PORT COLUMBUS INTERNATIONAL AIRPORT

COLUMBUS AIRPORT AUTHORITY

Port Columbus International Airport

Capacity Enhancement Plan

September 1993

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

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Figure 1. Port Columbus International Airport

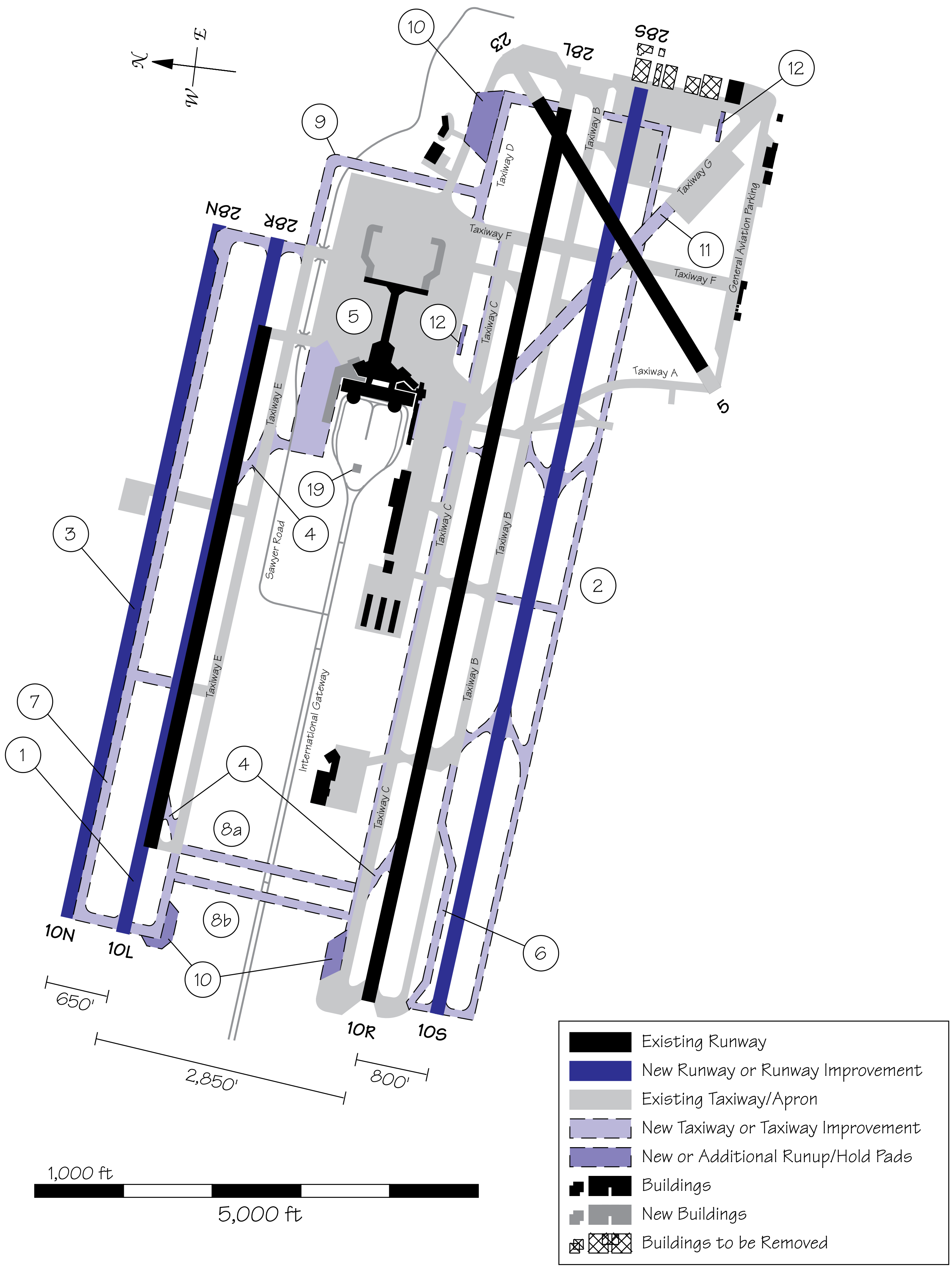


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives	Project Cost ('92 $M)	Estimated Annual Delay Savings[1] (in hours and millions of 1992 dollars) Baseline (217,468)	Future 1 (319,084)	Future 2 (421,694)	Future 3 (461,414)
Airfield Improvements					
1. Relocate and extend Rwy 10L/28R (dependent operations)	$21.2	—	910/$1.18	4,980/$6.57	7,450/$9.90
2. Build third parallel Rwy 10S/28S 800 ft. south of Rwy 10R/28L	$108.1	571/$0.59	2,065/$2.71	9,612/$12.83	18,633/$24.85
3. Build fourth parallel Rwy 10N/28N[2] 650 ft. north of Rwy 10L/28R Inboard runways for departures; outboard runways for arrivals	$49.4	643/$0.66	2,687/$3.51	13,988/$18.52	27,076/$35.80
4. Improve or add angled exits	$2.1	60/$0.06	330/$0.43	1,960/$2.55	4,590/$6.01
5. Expand passenger terminal				†	
5a. Add 4 to 10 gates on west side	$20.1–$32				
5b. Add 6 gates on east side	$16				
5c. Add 10 additional gates	$22				
6. Relocate west end of Twy B	$2	—	141/$0.18	384/$0.49	413/$0.53
7. Build north parallel taxiway for Rwy 10L/28R	$4.9			†	
8. Build crossover taxiway at west end between Rwys 10L/28R and 10R/28L					
8a. One-way crossover taxiway	$8.9	910/$0.90	1,500/$1.92	1,820/$2.37	2,000/$2.58
8b. Two-way crossover taxiway	$5.9	1,500/$1.50	2,300/$2.95	2,950/$3.84	3,010/$3.90
9. Build bypass taxiway on east side of terminal	$2.8	—	—	—	—
10. Build run-up/hold pads at all air carrier runway ends	$3.4	220/$0.22	1,320/$1.70	10,490/$13.68	23,740/$30.95
11. Reconstruct/strengthen Twy G south of Rwy 10R/28L	$1.4			†	
12. Build blast walls for engine runups north and south of Rwy 28L	$0.5			†	

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

2 The delay savings shown for alternative 3 include the delay savings for alternative 2.

† 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.

Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Alternatives	Project Cost ('92 $M)	Estimated Annual Delay Savings[1] (in hours and millions of 1992 dollars) Baseline (217,468)	Future 1 (319,084)	Future 2 (421,694)	Future 3 (461,414)
Facilities and Equipment Improvements					
13. Install CAT I ILS on Rwy 28R	$2.6	—	123/$0.17	514/$0.73	1,078/$1.53
14. Install centerline and touchdown zone lights and runway visual ranges on Rwy 10R/28L	—		†		
15. Install CAT II ILS on Rwy 10R/28L	$12.9	328/$0.42	1,369/$2.18	3,331/$4.72	5,624/$6.98
16. Install Precision Runway Monitor (PRM)	—	571/$0.59	2,065/$2.71	9,612/$12.83	18,633/$24.85
17. Install Airport Surface Detection Equipment (ASDE)	—			†	
18. Install DME on Rwy 28L	—		†		
19. Construct new Airport Traffic Control Tower (ATCT)	$13		†		
20. Install additional NAVAIDs	—	634/$0.76	941/$1.32	3,159/$4.48	3,085/$4.39
Operational Improvements					
21. Impact of noise reduction procedures	—		†		
22. Provide 1.5 nm staggered approaches to Rwys 10R/28L and 10L/28R in IFR	—	15/$0.02	100/$0.14	470/$0.67	890/$1.26
23. Provide 2.5 nm in-trail separations between similar class aircraft	—	10/$0.01	60/$0.09	200/$0.27	670/$0.92
24. Redistribute traffic more uniformly within the hour	—	1,310/$1.32	1,955/$2.54	8,500/$11.09	9,340/$12.20
25. Continue enhancement of reliever airports to accommodate small/slow aircraft operations	—		†		
26. Conduct airspace capacity design project and restructure area airspace	—	956/$0.95	3,533/$4.53	17,072/$22.22	35,254/$45.79

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

2 The delay savings shown for alternative 3 include the delay savings for alternative 2.

† 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.

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 have initiated joint 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, decrease delays, and improve airport efficiency and works to develop a coordinated action plan for reducing airport delay. Over 30 Airport Capacity Design Teams have either completed their studies or have work in progress.

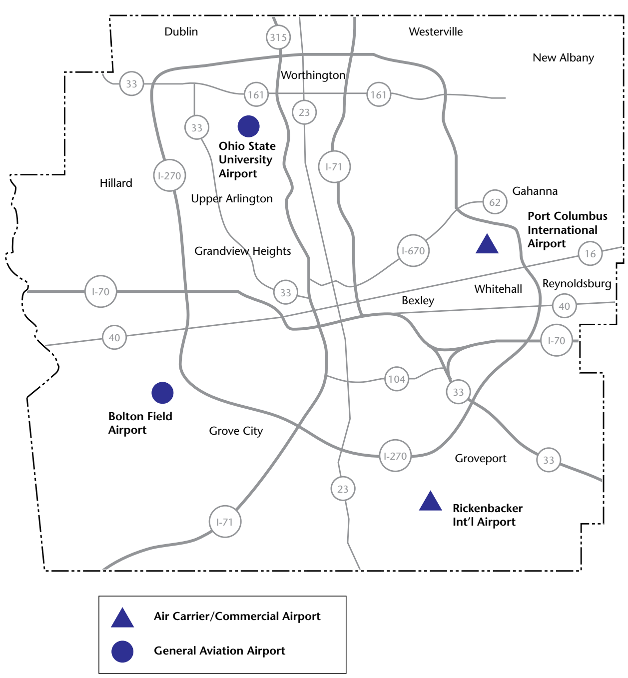
The need for this program continues. In 1991, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 36 by 2001.

Port Columbus International Airport

Port Columbus International Airport (CMH) is situated on 1,800 acres located six miles northeast of downtown Columbus. It is owned by the City of Columbus and operated by the Columbus Municipal Airport Authority. CMH is currently served by ten major airlines and nine commuter airlines. In 1992, 2.2 million passengers were enplaned at CMH, a 44 percent increase since 1983. CMH's total aircraft operations reached 230,655 in 1992. Cargo, including air mail and freight, has increased 165 percent since 1983, with 39.18 million pounds enplaned in 1992. Port Columbus International Airport and the City of Columbus are served by several public reliever airports in the immediate vicinity, including Bolton Field, Ohio State University, and Rickenbacker International.

As a result of the large increase in passenger traffic and aircraft operations, the Columbus Municipal Airport Authority has examined the possibility of accelerating development plans for CMH. An Airport Capacity Design Team for Port Columbus International Airport was formed in 1992. The CMH Capacity Team identified and assessed various actions which, if implemented, would increase CMH'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.

Airports in the Vicinity of Port Columbus International Airport



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 — 217,468 operations,
Future 1 — 319,084 operations,
Future 2 — 421,694 operations, and
Future 3 — 461,414 operations.

Figure 3 illustrates the capacity and delay curves for the current airfield configuration at CMH under instrument flight rules (IFR). It shows that aircraft delays will begin to escalate rapidly as hourly demand exceeds 55 to 70 operations per hour. Figure 4 shows that, while hourly demand does not exceed 55 operations during the day at Baseline demand levels, 70 operations per hour is frequently exceeded at the demand levels forecast for Future 2 and Future 3.

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

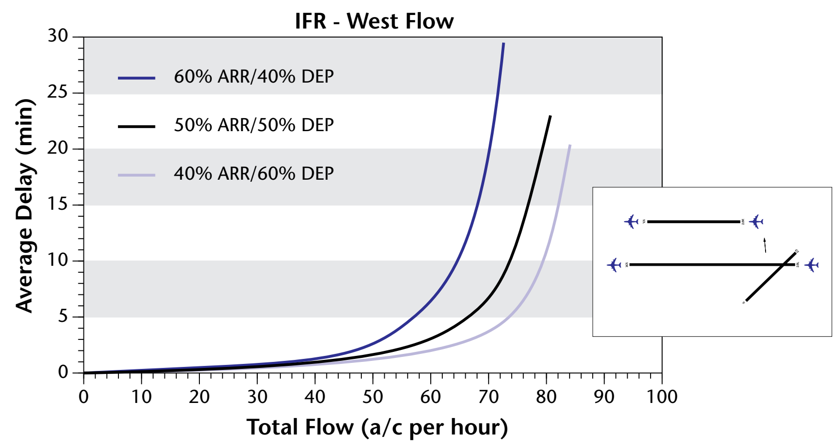
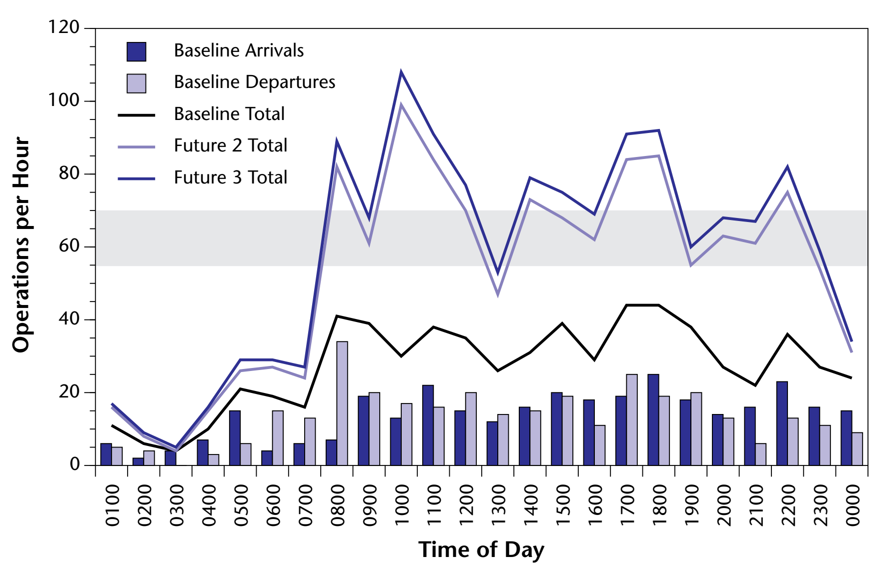


Figure 4. Profile of Daily Demand — Hourly Distribution



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 2,710 hours or $2.72 million at the Baseline level of operations to 34,897 hours or $45.79 million by Future 2.

Figure 5 illustrates the major delay-savings benefits from the improvement alternatives studied by the Capacity Team, first with an emphasis on improvements that are likely to be completed by the Future 1 level of operations, and second with an emphasis on Future 2. These improvements are also listed in the tables below.

Figure 6 shows the average delay in minutes per aircraft operation for these same alternatives. Under the Do Nothing scenario, the average delay per operation of 0.8 minutes in Baseline will increase to 5 minutes per operation by Future 2.

Figure 7 compares the average delay in minutes per aircraft for the Do Nothing case to the effect of introducing the noted improvements at Future 1, Future 2, and Future 3 levels of demand. This figure demonstrates that, by implementing these improvements during the recommended time frame, the airport would continue to operate below a 4.0 minute average delay even as demand increased through the Future 3 level of operations.

Figure 8 illustrates the annual delay-savings benefits for each of the improvement alternatives modeled at each of the four activity levels. It serves to highlight the alternatives that will provide the greatest savings in delay costs.

Capacity Enhancement Alternatives for Future 1

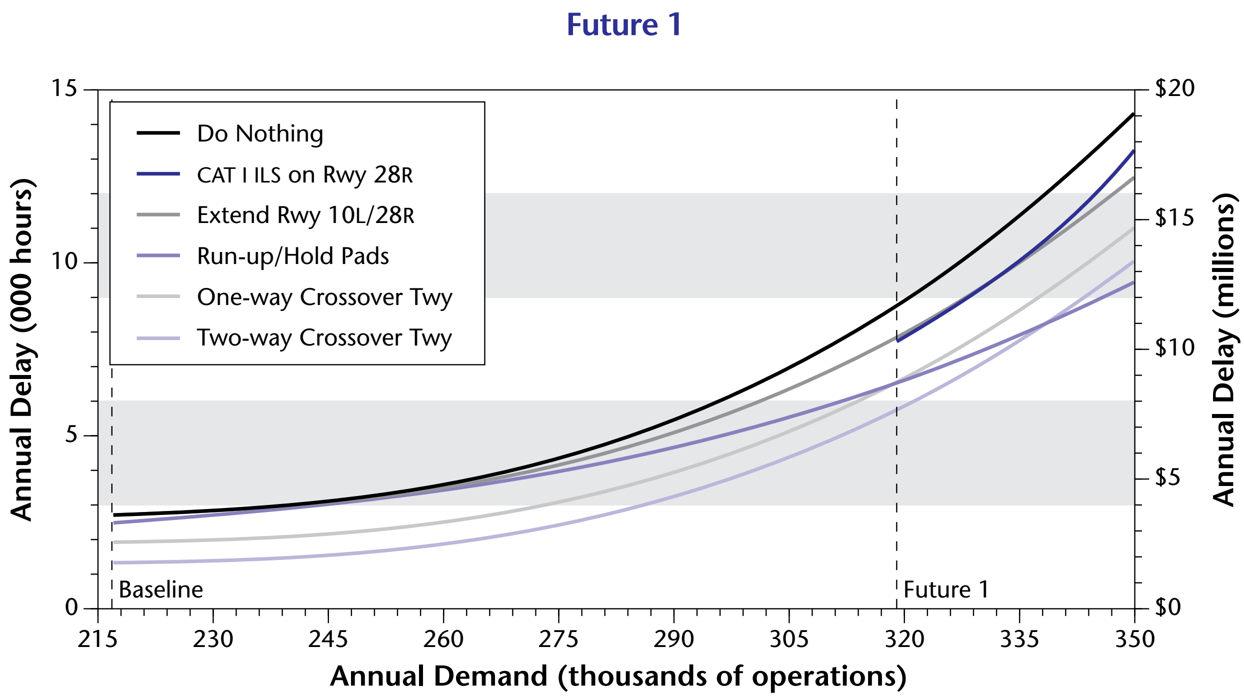
	Future 1 Annual Delay Savings	
	Hours	Millions of 1992 $
• Install Category I ILS on Runway 28R	123	$0.17
• Extend Runway 10L/28R to 8,000 feet	910	$1.18
• Build run-up/hold pads at all air carrier runway ends	1,320	$1.70
• Build one-way crossover taxiway at west end	1,500	$1.92
• Build two-way crossover taxiway at west end	2,300	$2.95

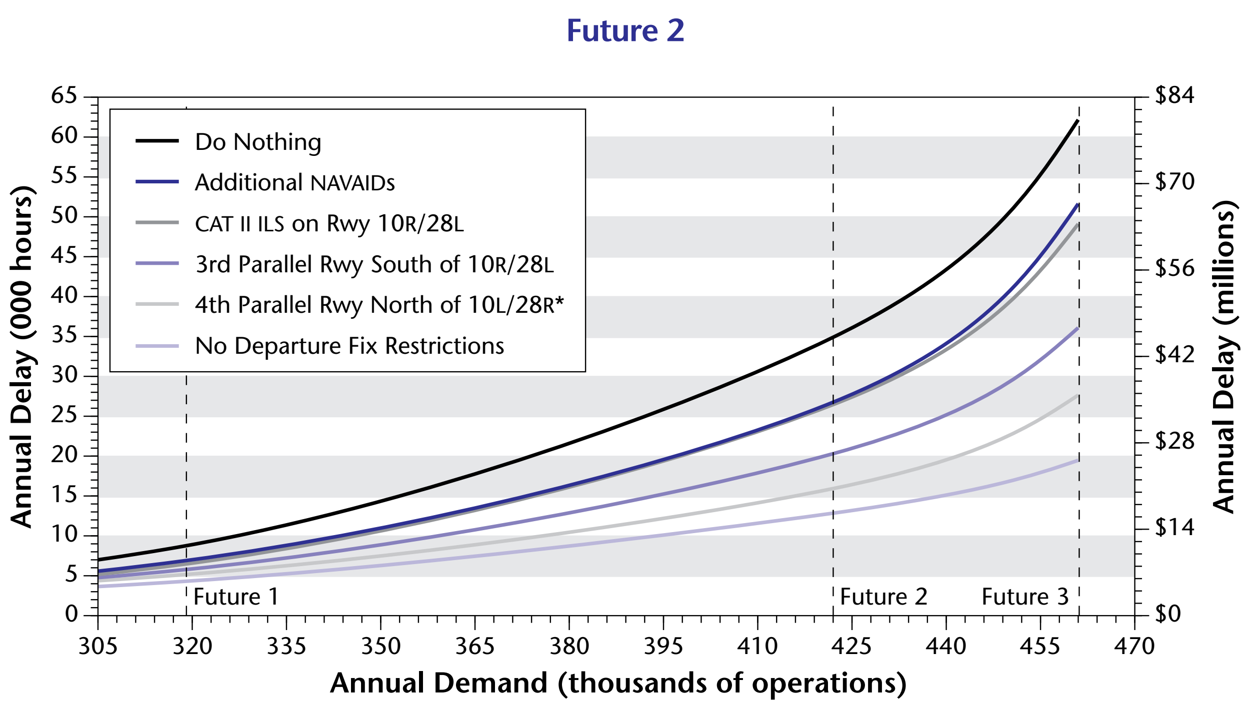
Capacity Enhancement Alternatives for Future 2

	Future 2 Annual Delay Savings	
	Hours	Millions of 1992 $
• Install additional NAVAIDs	3,159	$4.48
• Install Category II ILS on Runway 10R/28L	3,331	$4.72
• Build third parallel runway 800 feet south of Runway 10R/28L	9,612	$12.83
• Build fourth parallel runway 650 feet north of Runway 10L/28R*	13,988	$18.52
• Conduct airspace capacity design project — eliminate departure fix restrictions	17,072	$22.22

* Note: The delay savings shown for the fourth parallel runway include the delay savings for the third parallel runway.

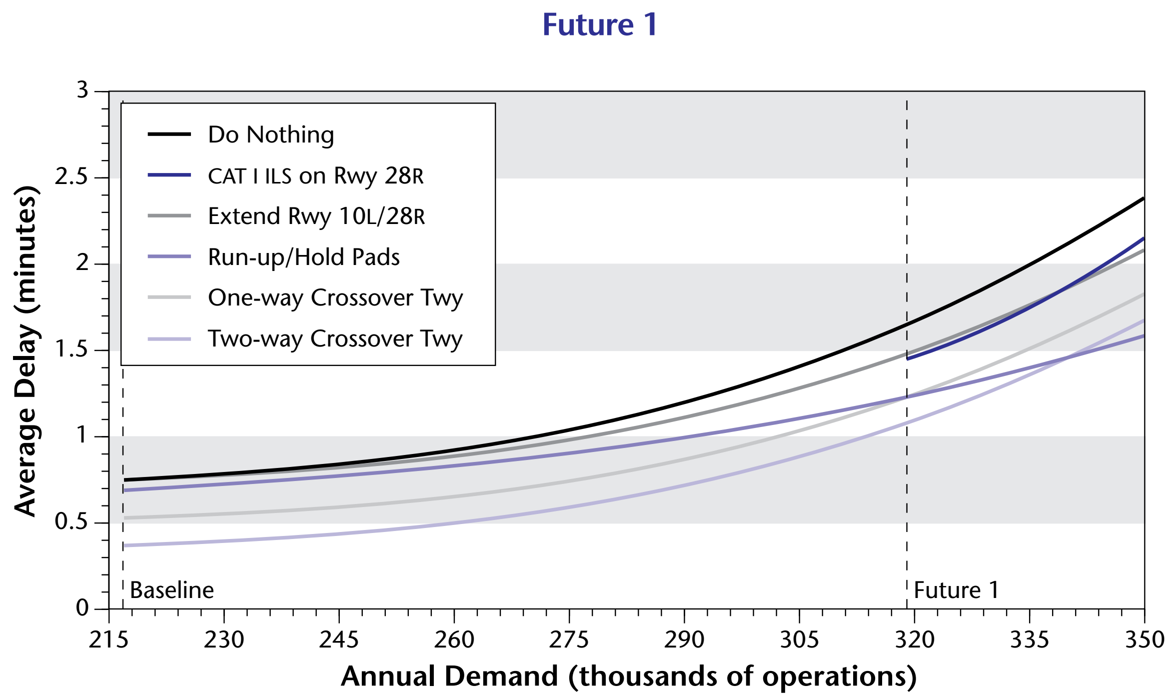
Figure 5. Annual Delay Costs — Capacity Enhancement Alternatives

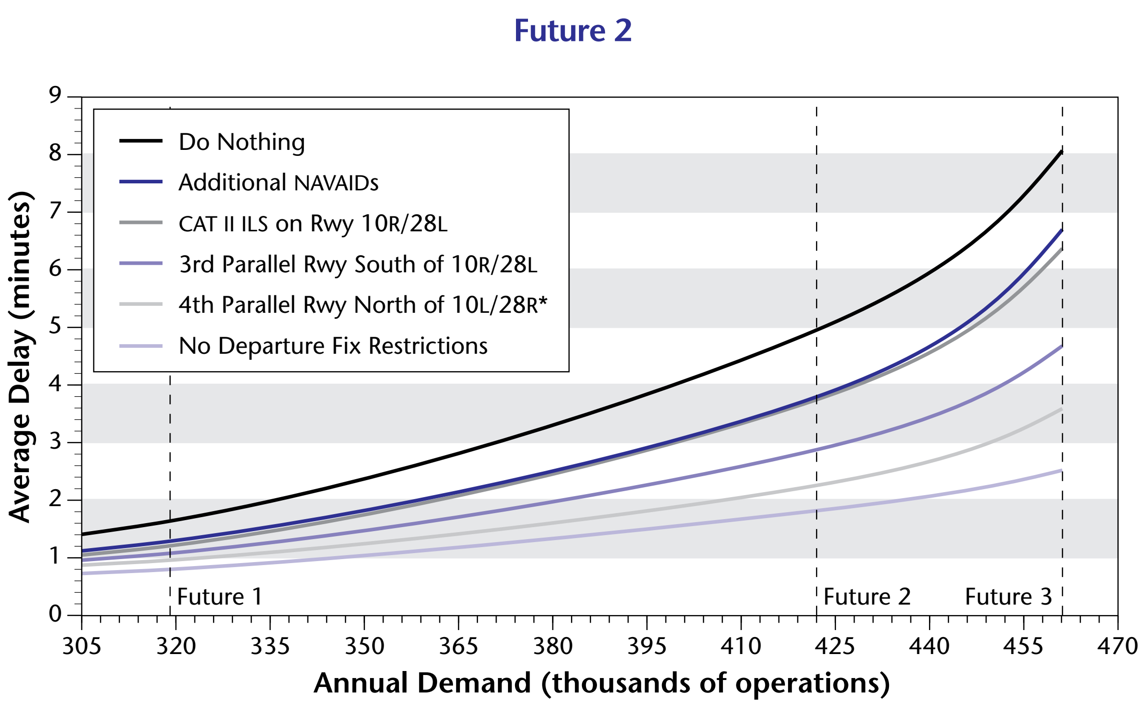




* Note: The delay savings shown for the fourth parallel runway include the delay savings for the third parallel runway.

Figure 6. Average Delays — Capacity Enhancement Alternatives





* Note: The average delays shown for the fourth parallel runway include the average delays for the third parallel runway.

Figure 7. Average Delay — Possible Capacity Enhancement Improvements

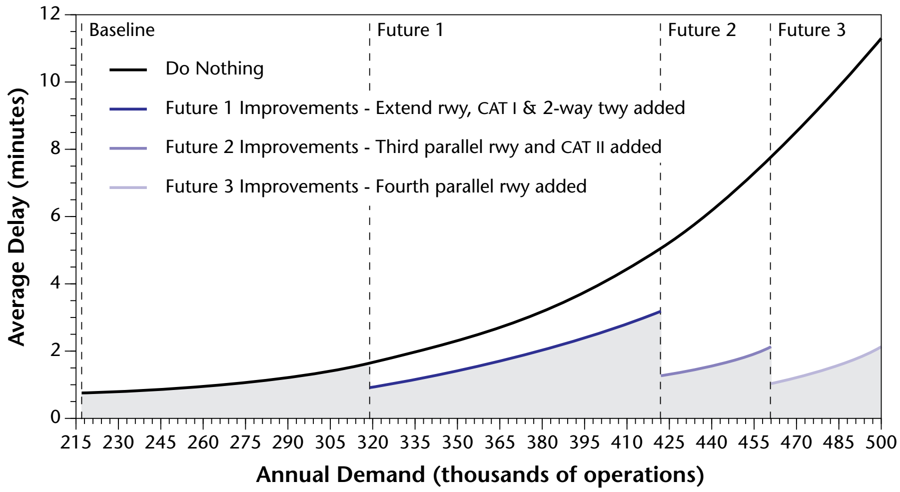
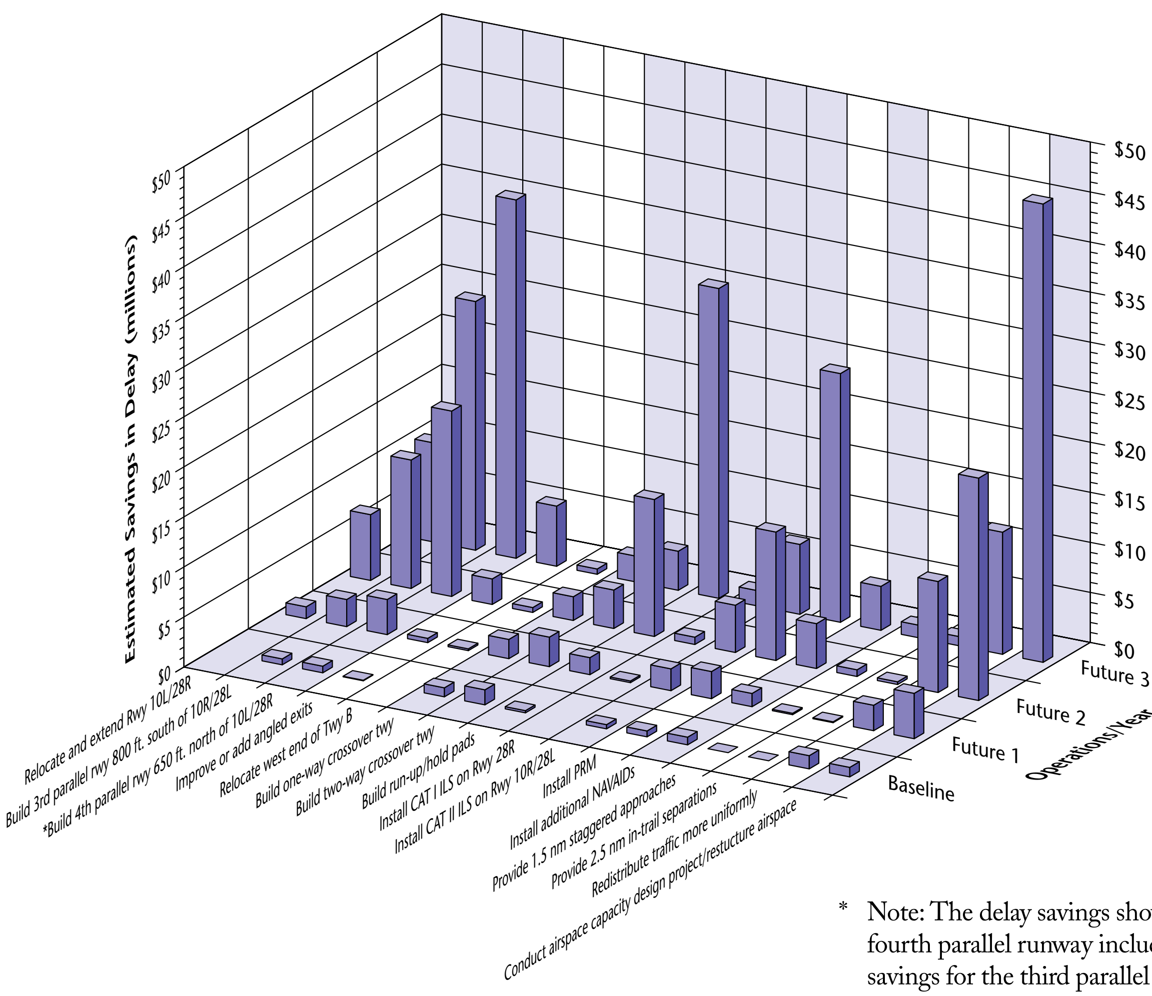


Figure 8. Annual Delay-Saving Benefits — Capacity Enhancement Alternatives



* Note: The delay savings shown for the fourth parallel runway include the delay savings for the third parallel runway.

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 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 30 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.

Port Columbus International Airport

Port Columbus International Airport (CMH) is situated on 1,800 acres located six miles northeast of downtown Columbus. It is owned by the City of Columbus and operated by the Columbus Municipal Airport Authority.

In 1927, Columbus convinced the newly formed Transcontinental Air Transport (TAT) (now Trans World Airlines) that Columbus would be the ideal location for the eastern terminal of its transcontinental train-plane service. Survey teams, including engineers from TAT and Charles Lindbergh, recommended the flat farm land lying north of the Pennsylvania and B&O railroad tracks, west of Hamilton Road and north of 5th Avenue. In 1928, the first terminal building was constructed on 768 acres through a $350,000 bond issue. This terminal building was located in the southeast corner of the airfield north of the railroad tracks that fed passengers to the air terminal for the flying portion of the route between the East Coast and the West Coast. More than 11,000 passengers were processed through the terminal building during the airport's first year of operation. In 1929, Port Columbus International Airport was nicknamed "America's Greatest Air Harbor" as it began its role in the first transcontinental air-rail transportation system.

Ten years later, in 1939, CMH had 14 scheduled flights per day, and the federal government provided $1.5 million to the airport for airport improvements. In the early forties, CMH reached 64,500 annual aircraft operations. In 1958, a new $4 million terminal was constructed across the field from the old terminal building. The airport's primary east-west runway was lengthened from 8,000 to 10,700 feet, and a new 6,000 foot parallel east-west runway was constructed north of the terminal building. During the 1980's and early 1990's, the airport terminal building and apron areas were improved and expanded.

Port Columbus International Airport is primarily an air carrier airport. In the FAA's National Plan of Integrated Airport Systems (NPIAS), CMH is classified as a medium-haul commercial service airport, which provides commercial airline service, frequently to destinations between 500 and 1,000 miles, as well as serving the needs of general aviation (GA) users. An airport's role within the region, state, and national systems is crucial in the development of that airport.

CMH is currently served by ten major airlines and nine commuter airlines. In 1992, 2.2 million passengers were enplaned at CMH, a 44 percent increase since 1983, with total aircraft operations reaching 230,655. Enplaned cargo, including air mail and freight, has increased 165 percent since 1983, with 39 million pounds enplaned in 1992.

CMH has three paved runways:

- Runway 10R/28L is a precision runway 10,250 feet long and 150 feet wide. Runway 10R is equipped with an instrument landing system (ILS), non-directional beacon (NDB), and medium-intensity approach lighting system with runway alignment indicator lights (RAIL) (MALSR). Runway 28L is equipped with an ILS, NDB, MALSR, and runway visual range (RVR). The runways are equipped with high intensity runway lights (HIRL).
- Runway 10L/28R is 6,000 feet long and 150 feet wide and is also a precision runway. Runway 10L has an ILS with distance measuring equipment (DME), NDB, MALSR, and RVR. Runway 28R is equipped with a localizer (LOC), back course (BC), DME, visual approach slope indicator (VASI), and runway end identifier lights (REIL). The runways are equipped with HIRL.
- Runway 5/23 is 3,908 feet long and 150 feet wide. Both runway ends have VASI and medium intensity runway lights (MIRL). Runway 5 also has REIL.

Port Columbus International Airport and the City of Columbus are served by several public reliever airports in the immediate vicinity. Bolton Field, which is located about 12 nautical miles (nm) southwest of Port Columbus International Airport, has a single paved 5,200 foot runway, equipped with an ILS, MALSR, VASI, REIL, and MIRL. and is operated by the Columbus Municipal Airport Authority. Ohio State University, which is located about 10 nm northwest of CMH, has four paved runways equipped with various navigational aids. Rickenbacker International Airport, which is located about 11 nm south of CMH, has three paved parallel runways. All three airports have precision approaches available.

Port Columbus Airport Capacity Design Team

As a result of the large increase in passenger traffic and aircraft operations, the Columbus Municipal Airport Authority has examined the possibility of accelerating development plans for CMH. An Airport Capacity Design Team for Port Columbus International Airport was formed in 1992. The CMH 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. Port Columbus is currently in the process of completing an update to the airport's Master Plan and Noise Compatibility Plan. This will allow for the linkage of master planning strategies and an assessment of their potential impact on airport environs.

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 217,468 aircraft operations (takeoffs and landings) was established. Three future traffic levels, *Future 1*, *Future 2*, and *Future 3* were established at 319,084, 421,694 and 461,414 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Port Columbus. If no improvements are made at CMH, annual delay levels and delay costs are expected to increase from an estimated 2,710 hours and $2.72 million at the Baseline activity level to nearly 34,897 hours and $45.79 million by the Future 2 demand level.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at CMH. 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 technical and operational feasibility of the proposed airfield improvements, but did not address environmental, socioeconomic, or political issues of 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 Columbus Municipal Airport Authority, and various airport user and aviation industry 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 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.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at CMH. Proposed improvements were analyzed in relation to current and future demands with the help of two 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 suggested improvements.

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 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

Figure 9. Capacity Enhancement Alternatives and Recommended Actions

Alternatives	Action	Completion Time Frame
Airfield Improvements		
1. Relocate and extend Rwy 10L/28R	Recommended	Baseline–Future 1
2. Build third parallel Rwy 10S/28S 800 ft. south of Rwy 10R/28L	Recommended	Future 2
3. Build fourth parallel Rwy 10N/28N 650 ft. north of Rwy 10L/28R Inboard runways for departures; outboard runways for arrivals	Recommended	Future 3
4. Improve or add angled exits	Recommended	Baseline
5. Expand passenger terminal		
5a. Add 4 to 10 gates on west side	Proposed	Baseline
5b. Add 6 gates on east side	Further Study*	—
5c. Add 10 additional gates	Further Study*	—
6. Relocate west end of Twy B	Further Study*	—
7. Build north parallel taxiway for Rwy 10L/28R	Recommended	Baseline–Future 1
8. Build crossover taxiway at west end between Rwy 10L/28R and Rwy 10R/28L		
8a. One-way crossover taxiway	Recommended	Baseline
8b. Two-way crossover taxiway	Recommended	Future 1
9. Build bypass taxiway on east side of terminal	Recommended	Baseline–Future 1
10. Build run-up/hold pads at all air carrier runway ends	Recommended	Baseline
11. Reconstruct/strengthen Twy G south of Rwy 10R/28L	Recommended	Baseline–Future 1
12. Build blast walls for engine runups north and south of Rwy 28L	Recommended	Baseline
Facilities and Equipment Improvements		
13. Install CAT I ILS on Rwy 28R	Recommended	Baseline–Future 1
14. Install centerline and touchdown zone lights and runway visual ranges (RVRs) on Rwy 10R/28L	Recommended	Baseline
15. Install CAT II ILS on Rwy 10R/28L	Recommended	Future 1–Future 2
16. Install Precision Runway Monitor (PRM)	Recommended	Future 2
17. Install Airport Surface Detection Equipment (ASDE)	Not Recommended	—
18. Install Distance Measuring Equipment (DME) on Rwy 28L	Recommended	Baseline
19. Construct new Airport Traffic Control Tower (ATCT)	Recommended	Baseline
20. Install additional NAVAIDs	Recommended	Baseline
Operational Improvements		
21. Impact of noise reduction procedures	FAR Part 150 Study Underway	—
22. Provide 1.5 nm staggered approaches to Rwys 10R/28L and 10L/28R in IFR	Recommended	Baseline–Future 1
23. Provide 2.5 nm in-trail separations for similar class aircraft	Recommended	Baseline–Future 1
24. Redistribute traffic more uniformly within the hour	Not Recommended	—
25. Continue enhancement of reliever airports to accommodate small/slow aircraft operations	Recommended	Future 1-Future 2
26. Conduct airspace capacity design project and restructure area airspace	Recommended	Baseline

* "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. These individual proposals require further investigation at a level of detail that is beyond the scope of this effort.

Background

The 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, Future 2, and Future 3 which correspond to annual aircraft operations of 217,468, 319,084, 421,694 and 461,414 respectively. The delay savings benefits of the improvements are not necessarily additive.

Figure 9 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

Airfield Improvements

1. Relocate and extend Runway 10L/28R (dependent operations).

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	910	4,980	7,450
$M	—	$1.18	$6.57	$9.90

This project would relocate Runway 10L/28R 50 feet to the north and extend the runway 1,000 feet on each end. By providing more usable runway length for arrivals and departures, the project would make Runway 10L/28R more acceptable to larger, heavier aircraft. As part of the runway extension project, land must be acquired to provide for the necessary runway clear zone.

The existing runway-to-taxiway separation is 350 feet. The entire runway must be relocated 50 feet in order to comply with the current runway-to-taxiway separation requirement of 400 feet. This project involves moving the centerline crown of the runway 50 feet to the north and adding 50 feet of runway pavement along the north edge of the existing runway. The entire runway would then need to be paved to provide for adequate drainage of water from the pavement surface. The runway lighting would also need to be relocated to accommodate this pavement relocation.

At the same time, 1,000 foot long and 150 foot wide runway extensions would be added to each end of the existing 6,000 foot runway. Runway 10L/28R would then be 8,000 feet long and would accommodate most aircraft used at Port Columbus today. This extension would help to increase capacity, reduce delay, and make the runway safer for larger aircraft. More aircraft would be able to use this runway with greater load factors and greater margins of safety.

The extension on the east end would require earthwork, relocation of Old James Road, removal of obstructions in the approach zone, additional runway and taxiway lighting, and relocation of the localizer, runway end identifier lights (REIL), and generic visual glide slope indicators (GVGI).

The extension on the west end would require earthwork, additional runway and taxiway lighting, land acquisition, and relocation of the approach light system (ALS) and the glide slope system. The land acquisition for the Runway Protection Zone west of Runway 10L would require the purchase of about 30 acres of property. This land contains 14 business, 11 residence, and 6 unimproved properties.

Cost Breakdown

- Relocate runway 50 ft. north .... $3,351,000 (includes pavement removal)
- Relocate runway lights 353,600
- Extend runway 1,000 ft. on .... 5,226,000 each end (total of 2,000 ft.)
- Extend runway lights 123,400
- NAVAIDs for Runways 28R and 10L........... 2,472,400
- Control cable network 143,600
- Relocate Old James Road......................... 1,192,200
- Extend Taxiway E 3,579,800
- Extend taxiway lighting 60,000
- Construct taxiway connectors at .... 963,000 new ends of runway (3)
- Connector taxiway lighting 69,000
- Clearing and grubbing for .... 361,000 improvements
- Land acquisition 3,300,000

Total $21,195,000

Annual savings at the Future 1 activity level with dependent parallel approaches under IFR would be 910 hours or $1.18 million, and, at Future 2 activity levels, 4,980 hours or $6.57 million.

Estimated 1992 project cost is $21.2 million.

2. Build third parallel Runway 10S/28S 800 feet south of Runway 10R/28L.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	571	2,065	9,612	18,633
$M	$0.59	$2.71	$12.83	$24.82

Under this project, a third parallel runway would be constructed 800 feet south of the existing Runway 10R/28L. This construction would begin only after the relocation of the existing taxiway pavements to meet the FAA-required runway-to-taxiway separation. The new runway would be 10,250 feet long and 150 feet wide. This runway would have two high-speed exits, a 90 degree exit at the center, and a 90 degree bypass taxiway at each end. A taxiway would also be constructed on the south side of this new runway. New runway and taxiway lights and navigational aids are included in the project.

Currently, FAA Order 7110.65 states that the separation between parallel runway centerlines must be at least 4,300 feet for independent operations in all weather conditions. If parallel runway centerlines are separated by less than 4,300 feet, the runways are considered dependent under instrument flight rules (IFR), and aircraft flying the approach to the two runways must be staggered. The parallel runways at CMH are currently 2,800 feet apart.

However, a developmental program known as the Precision Runway Monitor (PRM) (see alternative 16) has demonstrated the potential for reducing parallel runway spacing requirements. The ability to conduct independent operations would significantly increase capacity at CMH. The PRM consists of an improved radar system that provides highly accurate azimuth and range data on approaching aircraft, higher update rates of aircraft positions, and a new air traffic controller display system. National standards for simultaneous (independent) parallel approaches using the PRM to runways separated by 3,400 to 4,300 feet were published in November 1991. The first E-scan (electronically scanning) PRM systems are scheduled to be delivered in 1994.

Cost Breakdown

- Construct runway 10,250 ft. x 150 ft. ..... $19,529,000 (with runway lights)
- Two high-speed exits (with lights) 1,392,000
- 90 exit at center (with lights) 344,000
- Two bypass taxiways .... 1,376,000 (one at each end with lights)
- South taxiway (10,250 ft. with lights) 9,708,000
- NAVAIDs 7,337,000
- Land acquisition .... 1,929,000 (24 homes in RPZ west/Stelzer)
- Demolition of specific McDonnel .... 66,468,258 Douglas buildings

Total $108,083,258

Transfer of the Department of Defense (DoD) property currently leased to McDonnell Douglas would be required to construct the proposed runway. Selected parcels west of Stelzer Road would also have to be acquired due to penetrations of the Runway Protection Zone and noise compatibility. Specific buildings, structures, and pavements must be removed from the site (AF Plant 58) in order to meet FAA runway safety criteria. The seven northernmost buildings on the east hangar line would have to be removed, and the cost of relocating/replacing these buildings and the associated apron to the north side of the airport is included in this project. Pavements in the area of the general aviation (GA) apron on the east hangar line and Runway 5/23 would also need to be removed.

Annual savings at the Baseline activity level would be 571 hours or $0.59 million and, at Future 2 activity levels, 9,612 hours or $12.83 million.

Estimated 1992 project cost for the third parallel runway south of Runway 10R/28L and for the associated taxiway is $108.1 million.

3. Build fourth parallel Runway 10N/28N 650 feet north of Runway 10L/28R. The inboard runways would be used for departures, and the outboard, for arrivals.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	643	2,687	13,988	27,076
$M	$0.66	$3.51	$18.52	$35.80

When aircraft operations and airport capacity demand more runways, a fourth runway would be constructed. This project would include the construction of a new 8,000 foot long and 150 foot wide runway 650 feet north of the relocated Runway 10L/28R. The existing runway would be converted into a departure runway. The existing Runway 10L/28R will be relocated 50 feet north of its current location (alternative 1) to meet FAA runway-to-taxiway separation criteria and to provide more spacing between the two inboard runways. New runway and taxiway lights and navigational aids are included in the project.

This project will require the acquisition of land on the northwest and west ends of the airport for Runway Protection Zones. The maintenance buildings located in the southwest and southeast areas of the maintenance facility compound would also need to be relocated due to building penetration into the runway safety area and the obstacle free area. The existing Bridgeway Avenue and Old James Road would be relocated, Bridgeway due to its close proximity to the new runway and future development and Old James due to the roadway's intrusion into the Runway Protection

Zones of the two north runways. Numerous drainage ditches on the north airfield would also have to be piped or relocated due to runway construction.

Building these proposed third and fourth parallel runways (alternatives 2 and 3) would bring the two existing runways up to date with current runway-to-taxiway separation minimums. These projects would also provide a 4,300 foot separation between the outboard runways. The fourth runway to the north would only be built when the need for more capacity emerges. The two outboard runways could support simultaneous (independent) arrival streams, and the two inboard runways could support two departure streams. The building of these runways would greatly enhance runway capacity and remove departure delays due to regular runway maintenance.

Annual savings for the fourth parallel runway at the Baseline activity level would be 643 hours or $0.66 million; at Future 2 activity levels, 13,988 hours or $18.52 million; and, at Future 3 activity levels, 27,076 hours or $35.80 million. These delay savings figures include the delay savings for the third parallel runway, alternative 2.

Estimated 1992 project cost for a fourth parallel runway north of Runway 10L/28R and for the associated taxiway is $49.4 million.

Total estimated 1992 project cost for both third and fourth parallel runways is $157.5 million.

Cost Breakdown

- Construct runway 8,000 ft. x 150 ft. (with runway lights) $19,720,000
- Relocate interior roadways 801,000
- Relocate drainage ditch 2,991,000
- Construct connecting taxiways 2,920,000
- Pavement removal and clearing and grubbing 759,000
- Rebuild maintenance facilities 4,250,000
- NAVAIDs 2,616,000
- Land Acquisition and demolition 15,320,000

Total $49,377,000

4. Improve or add angled exits.

At present, CMH has no high-speed exits for aircraft use. This project would provide for three improved, high-speed runway exits, which would reduce runway occupancy times and enhance runway capacity. Aircraft would be able to leave the runway environment at a faster rate, increasing the amount of time available for additional landing traffic while simultaneously reducing aircraft user costs associated with arrival and departure delays. Two high-speed angled exits would be placed on Runway 10L/28R, and one, on Runway 10R/28L. Two of the high-speed exits would be located at the west end of the north and south runways at the crossover taxiway. The remaining exit would be located about 5,000 feet east of Runway 10L threshold.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	60	330	1,960	4,590
$M	$0.06	$0.43	$2.55	$6.01

Without high-speed exits, aircraft would not be able to achieve the runway occupancy times of less than 50 seconds needed to qualify for the use of reduced diagonal and in-trail separation standards (see alternatives 22 and 23). The delay savings of all three alternatives need to be considered in any cost/benefit deliberations.

Estimated 1992 project cost is $2.1 million.

Annual savings at the Baseline activity level would be 60 hours or $0.06 million, and, at Future 2 activity levels, 1,960 hours or $2.55 million.

5. Expand passenger terminal.

Expansion of the passenger terminal would provide the additional gates needed to accommodate the expected increase in aircraft operations at CMH. Currently, all gates are under lease and are being used. Three new airlines have just arrived at the airport, with one expected to open a hub. Hub operations would require the addition of many more gate positions at the existing terminal or the construction of a satellite terminal.

5a. Add four to ten gates on west side.

This project would involve construction of a 147,000 square foot (sq. ft.) expansion of the terminal building and renovation of 30,000 sq. ft. of existing space on the north end of the terminal building. The project would provide four to ten new aircraft gates in the area of old Gate 19 and would include additional hold room, concession space, ticket lobby, security, baggage claim, and office/support space.

Construction of a new North Concourse apron and an upgrade of the existing apron area would be included in the project. The new apron will accommodate a minimum of ten A320, B-757, B-737, MD-80, and DC-9 type aircraft parking positions and will facilitate the North Terminal expansion. In addition, Sawyer Road would be relocated, and a third taxiway overpass would be constructed to connect the terminal apron to Taxiway E.

Estimated 1992 project cost for four gates is $20.1 million and for 10 gates, $32 million.

5b. Add six gates on east side.

The east side expansion would provide for the net addition of six gates on the southeast and northeast corners of the main concourse "Tee" and represents the first step in a long-term, multi-phase expansion of airline gates to the east. Existing hold rooms along the north and south legs of the existing main concourse "Tee" would be relocated to the east, thereby widening the concourse and increasing pedestrian capacity.

New concourse construction would include ten hold rooms and concession and rest room facilities. Airline operations, tenant, and mechanical equipment space would be located at the apron level below.

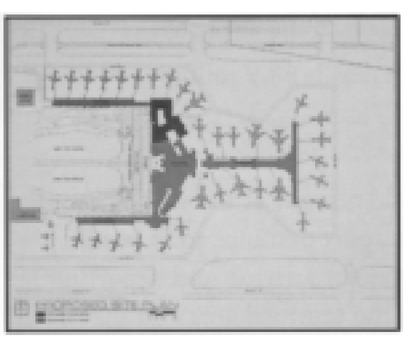
To provide additional ticket counters for the east side expansion, the existing concession space along the south side of the main public concourse would be removed, and about 90 feet of ticket counter and associated airline ticket offices would be created in its place. Sufficient for one, or possibly two, small air carriers, the new ticket lobby would afford easy access and adequate queuing space, without requiring relocation of the existing security checkpoint or any airline gates.

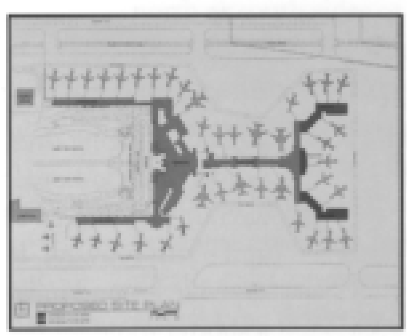
Estimated 1992 project cost is $16.0 million.

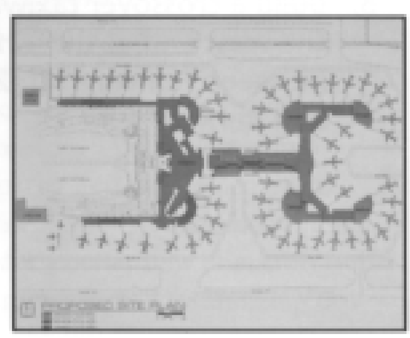
5c. Add ten additional gates.

This project would involve the construction of ten additional air carrier gates to the east. Five gates in a rotunda-like form would be added to both the north and south legs of the "Tee" expansion (alternative 5b).

Estimated 1992 project cost is $22 million.







6. Relocate west end of Taxiway B.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	141	384	413
$M	—	$0.18	$0.49	$0.53

This project consists of relocating the western 1,600 feet of Taxiway B around an existing glide slope antenna. The antenna is located on the centerline of Taxiway B about 950 feet east of the west end of the taxiway. Consequently, Taxiway B is unusable in that area. Resolving this situation by either relocating Taxiway B or acquiring a state-of-the-art end-fire glide slope (depending on cost) would improve accessibility to the southwest airfield and the approach end of Runway 10R. It would reduce departure delays for aircraft using Runway 10R from the south side of the airport, not only enhancing capacity but also supporting future aviation development on the southwest quadrant of the airport. The rerouted taxiway would be 1,700 feet long and 75 feet wide.

Annual savings at the Future 1 activity level would be 141 hours or $0.18 million, and, at Future 2 activity levels, 384 hours or $0.49 million.

Estimated 1992 project cost to relocate Taxiway B is $2.0 million.

7. Build north parallel taxiway for Runway 10L/28R.

Cost Breakdown

- Construct north parallel taxiway .... $3,788,000 (with lights)
- Construct three taxiway connectors 1,032,000

Total $4,820,000

This project would provide an additional full-length parallel taxiway 650 feet north of the existing Runway 10L/28R. It would allow for two-way traffic for arriving and departing aircraft to taxi to and from the terminal and the runway unimpeded. It would also improve the flow of ground traffic and reduce taxi interference and delays. The new taxiway, 8,000 feet long and 75 feet wide, would reduce taxi delays to the north airfield area for arriving and departing general aviation aircraft and greatly enhance development on the north side of the airport.

Estimated 1992 project cost is $4.9 million.

8. Build a crossover taxiway at the west end of the airfield between Runway 10L/28R and Runway 10R/28L.

Constructing a crossfield taxiway at the west end of the airfield, bridging over the airport entrance road, 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 reduce taxi interference, expedite ground movement, and reduce delays by providing a shorter route for taxiing aircraft. A new crossover taxiway would increase airport capacity, eliminate congestion on the terminal apron, lower fuel consumption, and attract development north of Runway 10L/28R.

8a. Build a one-way crossover taxiway.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	910	1,500	1,820	2,000
$M	$0.90	$1.92	$2.37	$2.58

Cost Breakdown

- Reconstruct entrance road $2,962,000
- One way crossover taxiway 5,922,500

Total $8,884,500

This project would be the first phase in the construction of a crossover taxiway. It would require the tunneling and depression of the airport entrance road and would also encompass the earth work necessary for the future construction of phase two of the project, a two-way crossover taxiway. In phase one, a one-lane crossover taxiway would be constructed approximately 2,200 feet long and 75 feet wide. Departing aircraft could taxi to either runway without being required to taxi across the terminal apron to reach their runway departure points. Arriving aircraft would be able to taxi to their respective terminal gate positions on the north or south sides of the terminal building without the necessity of taxiing through the terminal apron. This project would reduce taxi interference, expedite ground movement, minimize congestion on the terminal apron, thus reducing fuel consumption and departure/arrival time delays and increasing airport capacity.

Annual savings at the Baseline activity level would be 910 hours or $0.90 million, and, at Future 2 activity levels, 1,820 hours or $2.37 million.

Estimated 1992 project cost is $8.9 million.

8b. Build a two-way crossover taxiway.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	1,500	2,300	2,950	3,010
$M	$1.50	$2.95	$3.84	$3.90

This project would be the second phase in building a crossover taxiway. Because the earth work was completed during the initial phase of construction, this second phase would only require that a second taxiway bridge be built across the airport entrance road. This second crossover taxiway would also be about 2,200 feet long and 75 feet wide. Departing aircraft could taxi to either runway without being required to taxi across the terminal apron to reach their runway departure points. Arriving aircraft would be able to taxi to their respective terminal gate positions on the north or south sides of the terminal building without the necessity of taxiing through the terminal apron. By providing for a two-way flow of aircraft, a bidirectional taxiway would permit arriving and departing aircraft to move unimpeded between the north and south sides of the west airfield. The need for a two-way crossover taxiway would become critical in a hub scenario. This project would greatly enhance airport capacity and reduce departure/arrival time delays by further reducing congestion on the terminal apron, providing for a better flow of aircraft traffic from the north and south runways, and minimizing taxiway congestion, thus attracting development on the north and south sides of the airport.

Estimated 1992 project cost is $5.9 million.

Annual savings at the Baseline activity level would be 1,500 hours or $1.50 million, and, at Future 2 activity levels, 2,950 hours or $3.84 million.

9. Build a bypass taxiway on the east side of the terminal.

Under this project, a new taxiway, 75 feet wide and 2,300 feet long, would be built east of the eastern edge of the terminal apron in a north to south direction, bridging over Sawyer Road, then turning west to connect into the existing east end of Taxiway E. Construction would entail the relocation of the existing fuel farm, the relocation of Bridgeway Road, and the earth work and tunneling necessary to bridge over Sawyer Road. This project would improve the north/south flow of aircraft ground traffic around the terminal apron and reduce taxi interference, thus reducing delays and increasing capacity.

Estimated 1992 project cost is $2.8 million. This figure reflects the cost of the bypass taxiway and *not* the relocation of the fuel farm or the earthwork and tunneling of Sawyer Road.

10. Build run-up/hold pads at all air carrier runway ends.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	220	1,320	10,490	23,740
$M	$0.22	$1.70	$13.68	$30.95

Air traffic control often dictates that aircraft hold on the run-up/hold pads at the runway ends before takeoff because of departure fix restrictions. In addition, aircraft frequently have to hold position on these run-up/hold pads before entering the runway to meet operational requirements for the aircraft. Currently, the run-up/hold pads at the ends of the air carrier runways, Runways 10R/28L and 10L/28R, do not contain enough area for aircraft with departure clearance to taxi around aircraft on hold. Construction and expansion of the run-up/hold pads at the ends of the runways would improve the ability of departing aircraft to bypass those aircraft waiting for departure clearance.

Estimated 1992 project cost is $3.4 million.

Annual savings at the Baseline activity level would be 220 hours or $0.22 million, and, at Future 2 activity levels, 10,490 hours or $13.68 million.

11. Reconstruct/strengthen Taxiway G south of Runway 10R/28L.

This project would strengthen the Taxiway G pavement to support use by larger and heavier commercial aircraft. Taxiway G was originally Runway 13/31, which was designed to support general aviation aircraft. Runway 13/31 was closed in 1989 and converted to Taxiway G to provide a taxi route for general aviation aircraft and for larger commercial cargo aircraft to the south and east side of the airfield. The development of an air cargo area in the southeast quadrant of the airfield has necessitated the need to strengthen Taxiway G since the existing pavement was not designed to support the increased weights of these large cargo aircraft. This project will increase capacity by ensuring the unrestricted use of the strengthened Taxiway G, allowing for more taxi routes to the south and east airfield, decreasing taxi times, and minimizing taxiway congestion to and from the cargo area.

Estimated 1992 project cost is $1.4 million.

12. Build blast walls for engine runups to the north and south of Runway 28L.

Construction of an engine runup pad and blast fence is identified in the Part 150 Noise Compatibility Program to achieve compatibility with the surrounding community during the late evening and early morning hours commonly designated for aircraft engine maintenance runups.

Presently, engine runups for maintenance and equipment checks are performed on active apron areas and taxiways. Construction of runup pads and blast walls on the south edge of the terminal apron and in the south airfield east hangar line area would eliminate the need for closure of taxiways for engine runups and enable aircraft to taxi on the terminal apron without being blocked by aircraft performing engine runups. The two engine runup pads with blast fences would also help to reduce noise complaints due to regular engine maintenance runups performed in the late night and early morning hours.

Estimated 1992 project cost is $460,000.

Facilities and Equipment Improvements

13. Install Category I Instrument Landing System (ILS) on Runway 28R.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	—	123	514	1,078
$M	—	$0.17	$0.73	$1.53

Instrument flight rules (IFR) that restrict operations (IFR 1) occur about 11 percent of the time, and the impact of the associated delays can be significant. Installing an ILS on Runway 28R would, reduce visibility minimums and decision height to 200 feet for landings, enhance operational flexibility, and help to maintain capacity during Instrument Meteorological Conditions (IMC).

Estimated 1992 project cost is $2.6 million.

Annual savings at the Future 1 activity level would be 123 hours or $0.17 million, and, at Future 2 activity levels, 514 hours or $0.73 million.

14. Install centerline and touchdown zone lights and runway visual ranges on Runway 10R/28L.

The installation of centerline lights and three transmissometers (to provide runway visual ranges (RVRs)) on Runway 10R/28L would allow for takeoff minimums as low as 600 feet RVR. Most of the operational problems due to low visibility at CMH occur in the early morning hours when the bulk of the traffic is departures. In addition, installation of touchdown zone lights in the runway surface could reduce landing limits under CAT I conditions from 2,400 RVR to 1,800 RVR. The early installation of these aids would add considerably to airport reliability at modest cost and can be considered a prelude to a full CAT I ILS. If the ILS/Distance Measuring Equipment (ILS/DME) for Runway 10L were augmented with an ILS/DME for the Runway 10R/28L ILS system, they could be used to support noise abatement profiles and procedures for both arrivals and departures .

15. Install Category II ILS on Runway 10R/28L.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	328	1,369	3,331	5,624
$M	$0.42	$2.18	$4.72	$6.98

Instrument flight rules (IFR) that severely restrict operations (IFR 2) only occur about 1 percent of the time, but the impact of the associated delays can be significant. Installing Category II ILS equipment would further reduce visibility minimums for both arrivals and departures, enhance operational flexibility, and thereby help to maintain capacity during IMC. With Category II capability, the duration of IFR 2 operations could be reduced from 2 hours to approximately 1.5 hours, and arrival operations would be permitted for a longer period under IFR 1 procedures.

Certain structures within the building restriction line will have to be removed to meet the obstacle clearance criteria for CAT II ILS on Runway 10R/28L.

Estimated 1992 project cost is $12.9 million.

Annual savings at the Baseline activity level would be 328 hours or $0.42 million, and, at Future 2 activity levels, 3,331 hours or $4.72 million.

16. Install Precision Runway Monitor (PRM).

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	571	2,065	9,612	18,633
$M	$0.59	$2.71	$12.83	$24.82

The capacity of CMH 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. CMH's parallel runways are currently 2,800 feet apart.

A developmental program known as the Precision Runway Monitor has demonstrated that simultaneous independent parallel approaches can be conducted in all weather conditions on runways spaced less than 4,300 feet apart. This program relies on improved radar surveillance with higher update rates of aircraft positions and a new air traffic controller display system. When PRM equipment becomes available, installing it at CMH may allow simultaneous independent parallel ILS approaches to be implemented. National standards for simultaneous (independent) parallel approaches using the PRM to runways separated by 3,400 to 4,300 feet were published in November 1991.

17. Install Airport Surface Detection Equipment (ASDE).

Monitoring ground traffic flow during poor weather conditions is difficult and restricts the flow of ground traffic. ASDE is a short-range, high-resolution radar designed to support air traffic controllers in the monitoring and control of ground traffic.

The installation of ASDE would improve airport ground operations significantly during poor visibility conditions. ASDE would eliminate the need to rely totally on pilot position reports when aircraft are not visible from the airport traffic control tower (ATCT). In addition to the obvious safety benefits, it would reduce congestion and delays in the movement of ground traffic.

18. Install Distance Measuring Equipment (DME) on Runway 28L.

DME is used to measure, in nautical miles, the slant range of an aircraft from a navigation aid. At an airport, DME is commonly paired to the frequencies of a single or dual ILS system serving a runway and designated an ILS/DME. At CMH, a DME is paired to the single CAT I ILS system now serving Runway 10L. With the proposed addition of a CAT I ILS on Runway 28R, that existing DME will be paired with shared frequencies of both the ILS units serving the north runway, Runway 10L/28R.

At this time, the south runway, Runway 10R/28L, has a dual CAT I ILS system serving both directions, 10R and 28L, but has no DME paired to the shared frequencies. In order for some pilots to use the only DME located on the airport, they must tune one of their ILS receivers to the ILS frequencies of the north runway. Some aircraft are then capable of switching back to receiving the ILS cockpit presentation of the south runway with the DME of the north runway system locked on (not a true ILS/DME), but other aircraft are not. At best, this is not a desirable combination, and some airline aircraft can't properly use the DME for position awareness while making instrument landings on the south runway.

An additional DME should be installed on Runway 10R/28L. This would not only provide convenience in establishing position awareness for aircraft using the south runway, but also add greater redundancy in substituting position fixing for locator and marker positions in case of outages at those facilities. This would also greatly improve the possibilities of creating new arrival and departure intersections to expedite traffic flow and noise abatement profiles.

19. Construct new Airport Traffic Control Tower (ATCT).

Air traffic controllers are required to have a clear view of all operational surfaces in order to control traffic safely and efficiently. The current tower, built in 1954, is only 90 feet tall, and the cab has only 347 square feet of space. Given the airport and terminal layout in the past, this was sufficient. With the planned expansion of the terminal, the possible addition of runways, and additional taxiways, a taller ATCT in a new location with a larger tower cab would be very advantageous. Some of the proposed terminal expansions could cause "shadow" problems for the present tower.

Engineering analyses have determined that a new 180 foot tower, located to the west of the current location, at the western end of the short-term parking lot, would provide adequate visibility. This would also provide the opportunity to design a work environment to meet projected facility needs. The new tower, with 625 square feet of space, would provide for planned equipment additions and allow for additional positions as demand increases.

Estimated 1992 project cost is $13 million.

20. Install additional navigational aids (NAVAIDS).

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	634	941	3,159	3,085
$M	$0.76	$1.32	$4.48	$4.39

Modernization is planned for existing NAVAIDs in the area. The Appleton VOR (APE), which is currently operating with a deteriorated capability, is slated for upgrade to a doppler VOR in 1995 to correct this deficiency. It may be possible to expedite this upgrade into the 1994 schedule. Another VOR in the vicinity, Yellow Bud (XUB), is in the process of having DME added and being flight checked as a high-altitude facility. When these things are accomplished and a large airspace restriction to the southwest is removed in 1994, Columbus area airspace has the potential to be better organized, with the probability of new high and low altitude airways and additional arrival and departure points to enhance flow into and out of the airspace.

It is anticipated that the reductions in minimums for departures would reduce the duration of IFR 2 operations. The period of IFR 2 operations during which departures are held at the airport could be reduced from about 2 hours to 1.5 hours. Annual savings at the Baseline activity level would be approximately 634 hours or $0.76 million, and, at Future 2 activity levels, 3,159 hours or $4.48 million.

In addition, with the imminent use of the Global Positioning System (GPS) for approaches and the potential for GPS to provide precision approach capability, the future availability of a ground-based Differential GPS (DGPS) or "pseudo satellite" to serve the Columbus terminal area should be considered and encouraged.

Operational Improvements

21. Impact of noise reduction procedures.

The relaxation or modification of noise restrictions would benefit operations at CMH. Restrictions on the use of Runway 10L/28R by turbojet aircraft are presently in effect from 10 PM to 8 AM local time. These restrictions limit the airport's flexibility to use the runways in the most convenient and efficient manner. Under present day traffic demand, however, the impact is limited because traffic can be accommodated without undue delay.

Every effort should be made to encourage both noise reduction improvements and greater use of airport facilities in order to meet arrival and departure demand. Analysis of the data indicates that any reduction in delay that could occur from reducing the effect of noise restrictions is dependent upon the actual distribution of traffic within the hours specified. Time within the hour is significant in the delay encountered by each aircraft, and spreading traffic out during the evening and early morning hours reduces delay even at the higher activity levels.

As the activity level at the airport increases, the additional demand will necessitate the use of Runway 10L/28R, particularly when the extension to 8,000 feet is completed. Use of Runway 10L/28R will relieve any congestion on Runway10R/28L, decreasing the average delay for both arrivals and departures. Greater use of the runway could be accomplished by continuing the introduction of Stage III aircraft and allowing them to operate without restrictions during off-peak hours or by permitting unrestricted use of the runway during all hours of the day.

22. Provide 1.5 nm staggered approaches to Runways 10R/28L and 10L/28R in IFR.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	15	100	470	890
$M	$0.02	$0.14	$0.67	$1.26

Existing rules for dependent IFR operations require that the spacing between parallel runways be at least 2,500 feet and the diagonal separation between aircraft on adjacent approaches be at least 2.0 nautical miles (nm). The diagonal separation requirement places speed and in-trail restrictions on aircraft that reduce the arrival rate and operational flexibility of dependent parallel approaches, limiting the capacity increase associated with using two arrival streams. Demonstration programs have shown that this diagonal separation can be safely changed to 1.5 nm for runways at least 2,500 feet apart. This spacing would permit about four additional arrivals per hour.

Annual savings at the Baseline activity level would be 15 hours or $0.02 million, and, at Future 2 activity levels, 470 hours or $0.67 million.

23. Provide 2.5 nm in-trail separations between similar class aircraft.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	10	60	200	670
$M	$0.01	$0.09	$0.27	$0.92

Existing procedures for instrument flight rules (IFR) require that arriving aircraft be separated by 3 nautical miles 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. Most of the savings occurs at the highest demand levels under IFR, but, if the runway exits are not visible from the tower, the 2.5 nm separation cannot be applied.

Annual savings at the Baseline activity level would be 10 hours or $0.01 million, and, at Future 2 activity levels, 200 hours or $0.27 million.

24. Redistribute traffic more uniformly within the hour.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	1,310	1,955	8,500	9,340
$M	$1.32	$2.54	$11.09	$12.20

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, CMH is a part of hub-and-spoke operations, 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 savings at the Baseline activity level would be 1,310 hours or $1.32 million, at Future 1 activity levels, 1,955 hours or $2.54 million, and, at Future 2 activity levels, 8,500 hours or $11.09 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.

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

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 CMH. "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 in 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.

26. Conduct an airspace capacity design project and restructure Columbus area airspace.

Estimated Savings in Delay

Ops/Yr	Baseline	Future 1	Future 2	Future 3
Hrs	956	3,533	17,072	35,254
$M	$0.95	$4.53	$22.22	$45.79

The Capacity Team highly recommends a complete analysis of all of the airspace in the Columbus area. This analysis should include concepts of airspace restructuring that offer the potential for improving arrival and departure air route capacity in conjunction with area airport improvements. New technology and operating concepts need to be reviewed in an effort to improve flow-control procedures and reduce or eliminate miles-in-trail restrictions that exceed optimal aircraft spacing. The goal would be to ensure sufficient airspace capacity to fully utilize area airport surface capacity.

Particular emphasis should be placed on eliminating the departure fix restrictions at the airport. Providing alternative fixes for sequential departures rather than using run-up/hold pads would eliminate construction costs. The advantages of alternative departure fixes were substantial for all activity levels and all of the improved conditions. For example, operations without departure fix restrictions saved 17,072 hours of annual delay or $22.22 million at Future 2 activity levels with the extended runway improvement in place.

Section 3

Summary of Technical Studies

Overview

The Port Columbus International Airport 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 CMH. Details can be found in the data packages produced by the FAA Technical Center during the course of the study. Figure 10 shows airfield weather conditions, Figure 11 runway utilization, and Figure 12, runway configuration. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

The average direct operating cost (weighted by weather usage) for the fleet mix at CMH is indicated below. These figures represent the costs of operating the aircraft and include such items as fuel, maintenance, and crew costs, but they do not consider lost passenger time, disruption to airline schedules, or any other intangible factors.

	Cost per minute	Cost per hour
Baseline	$16.68	$1,001
Future 1	$21.44	$1,286
Future 2	$21.70	$1,302
Future 3	$21.58	$1,295

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. The Runway Delay Simulation Model (RDSIM) was 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 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 10. Airfield Weather

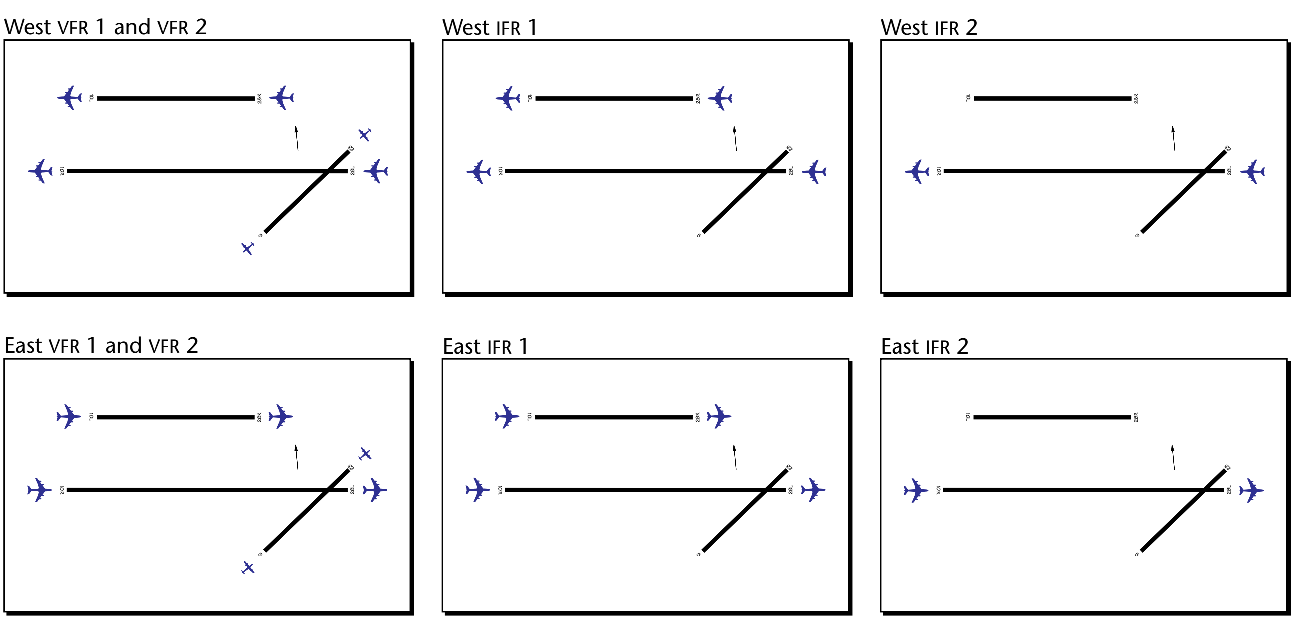
	Ceiling/Visibility	Occurrence (%)
VFR 1	2,500 feet and above/5 mi and above	85.2
VFR 2	1,000 to 2,500 feet/3 to 5 mi	3.6
IFR 1	200 to 1,000 feet/0.5 to 3 mi	10.7
IFR 2	below 200 feet/below 0.25 mi	0.5
	Total	100.0

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

Figure 11. Runway Utilization (percentage use)

	East Flow	West Flow	Total
VFR 1	36.6	48.6	85.2
VFR 2	1.6	2.0	3.6
IFR 1	4.8	5.9	10.7
IFR 2	0.2	0.3	0.5
Total	43.2	56.8	100.0

Figure 12. Runway Configuration



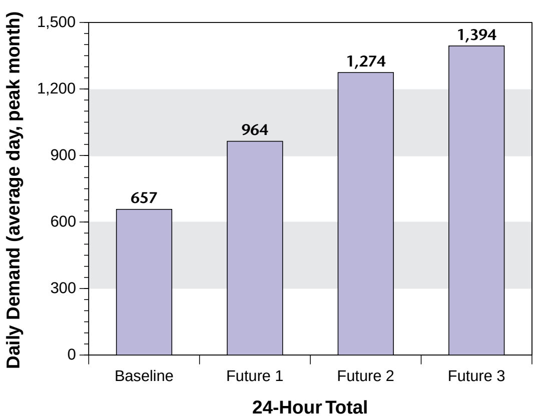
Airfield Capacity

The CMH 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 13 illustrates the average-day, peak-month arrival and departure demand levels for CMH for each of the four annual activity levels used in the study, Baseline, Future 1, Future 2, and Future 3.

Figure 13. Airfield Demand Levels



	Annual	24-Hour Day*	Peak Hour
Baseline	217,468	657	44
Future 1	319,084	964	68
Future 2	421,694	1,274	99
Future 3	461,414	1,394	108

* Average Day, Peak Month

Figure 14 presents the airport capacity curves for CMH. The curves were developed for the west flow runway configuration, under both visual flight rules (VFR) and instrument flight rules (IFR), with a 40/60, 50/50, and 60/40 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 14 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 15 illustrates the hourly profile of daily demand for the Baseline activity level of 217,468 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 421,694 aircraft operations per year.

Comparing the information in Figures 14 and 15 shows that:

- aircraft delays will begin to rapidly escalate as hourly demand exceeds 55 to 70 operations per hour, and,
- while hourly demand does not exceed 55 operations during the day at Baseline demand levels, 70 operations per hour is frequently exceeded at the demand levels forecast for Future 2.

Figure 14. Airport Capacity Curve — Hourly Flow Rate Versus Average Delay

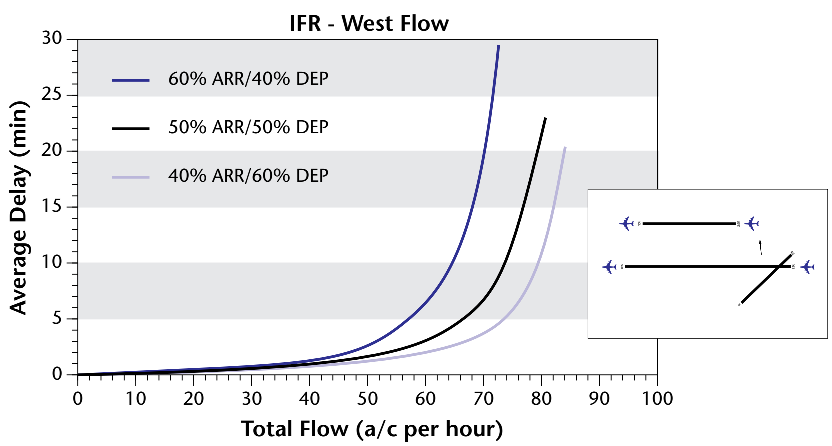


Figure 15. Profile of Daily Demand—Hourly Distribution

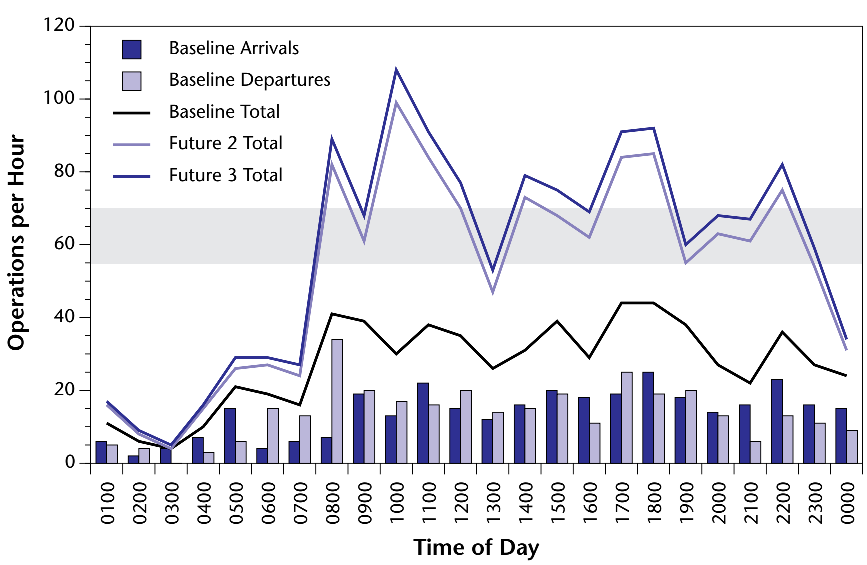
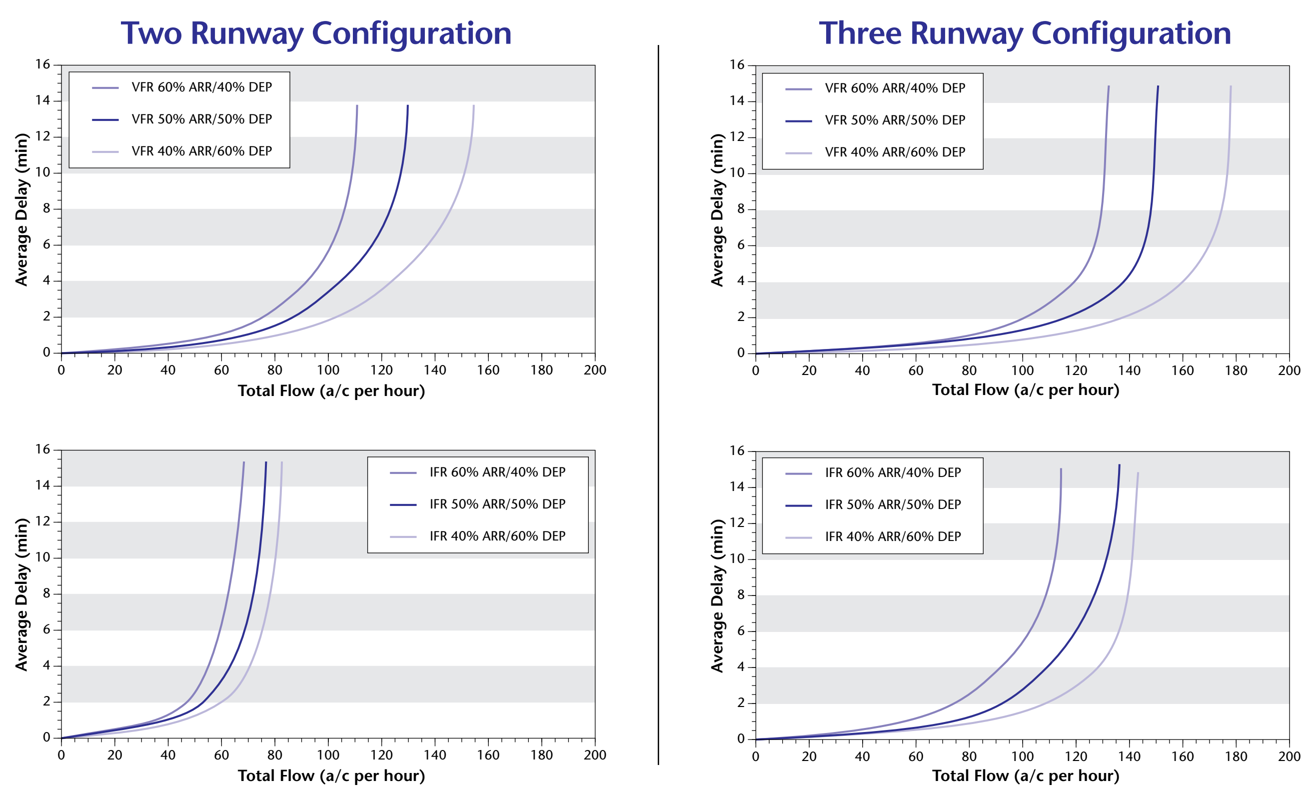


Figure 16 presents a summary of airport capacity curves under VFR and IFR for the existing, baseline airport configuration with two parallel runways and for a future airport configuration with three parallel runways. Each of these graphs includes three capacity curves that show the different ratios of arrivals to departures. In all cases, as the operational flow increases, the average delay per operation also increases. These curves can be used to determine the flow associated with a given level of delay. For example, with the baseline airport configuration under VFR, at an average delay of 5 minutes per operation with a 60/40 ratio of arrivals to departures, the flow is 95 operations per hour. For a 50/50 ratio of arrivals to departures, the flow at an average delay of 5 minutes per operation is 109 operations per hour. The maximum flow rates shown for each curve and the large average delay associated with these maximum rates indicate the situation that would occur as the maximum theoretical capacity is approached. By using this family of curves, one can interpolate between the curves to determine flow rates that can be achieved at different arrival and departure ratios. These curves also provide a graphic depiction of the relationship between achievable flow rates and resulting delay.

Figure 16. Airport Capacity Curves — Hourly Flow Rate Versus Average Delay



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. If no improvements are made in airport capacity, the average delay per operation of 0.8 minutes in Baseline will increase to 5 minutes per operation by Future 2.

Under the Do Nothing situation, if there are no improvements in airfield capacity, the annual delay cost could increase as follows:

	Annual Delay Costs	
	Hours	Millions of 1992 $
Baseline	2,710	$2.72
Future 1	8,760	$11.33
Future 2	34,900	$45.79
Future 3	62,170	$81.48

Conclusions

Figure 17 demonstrates the impact of delays at Port Columbus 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, first with an emphasis on improvements that are likely to be completed by the Future 1 level of operations and second with an emphasis on Future 2, that the greatest savings in delay costs would be provided by:

- Installing Category I ILS on Runway 28R.
- Extending Runway 10L/28R to 8,000 feet.
- Building run-up/hold pads at all air carrier runway ends.
- Building one-way crossover taxiway at west end.
- Building two-way crossover taxiway at west end.
- Installing additional NAVAIDs.
- Installing Category II ILS on Runway 10R/28L.
- Building third parallel runway 800 feet south of Runway 10R/28L.
- Building fourth parallel runway 650 feet north of Runway 10L/28R*.
- Conducting an airspace capacity design project — eliminating departure fix restrictions.

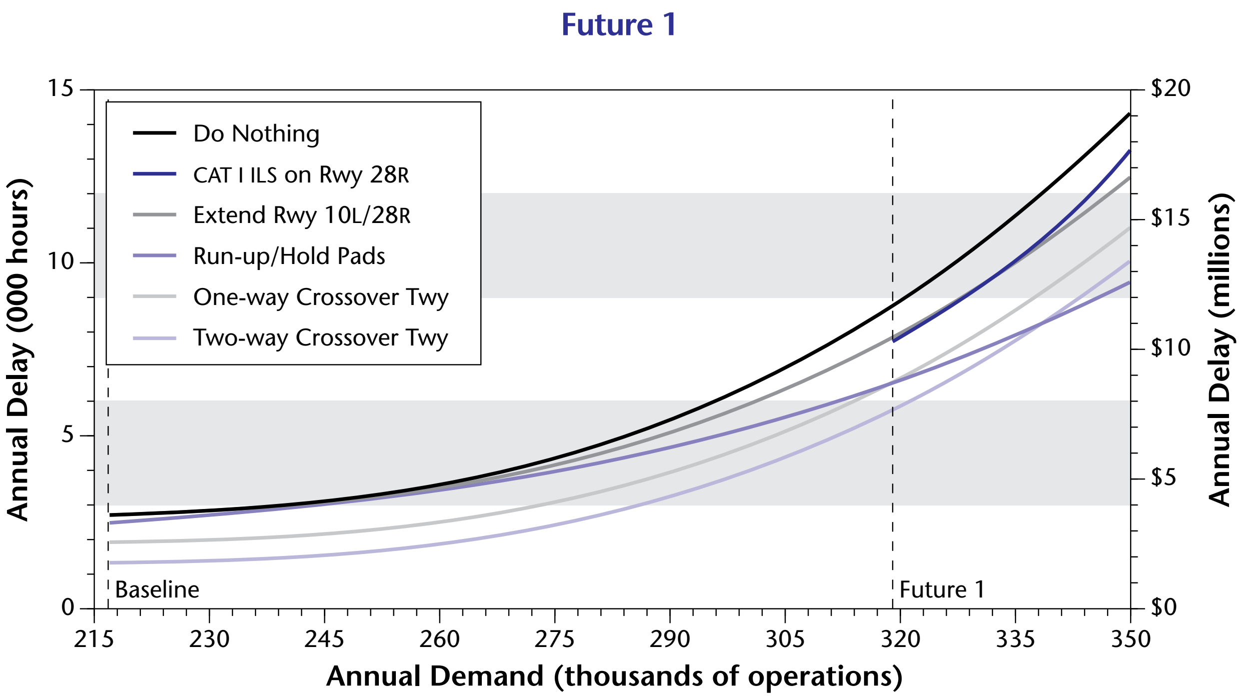
* Note: The delay savings for the fourth parallel runway include the delay savings for the third parallel runway.

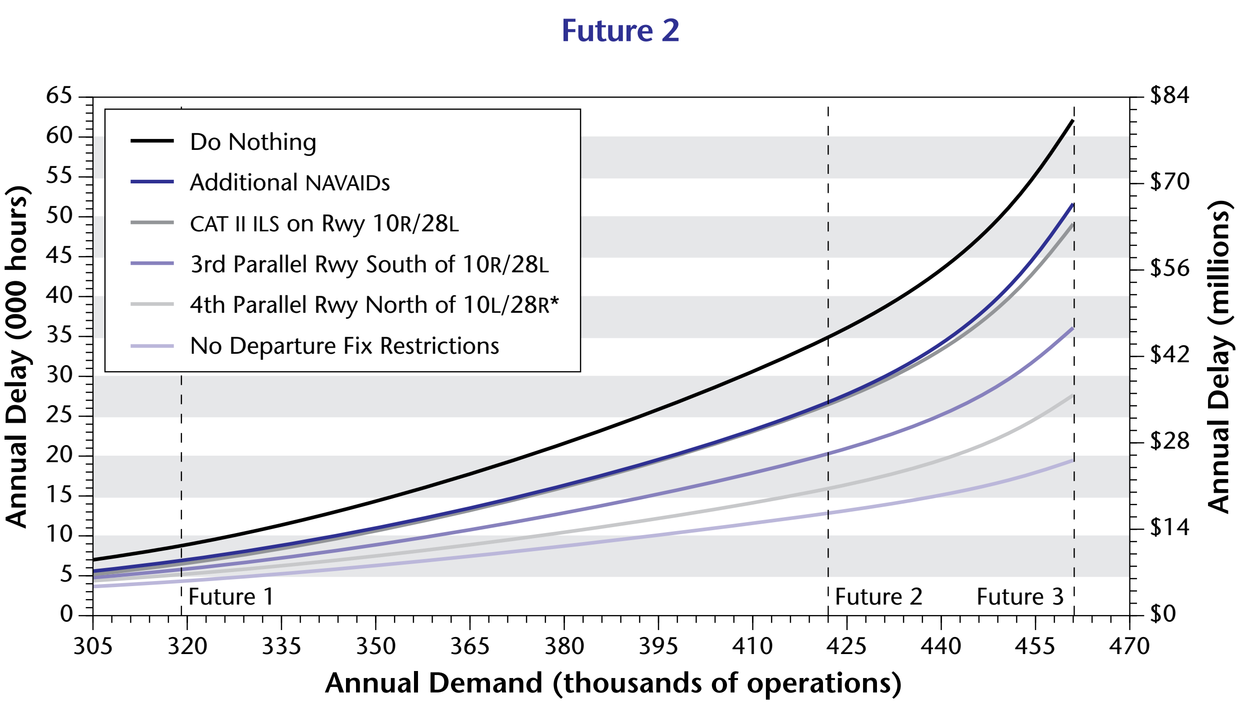
Figure 18 illustrates the average delay in minutes per aircraft operation for these same alternatives. Under the Do Nothing alternative, if there are no improvements made in airfield capacity, the average delay per operation of 0.8 minutes at the Baseline level of activity will increase to 5 minutes per operation by Future 2.

Figure 19 compares the average delay in minutes per aircraft for the Do Nothing case to the effect of introducing the noted improvements at Future 1, Future 2, and Future 3 levels of demand. This figure demonstrates that, by implementing these improvements during the recommended time frame, the airport would continue to operate below a 4.0 minute average delay even as demand increased through the Future 3 level of 461,414 operations per year.

Figure 20 illustrates the annual delay-savings benefits for each alternative and for each of the four annual activity levels. It serves to highlight the alternatives that will provide the major delay-savings benefits.

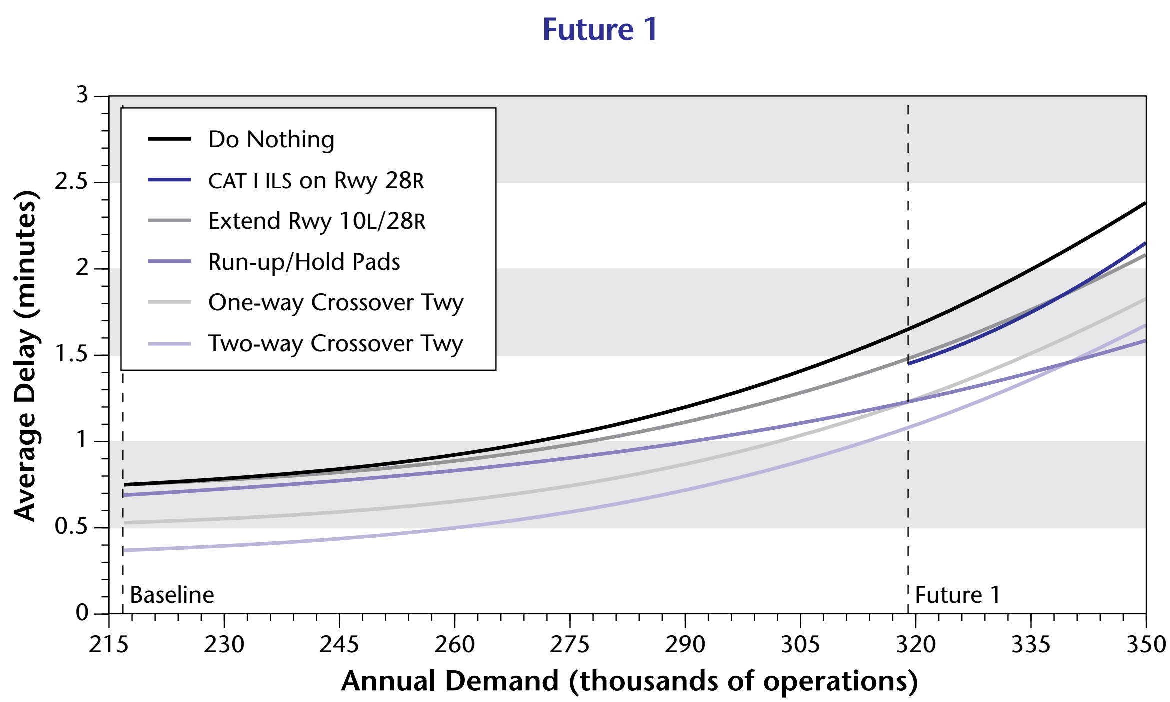
Figure 17. Annual Delay Costs — Capacity Enhancement Alternatives

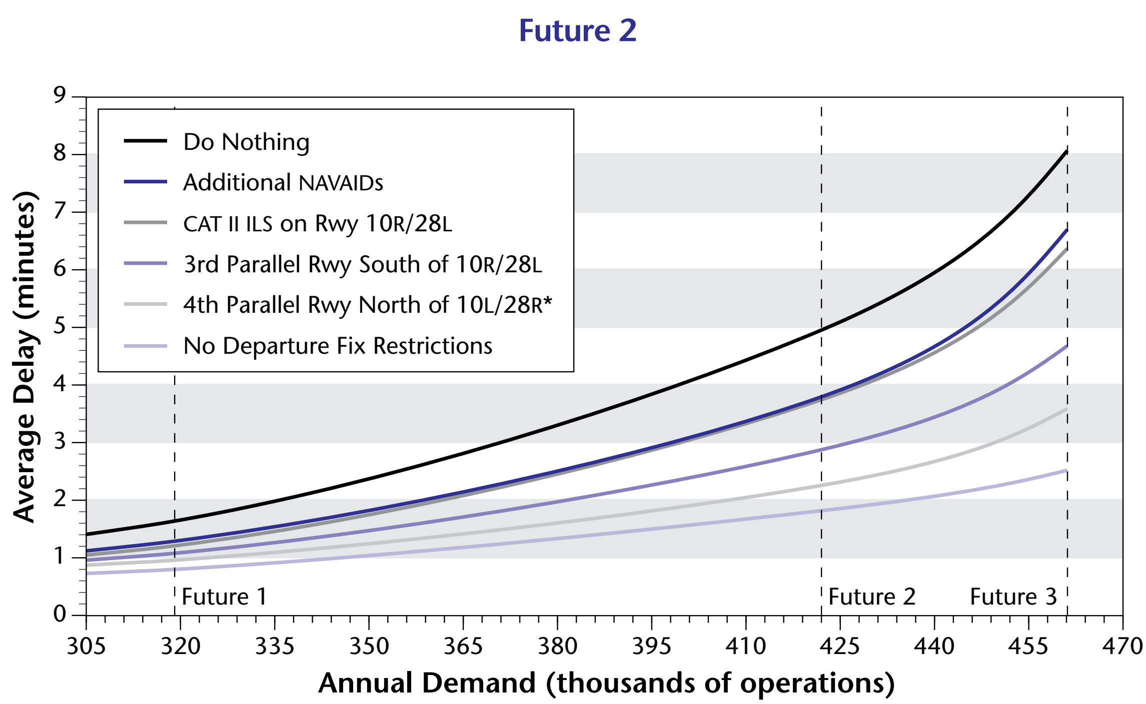




* Note: The delay savings shown for the fourth parallel runway include the delay savings for the third parallel runway.

Figure 18. Average Delays — Capacity Enhancement Alternatives





* Note: The average delays shown for the fourth parallel runway include the average delays for the third parallel runway.

Figure 19. Average Delay — Possible Capacity Enhancement Improvements

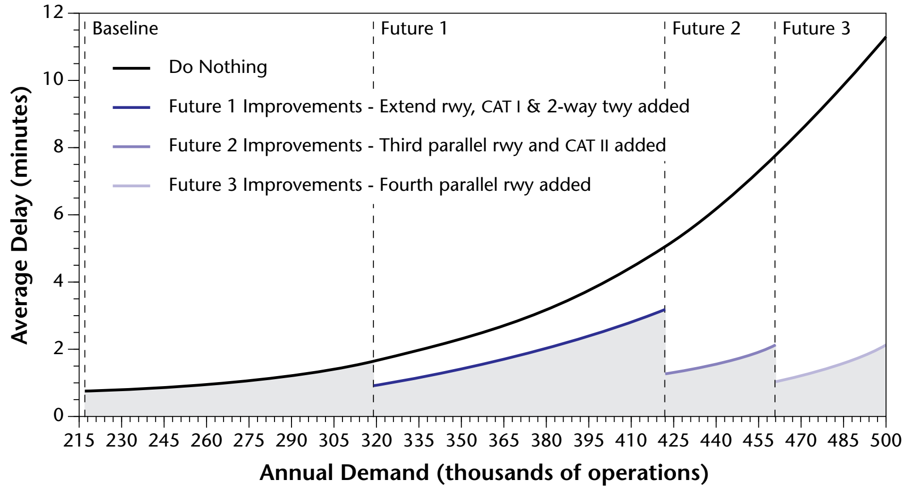
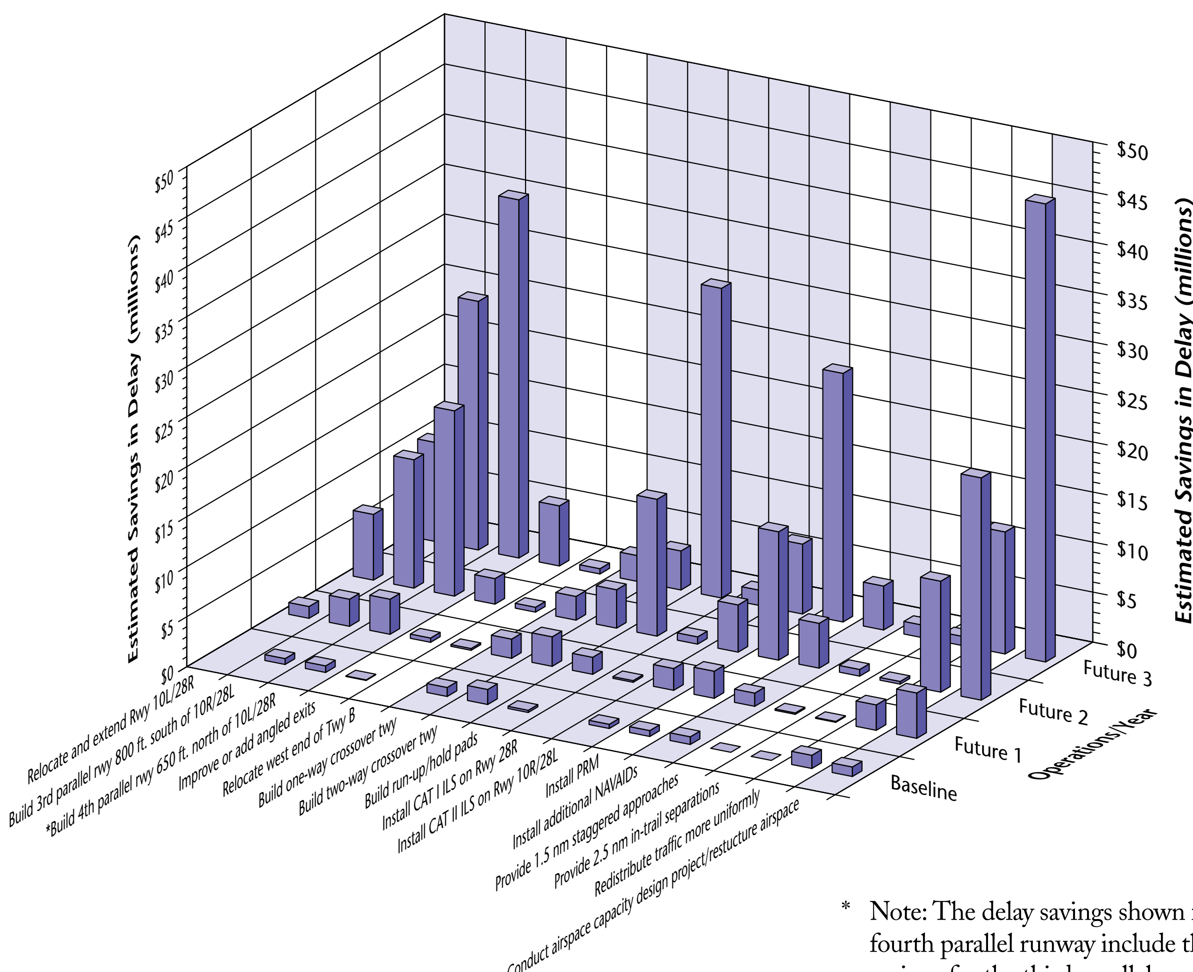


Figure 20. Annual Delay-Saving Benefits—Capacity Enhancement Alternatives



* Note: The delay savings shown for the fourth parallel runway include the delay savings for the third parallel runway.

Appendix A

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Appendix B

Computer Models and Methodology

The CMH 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

Airfield Delay Simulation Model (ADSIM)

This 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 CMH 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 delay 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.

For a given demand, the model calculates 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.

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 with the Do Nothing case and the Extended Runway case.

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

Appendix C

List of Abbreviations

ADSIM .... Airfield Delay Simulation Model
ALS .... Approach Light System
APE .... Appleton VOR
ASC .... FAA, Office of System Capacity and Requirements
ASDE .... Airport Surface Detection Equipment
ATC .... Air Traffic Control
ATCT .... Airport Traffic Control Tower
BC .... Back Course
CMH .... Port Columbus International Airport
DGPS .... Differential Global Positioning System
DME .... Distance Measuring Equipment
FAA .... Federal Aviation Administration
FAR .... Federal Aviation Regulation
GA .... General Aviation
GVGI .... Generic Visual Glide Slope Indicators
HIRL .... High-Intensity Runway Lights
IFR .... Instrument Flight Rules
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions
LOC .... Localizer
MALSR .... Medium-Intensity ALS with RAIL
MI .... Miles
MIRL .... Medium-Intensity Runway Lights
MLS .... Microwave Landing System
NAVAID .... Navigational Aid — aviation navigation facility
NDB .... Non-Directional Beacon
NM .... Nautical miles
NPIAS .... National Plan of Integrated Airport Systems
PRM .... Precision Runway Monitor
RAIL .... Runway Alignment Indicator Lights
RDSIM .... Runway Delay Simulation Model
REIL .... Runway End Identifier Lights
RVR .... Runway Visual Range
RWY .... Runway
TWY .... Taxiway
VASI .... Visual Approach Slope Indicator
VFR .... Visual Flight Rules
VHF .... Very High Frequency
VMC .... Visual Meteorological Conditions
VOR .... VHF Omnidirectional Range — course information only
XUB .... Yellow Bud VOR

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