length of new Runway 5W/23W.
5. Runway 18/36 converted to non-intersecting 3,500 ft. runway by shortening it on the north end.
6. Runway 10/28 remains unchanged at 6,015 ft. in length.
7. Complete Taxiway W parallel to Runway 10/28.

Package 1B represents an alternative to Package 1A. Package 1B is the same as Package 1A except that the airport layout was adjusted so that the northeast end of Runway 23W was translated back to intersect the completed Taxiway W. Under Package 1B, the Runway 23W and 23L arrival thresholds would not be staggered by 3,500 feet.

Package 1C — Master Plan Airfield	Estimated Annual Delay Savings [9] (millions of 1991 dollars) Baseline	Future 1	Future 2
Package 1C	—	$2.2	$5.3
With 2.5 nm arrival separations	$0.7	$5.8	$15.8
With displaced arrival thresholds	$0.8	$5.9	$15.9
With intersection departures	$1.0	$6.1	$16.2
With intersection departures/displaced thresholds	$1.1	$6.2	$16.3

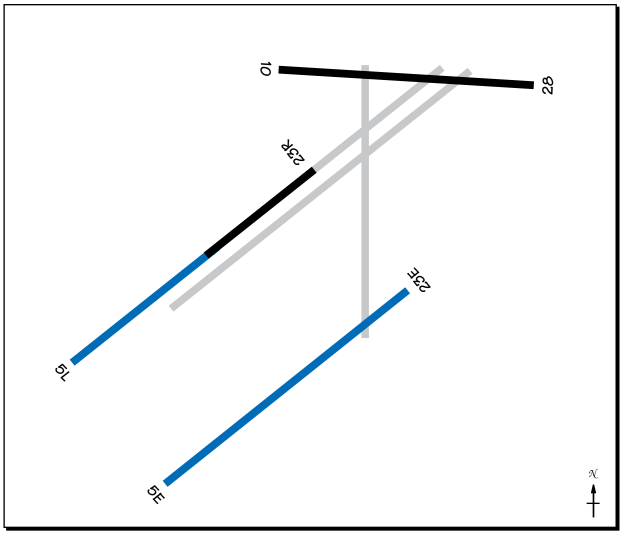


1. Existing Runway 5L/23R becomes relocated Runway 5R/23L. It is extended 4,504 ft. on the 5L end, and the northeast threshold is relocated 1,100 ft. to the southwest so that it is south of Runway 10/28. Length of new Runway 5R/23L is 10,500 ft.
2. Existing Runway 5R/23L converted to taxiway and extended to become full-length parallel taxiway to new Runway 5R/23L.
3. Construct new 10,000 ft. Runway 5W/23W with 800 ft. centerline separation from new Runway 5R/23L.
4. Construct new parallel taxiway between new Runway 5W/23W and new Runway 5R/23L.
5. Runway 23 thresholds to be relocated south of Runway 10/28. Runway 23W threshold located west of Runway 18/36.
6. Runway 18/36 remains unchanged at 6,411 ft. in length.
7. Runway 10/28 remains unchanged at 6,015 ft. in length.
8. Complete Taxiway W parallel to Runway 10/28.

Package 1C represented the Master Plan recommendations for beyond the year 1998. Here, the two Runway 5/23 parallel runways are spaced 800 feet apart. In this package, the northeast thresholds of Runways 5L/23R and 5R/23L do not extend north of Taxiway W, thus removing the runway intersections with Runway 10/28. In addition, Runways 5W/23W and 18/36 do not intersect.

9 The savins benefits in this table are cumulative. Here, for each item in the table, all improvement items above it are in effect.

Package 2 (Airfield improvement 1)	Estimated Annual Delay Savings (in hours and millions of 1991 dollars) Baseline	Future 1	Future 2
	5,232/$6.2	13,269/$15.6	25,142/$29.6



1. Two Runway 5/23's with a centerline spacing of 3,400 ft. or greater.
2. Runway 23 thresholds to be relocated to SW so as not to intersect with Runway 10/28.
3. New midfield terminal building to be located between new parallel Runway 5/23's.
4. Runway 10/28 remains unchanged at 6,015 ft. in length.
5. Runway 18/36 is closed.

Package 2 represents an airport layout with two parallel runways, Runways 5L/23R and 5E/23E, spaced at 3,400 feet or more apart, with a midfield terminal between the two runways. Both runways would be 8,000 feet in length. The existing Runway 10/28, 6,015 feet in length, would remain, and Runway 18/36 would be closed.

Appendix D

List of Abbreviations

ADSIM	Airfield Delay Simulation Model
ARR	Arrivals
ASC	Office of System Capacity and Requirements, FAA
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
BKL	Burke Lakefront Airport
CAT	Category — of Instrument Landing System
CLE	Cleveland-Hopkins International Airport
CRDA	Converging Runway Display Aid
DCIA	Dependent Converging Instrument Approaches
DEP	Departures
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LBS	Pounds
LOC	Localizer Only
MLS	Microwave Landing System
MVFR	Marginal Visual Flight Rules
NM	Nautical miles
OM	Outer Marker
PRM	Precision Runway Monitor
RDSIM	Runway Delay Simulation Model
RVR	Runway Visual Range
RWY	Runway
SCIA	Simultaneous Converging Instrument Approaches
SM	Statute Miles
TERPS	Terminal Instrument Procedures
TVOR	Terminal VOR
TWY	Taxiway
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range — course information only

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