Boston Logan International Airport

Airport Capacity Enhancement Plan

October 1992

Boston Logan International Airport

Airport Capacity Enhancement Plan

October 1992

FEDERAL AVIATION ADMINISTRATION

Figure 1 Boston Logan International Airport
Figure 2 Summary of Recommendations

Figure 1 Boston Logan International Airport

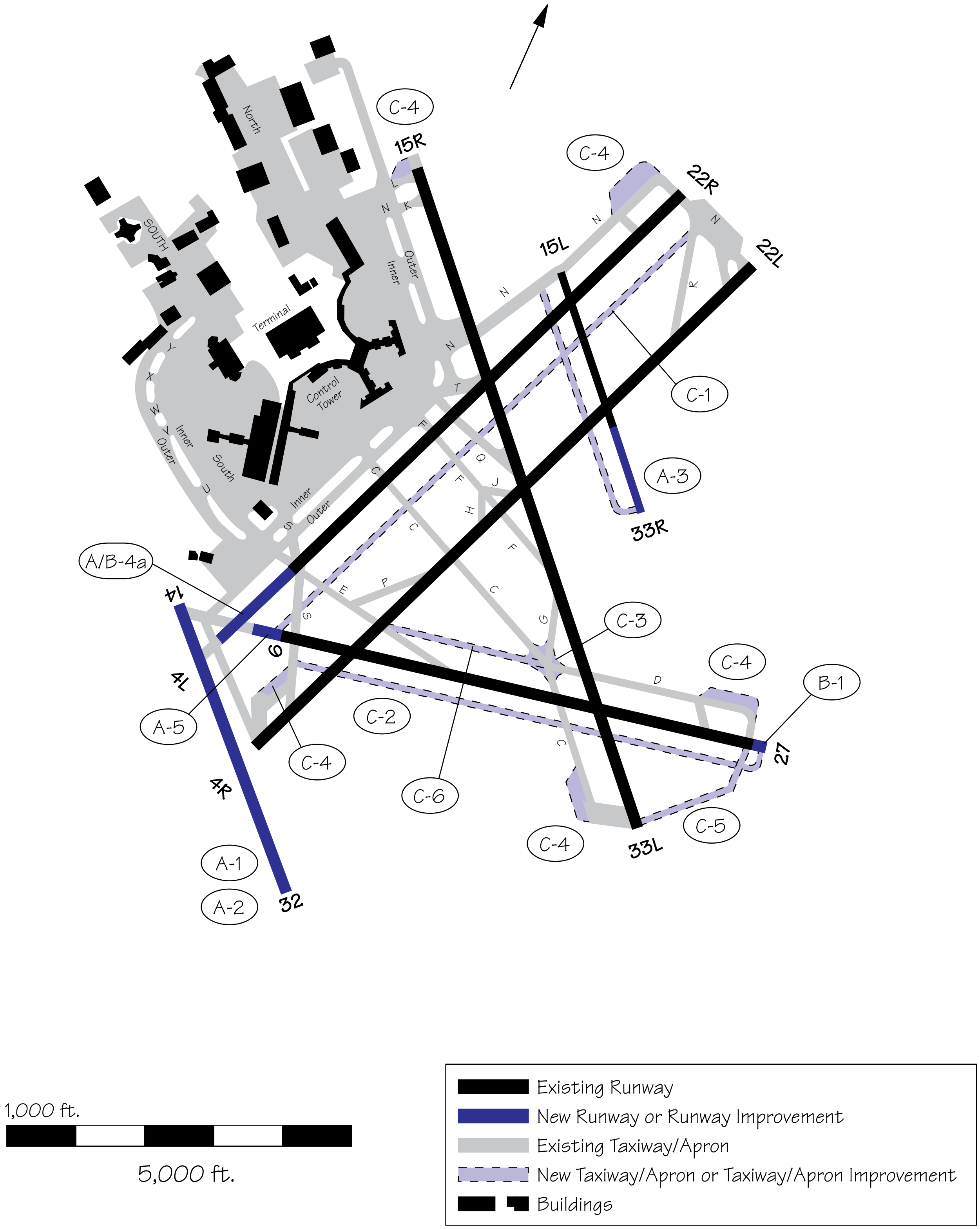


Figure 2 Summary of Recommendations

		Estimated Savings in Delay (000 hrs)			
Strategy	Alternative Description	412, 000 ops/year	450,000 ops/year	504,000 ops/year	Status
Strategy A: Separation of Small And Jet Aircraft Operations					
A-1	New commuter Rwy 14/32, unidirectional.	33.6	81.3	171.4	Further Study
A-2	New commuter Rwy 14/32, bi-directional.	34.8	86.0	193.1	Not Recommended
A-3	Extend Rwy 15L/33R to 3,500' with new taxiway.	34.9	85.0	178.4	Further Study
A-3a	Combine alternatives A1 and A3.	34.0	84.4	178.4	Not Recommended
A-3b	Combine alternatives A2 and A3.	34.4	85.1	181.9	Not Recommended
A/B-4	Removal of noise restrictions on arrivals on Rwy 22R.	0.332	0.255	0.6	Not Recommended
A-5	400' extension of Rwy 9 for commuters to hold short of Rwy 15R.	1.8	5.6	12.9	†
A-6/D-2	Application of MLS technology with new procedures.		see narrative		†
A-7	Simultaneous parallel approaches to Rwy 33L, circle to Rwy 4L.	1.5	0.0	0.0	†
Strategy B: Expand The Number of Rwys For Simultaneous Jet Operations					
B-1	East extension Rwy 27, hold short of Rwy 22L, daylight, VFR.	0.089	0.12	0.5	Not Recommended
B-2	Simultaneous approaches to Rwys 4R, 4L, 22R & 22L < VFR 1 cond's.	15.1	30.0	30.2	†
B-3	Simultaneous IFR approaches to Rwys 27, 22L, 4L & 33L.	2.1	4.0	4.5	†
A/B-4	Removal of noise restrictions on Rwy 4L departures.	0.332	0.255	0.6	Not Recommended
A/B-4a	Remove noise restrictions on Rwy 4L & extension to Twy B.	0.2	0.2	0.6	Not Recommended
B-5	Side step approaches from Rwy 4R to Rwy 4L.	1.6	0.7	0.0	Further Study
B-6	Utilize fan headings for aircraft departing Rwys 22L & 22R.	1.9	2.7	6.2	Not Recommended
B-7	Use of hold short procedures Rwys 15R, 22L, & 33L.	3.2	8.3	17.9	†
Strategy C: Improve Taxiway Circulation					
C-1	New parallel taxiway between Rwys 4L/22R & 4R/22L.		see narrative		Massport is currently pursuing a comprehensive system analysis of the taxiway system using a simulation model to improve taxiway efficiency and reduce the potential for runway incursions.
C-2	New south exit parallel taxiway for Rwy 27.		see narrative		
C-3	Add fillets at intersection of Twys D and C with Rwy 15R/33L.	0.061	0.104	0.156	
C-4	Staging areas for Rwys 15R/33L, 27, 4R, 22R and 33L/Twy G.	0.75	0.83	1.6	
C-5	New taxiway from the end of Rwy 27 to the end of Rwy 33L.				
C-6	Extend Twy D to Rwy 4R/22L.		see narrative		
Strategy D: Lowering Approach Minimums					
D-1	Install CAT II/II ILS on Rwys 15R, 22L, 27, and 33L.	1.1	1.3	1.7	†
A-6/D-2	Utilization of Microwave Landing Systems (MLS) technology.		see narrative		†
D-3	Reduce min's to 250' & 3/4 mi on Rwy 22L for CAT I approaches.		see narrative		†
Strategy E: Demand Management Policies					
E-1	Increase the % of large and heavy jets in the fleet mix.	0.6	0.8	2.7	Not Recommended
E-2	Redistribute airline schedules within the hour.	8.2	20.7	28.4	Not Recommended
Strategy F: Develop More Efficient Use of The Airspace					
F-1	Improve metering and spacing and segregate heavy jets.	1.8	2.8	3.2	Not Recommended
F-2	Benefit of Vortex Advisory System	12.8	20.9	24.2	†
F-2a	Benefit of Wake Vortex Avoidance System	17.7	29.6	41.1	†

† Will proceed toward implementation, unless otherwise noted.

Executive Summary

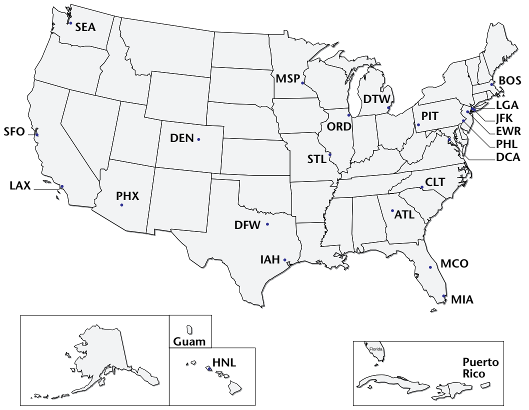
Background

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

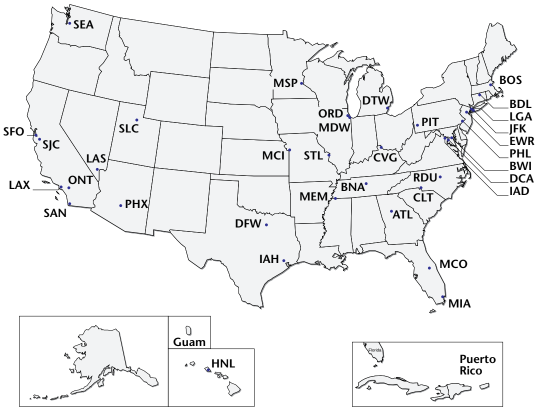
By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity and Requirements (ASC).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

In 1985, the FAA initiated a renewed program of local Airport Capacity Design Teams at forecast delay-problem airports. Each Capacity Team 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.



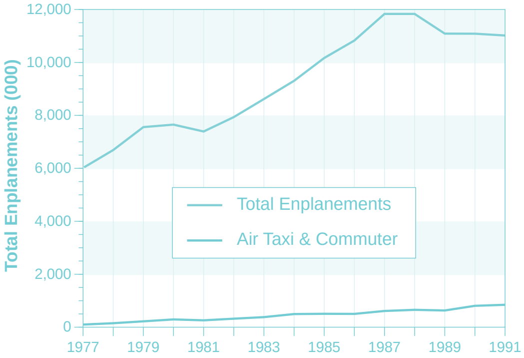
Airports Exceeding 20,000 Hours of Annual Delay in 1991



Airports Forecast to Exceed 20,000 Hours of Delay in 2001, Assuming No Capacity Improvements

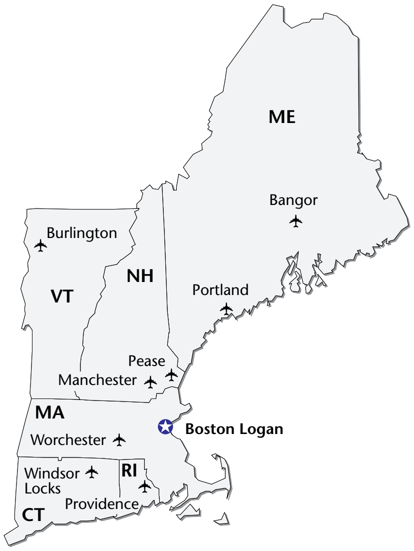
Logan International Airport – Capacity and Delay

In FY1991, Boston's Logan Airport enplaned nearly 10.7 million passengers. From 1980 to 1991, passenger enplanements grew at an average of 3.5 percent per year. While enplanements have decreased during the recent recession and the Gulf War period, resumption of a 3.5



percent rate of growth would result in approximately 19 million enplanements by the year 2007.

Logan's Airport Modernization Program (LAMP) assumes that passenger growth will be accommodated through the use of larger size aircraft, reduction in the proportion of operations by smaller regional commuter aircraft, flattening of demand peaks, and significant enhancements to air traffic control technology. LAMP does not include any additions to the runway and taxiway systems. The primary objectives of LAMP are to improve access to the airport, expand gate capacity, and improve processing of international passengers.

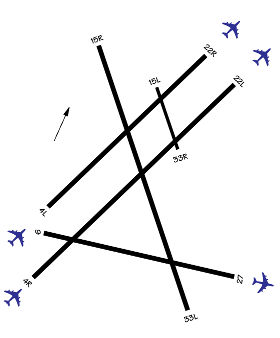


The other major air carrier airports in the New England region — Portland, Bangor, Manchester, Worcester, Windsor Locks/Bradley, Providence, and Burlington — have been growing rapidly since the deregulation of the airline industry and the evolution of the national hubbing system. However, Logan has maintained the dominant role in providing the region with access to the national and international air transportation system. During the eighties, there was a rapid expansion in the number of commuter aircraft operating between Logan and the outlying airports throughout New England. As a result, there has been a steady increase in total aircraft operations even though passenger enplanements have actually declined during certain periods.

Best Case

Configuration 1 - VFR

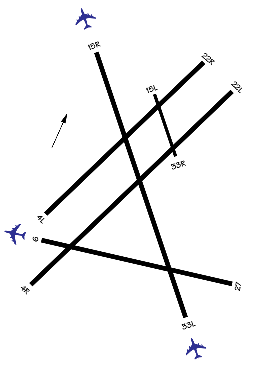
120 ops/hr w/40% arrivals



Worst Case

Configuration 3 - VFR 2/IFR 1

46 ops/hr w/60% arrivals



The 1980's saw historically high delays at Logan. From 1986 through 1990, an average of 4.4 percent of all operations were delayed for fifteen minutes or more.[1] Fluctuations in weather and loss of runways and NAVAIDs for repairs or other reasons may result in changes in annual delay from year to year. In the long run, factors such as airfield capacity, terminal and en route airspace congestion, aircraft fleet mix, and the concentration of operations within peak hours establish trends in delays.

When weather conditions reduce visibility to Instrument Flight Rules (IFR) operations, separations between aircraft must be increased. In addition, Logan is

---

[1] Statistics are available only for delays greater than fifteen minutes. Total impact of delay is actually greater than these statistics indicate.

limited by the lack of parallel runways with adequate spacing between them for simultaneous IFR approaches. All landing aircraft must be sequenced into a single arrival stream. Logan's hourly flows can decrease from 120 operations per hour under Visual Flight Rules (VFR) to 46 operations per hour under the most restrictive IFR operations.[2] Typical peak hour demand at Logan is 100 operations per hour.[3]

When weather conditions restrict operations to a single arrival stream, the relatively high proportion of commuter aircraft operations at Logan lowers the airport's effective capacity. The least amount of in-trail separation is required between two small aircraft. When smaller aircraft follow heavy jets, much greater spacing is required to avoid the hazards of wake turbulence. In addition, controllers must use increased spacing to ensure that the slower small aircraft are not overtaken by the faster jet aircraft. Generally, runways are most efficient when their use is limited to aircraft of similar size and approach speeds.

In summary, any systematic approach to reducing delays at Logan must:

- provide for separate arrival streams for smaller commuter aircraft and larger jet aircraft;
- develop new approach procedures that can safely reduce the required spacing between dependent runways in IFR and marginal VFR weather, including the use of new air traffic, aviation, navigation, and radar technologies;
- increase the overall efficiency of the runway and taxiway system by properly locating exits, departure queues, and bypasses, etc. (This reduces runway occupancy times, provides controllers with greater flexibility in managing departure queues, and reduces interference at runway and taxiway crossings.); and
- consider demand management programs to use the airport's capacity more efficiently.

---

2. Hourly flow rates were based on a Massport Report, *Airfield Capacity Analysis for Boston-Logan International Airport,* Flight Transportation Associates, Inc., November, 1982, Table 10-1.

3. Cohen, Dayl, "Revised CHART Forecasts," technical memorandum included in *Passenger Forecasts for Logan International Airport,* July, 1991.

Physical Considerations

Logan Airport lies at the edge of Boston Harbor, two miles from downtown Boston. It is surrounded by water on three sides. On the fourth side are the residential and commercial town of East Boston and, across a narrow strip of water, the seaside residential area of Winthrop. Community sensitivity to airport noise, combined with a regional sensitivity to preserving the current coastline,[4] have precluded any expansion of Logan's land area beyond its existing property lines and low water mark. The only possible site for a new runway lies in an area of the airport known as Bird Island Flats. A 1974 federal court order stopped the preparation of the site for a new Runway 14/32 in response to litigation filed by local citizens, the City of Boston, the State Attorney General, the State Secretary of Transportation, *et al.*

The Airport Capacity Design Team

An Airport Capacity Design Team for Logan was established in 1987 and included representatives of Massport, Federal Aviation Administration's major operating divisions—Air Traffic, Flight Standards, Airports, and Airway Facilities, FAA's Technical Center and Office of System Capacity and Requirements, Massachusetts Aeronautics Commission, Massachusetts Executive Office Of Transportation and Construction, the Air Transport Association, Delta Airlines, Pan American Airlines, American Airlines, Piedmont Airlines (USAir), Eastern Airlines (Continental), Aircraft Owners and Pilots Association, Transportation Management Associates, and Computer Resource Management, Inc.

---

[4] Harbor line may only be changed by state legislation.

The Capacity Team conducted almost two dozen full-day meetings and reviewed 18 technical interim reports produced by the FAA's Technical Center. The Technical Center spent four work-years in developing and refining a computer simulation of Logan. They analyzed more than 20 different alternatives with the potential to increase capacity and reduce delay, typically for nine different combinations of weather and demand, with some repeated for a variety of runway configurations.

The Capacity Team members considered the technical and philosophical issues regarding the design of the alternatives to be analyzed, the appropriate method to estimate savings in annual delay, the interpretation of the simulation results, and the recommendations. Recommendations were finally developed that reflect the results of the technical analysis and remain within current policy of all members.

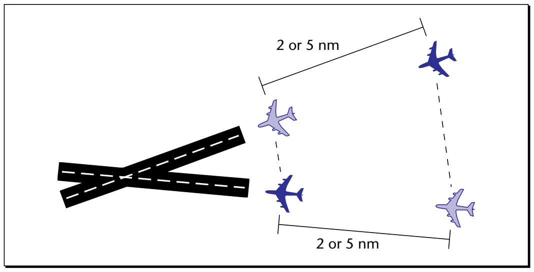
Conclusions

Computer modeling indicated that either developing a new commuter Runway 14/32, with uni- or bidirectional operations, or adequately extending the existing shortest Runway 15L/33R would reduce current delays by about 50 percent and future delays by about 70 percent. None of the other alternatives or combinations of alternatives provided this level of savings. However, given the existence of a permanent court injunction against construction of Runway 14/32 and Massport's opposition to developing the runway, this alternative may be very difficult to implement.

Note: Unidirectional operations of Runway 14/32 would result in arrivals from over the harbor and departures out over the harbor. Bidirectional operations are the more conventional use of runways, with both ends of the runway available for arrivals and departures.

Other alternatives that could contribute to reducing delays included: using new technologies to reduce required aircraft separation for wake turbulence; establishing dependent simultaneous IFR approaches; modest depeaking of airline schedules within the same hour; and developing hold-short procedures on the current runway pavement, but with some adjustment to the displaced thresholds.

Adjustment of airline schedules within the hour could provide about an 11 percent reduction in delays at Logan. Given the Airline Transport Association's (ATA's) opposi-



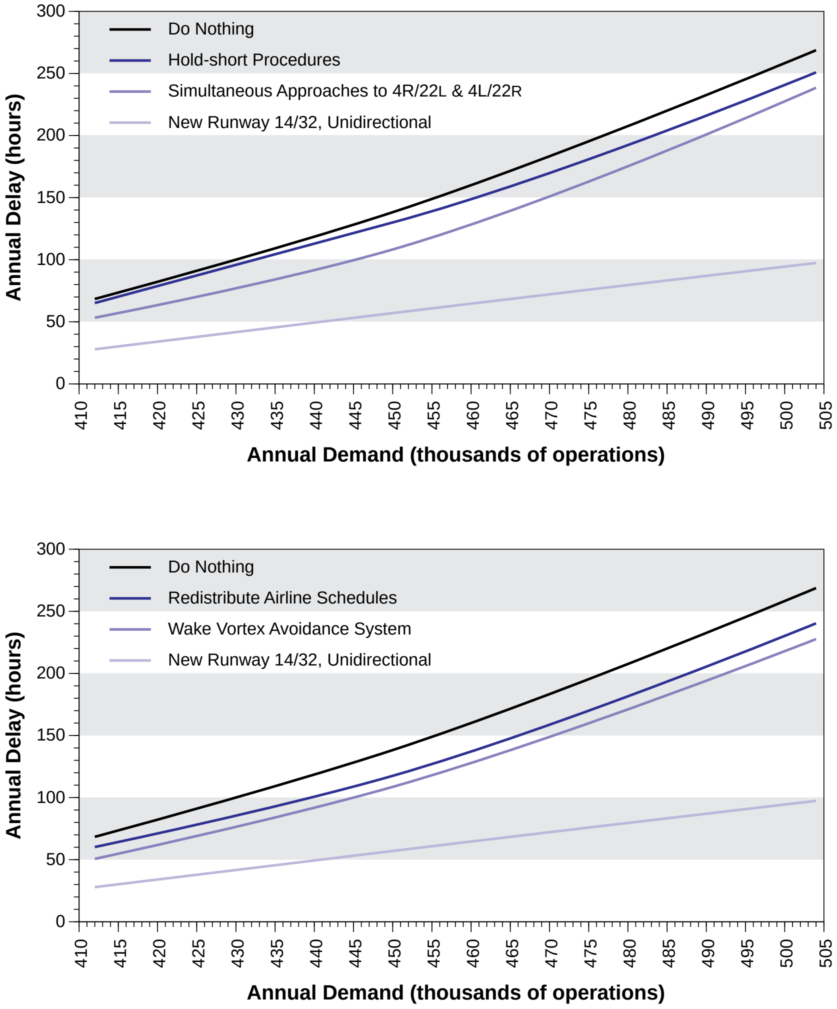
Dependent Converging IFR Approaches Using CRDA (Ghosting Techniques) tion and the lack of clear authority for airports to regulate airline schedules, this alternative may is not being recommended at this time.

The taxiway system was not modeled in this effort. However, as a result of their examination of limitations on some runways due to taxiway access, the Capacity Team recommended that Massport undertake a comprehensive taxiway study to develop a more efficient taxiway system and to reduce confusion which can contribute to runway and taxiway incursions.

The following figure shows how delay could continue to grow at a substantial rate as demand increases if there are no improvements in airfield capacity, i.e., the "Do Nothing" scenario. Annual delay costs would increase from 68,400 hours with 412,000 operations per year to 268,700 hours with 504,000 operations per year.

The figure also illustrates that significant savings in hours of annual delay would be provided by:

- Constructing a unidirectional Runway 14/32.
- Installing a Wake Vortex Avoidance System.
- Developing simultaneous dependent IFR approaches to Runway 4R/22L and 4l/22R.
- Redistributing airline schedules within the hour.
- Developing hold-short procedures for Runways 9/27, 15R, 22L, and 33L.



Potential Annual Delay Savings of Major Alternatives

Recommendations

These recommendations are based primarily on the Capacity Team's analysis of alternatives that have the potential to reduce aircraft delays. They are intended only to provide guidance for future planning. They do not represent any change in the policies of the participating member agencies.

- The Capacity Team recognizes the appropriate responsibility of the Massport Board of Directors to establish policy which balances airport development requirements with other regional and community concerns. In view of the significant benefits of constructing a unidirectional Runway 14/32 shown by their analysis, the Capacity Team recommends that the FAA and Massport staffs develop the appropriate technical and environmental analyses to provide a factual basis for a re-examination of the current policy opposing the construction of this runway.
- The FAA and Massport will continue to monitor the progress of development of new technologies for reducing separation requirements for wake turbulence (the Vortex Advisory System and the Wake Vortex Avoidance System) and take whatever initiatives are practical to implement this technology at Logan.
- Members of the Capacity Team will support Logan's candidacy for installation of equipment to support dependent simultaneous IFR approaches.
- No specific demand management measures are recommended at this time, though such measures can result in delay reductions. The Capacity Team supports the development of appropriate technical and economic studies to guide any future policy considerations in this area.
- The FAA should develop hold-short procedures for Runways 9/27, 15R, 22L, and 33L. These procedures would add new independent arrival streams for specific configurations and weather conditions.
- The Capacity Team recommends that Massport conduct a comprehensive analysis of the taxiway system to improve the efficiency of airfield operations.

Table of Contents

Background

The Role of the FAA in Airport Capacity Enhancement

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

By 1984, the 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 an acceptable level of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of local Airport Capacity Design Teams at forecast delay-problem airports. Each Capacity Team works to develop a coordinated action plan for reducing airport delay. Over 30 Airport Capacity 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 FAA Technical Center

The FAA Technical Center's Aviation Capacity Branch provides technical and analytic support to all of the Airport Capacity Teams. Their computer models use traffic, weather, and runway configuration data to calculate hours of aircraft delay for base case and future levels of demand, with and without airport improvements. The Technical Center was able to draw on its experience from capacity enhancement analyses at airports nationwide during the work of the Logan Capacity Team.

Logan International Airport

Boston-Logan International Airport lies at the edge of Boston Harbor, two miles from downtown Boston. It is surrounded by water on three sides. On the fourth side are the residential and commercial town of East Boston and, across a narrow stretch of the harbor, the seaside residential area of Winthrop.

Logan has four long runways, which are capable of handling all of today's large transport aircraft. Three of these runways are fully instrumented. Since 1956, the airport has been owned and operated by the Massachusetts Port Authority (Massport).

1. Traffic Growth

Over the last twenty years, passenger traffic at Logan International Airport has grown at an average annual rate of 4.7 percent. From 1980 to 1991, the average rate was 3.5 percent. In 1990, 22.8 million passengers moved through the airport.

In recent years, passenger traffic has faltered. In 1991, as a result of the combined effects of a recession and the Gulf War, passenger enplanements dropped 7 percent below the peak year of 1988. However, if the former 3.5 percent annual growth rate is re-established, passenger demand could reach 37.5 million by 2008.

In the meantime, the number of flight operations, which is a more appropriate measure of demand on the airside of the field, has grown at an annual average rate of 2.4 percent over the past 20 years and 3.6 percent over the last 10 years. Because Logan has been developing into a commuter hub for northern New England, the increase in commuter flight operations has been greater than that of other flights, with the result that the average passengers-per-flight has remained steady, or even declined. Despite the tapering off of passenger growth in the last three years, the number of commuter flight operations has continued to rise.

Over the years, many estimates have been made of when Logan would reach its capacity. Somehow, the Airport has always been able to accommodate demand beyond what theory would suggest was its limit. However, by the end of the eighties, it was clear to an increasing number of passengers that congestion and delay at Logan were growing worse.

2. Logan's place in the Regional Airport System

Logan is part of a regional airport system that also includes the airports serving Hartford, Hyannis, Manchester, Portland, Providence, and Worcester. But Boston is the population center of the region, so Logan dominates this seven-airport system, with 70 percent of the passengers. This share has been decreasing slightly over the years because of more robust growth at the smaller airports. However, there is some evidence that the current recession has had a greater dampening effect on traffic at these airports than at Logan. Historically, these airports have had a modest increase in their share of the total regional market, but are generally constrained physically from significantly expanding their capacity. It is unlikely that future congestion at Logan can be substantially relieved by the regional airports.

The Boston Airport Capacity Design Team

In response to an FAA initiative, the Logan Capacity Team began to coalesce in the summer of 1987 with a number of informal meetings. The first official meeting was in September 1987, and its seventeenth and last formal meeting was on April 11, 1990. Since then, there have been several informal meetings to discuss the contents of the report.

The composition of the Capacity Team changed over the three years of its existence, but its key members came from:

- The FAA New England Regional Office, Burlington, MA
- The FAA Office of System Capacity and Requirements, Washington, DC
- The FAA Technical Center, Atlantic City, NJ
- The FAA Airport Air Traffic Control Tower, Logan International Airport
- The Massachusetts Port Authority (Massport)
- The Air Transport Association of American, Eastern Region
- Computer Resource Management, Inc.
- Representatives of the individual airlines serving Boston
- Transportation Management Associates

Strategies for Reducing Aircraft Delay

The Logan Capacity Team and the Technical Center staff generated a list of alternatives that, based on their collective experience, held some potential for reducing delays at Logan, within the limits of the Airport's constraints.

The original list of improvements was continually amended over the life of the Capacity Team. Of the final list of 27 improvements, 19 were analyzed using the Technical Center's computer models. The other eight, less amenable to computer modeling, were dealt with in narrative form.

This final list of alternatives has been grouped under six strategies for reducing aircraft delays at Logan.

Strategies

A Separate the operations of smaller aircraft from larger and heavier jet aircraft.

B Expand the number of runways on which jets can operate independently under VFR and IFR.

C Improve taxiway circulation to expedite ground movement and improve departure sequencing.

D Lower minimum visibility requirements for IFR approaches.

E Adopt policies which manage demand to utilize the airfield more efficiently.

F Develop more efficient use of the airspace around Logan and Boston Approach Control.

By grouping the proposed alternatives under these strategies, the findings can be used not only to evaluate individual alternatives, but also to learn which general strategies may be most effective in reducing delays. This understanding can then be used to focus more effectively on refining these alternatives and guide other airfield planning and design activities at Logan. The following tables summarize the alternatives evaluated by the Capacity Team.

Strategy A: Separate the operation of smaller aircraft from large jet aircraft.

A-1	New commuter Runway 14/32, unidirectional (with arrivals only on Runway 32).
A-2	New commuter Runway 14/32, bidirectional.
A-3	Extend Runway 15L/33R to 3,500' with new taxiway.
A-3a	Combine alternatives A-1 and A-3.
A-3b	Combine alternatives A-2 and A-3.
A-4/B-4*	Remove noise restrictions on arrivals on Runway 22R.
A-5	400-foot westward extension of Runway 9 to permit commuters to land on Runway 9 and hold short of Runway 15R during daylight VFR dry conditions.
A-6/D-2*	Use of Microwave Landing System (MLS) technology for high-angle commuter approaches to avoid wake turbulence, missed approach guidance off Runway 32, and offset approach courses for independent IFR descents into VFR conditions.
A-7	Simultaneous LDA parallel point-in-space approaches to Runway 33L, circle to land Runway 4L in marginal IFR (IFR 1) and calm winds.

* Several alternatives contribute to more than one strategy and have been given a double reference code.

Strategy B: Expand the number of runways on which jets can operate independently under VFR and IFR conditions.

B-1	Extend Runway 27 200 feet to the east to allow landings holding short of Runway 22L in daylight VFR dry conditions.
B-2	Simultaneous approaches to Runways 4R and 4L and Runways 22R and 22L in less than VFR 1 operations.
B-3	Modify ATC procedures to allow simultaneous approaches to Runways 27 and 22L and to Runways 4L and 33L under IFR.
A-4/B-4*	Remove noise restrictions on Runway 4L departures.
A-4a/B-4a*	Remove noise restrictions on Runway 4L combined with an extension of Runway 4L to a new Taxiway B.
B-5	Side-step approaches from Runway 4R to Runway 4L.
B-6	Use of fan headings for aircraft departing Runways 22L and 22R.
B-7	Use of hold-short procedures under VFR wet conditions for turbojet aircraft on Runways 15R (hold short of 09), 22L (hold short of 27), and 33L (hold short of 4L).

* Several alternatives contribute to more than one strategy and have been given a double reference code.

Strategy C: Improve taxiway circulation to expedite ground movement and improve departure sequencing.

C-1 New parallel taxiway between Runways 4L/22R and 4R/22L.

C-2 New south exit parallel taxiway for Runway 27.

C-3 Add fillets at intersection of Taxiways D and C with Runway 15R/33L.

C-4 Add staging areas at the ends of Runways 15R/33L, 27, 4R, and 22R and at the intersection of Taxiway G with Runway 33L.

C-5 New taxiway from the end of Runway 27 to the end of Runway 33L.

C-6 Extend Taxiway D to Runway 4R/22L.

Strategy D: Lower minimum visibility requirements for IFR approaches.

D-1 Install Category II/III ILS on Runways 15R, 22L, 27, and 33L.

D-2 Use of Microwave Landing System (MLS) technology.

D-3 Reduce minimums to 250 feet and 3/4 mile on Runway 22L for Category I approaches.

Strategy E: Adopt policies which manage demand to utilize the airfield more efficiently.

E-1 Increase the percentage of large jet aircraft in the fleet mix.

E-2 Redistribute airline schedules within the hour.

Strategy F: Develop more efficient use of the airspace around Logan and Boston approach control.

F-1 Improve metering, spacing, and segregation of heavy jets.

F-2 Use Wake Vortex Avoidance System (WVAS) and Vortex Advisory System (VAS) to decrease separation standards.

Evaluation of Alternatives

Introduction

The FAA Technical Center used the Runway Delay Simulation Model (RDSIM) to estimate the delay savings for most of the improvement options. A few of the improvements, such as the introduction of MLS, were not amenable to computer analysis and were dealt with in narrative form. Computer simulation of runway operations was based on present and future air traffic control procedures, various airfield improvements, and different levels of traffic demand. To assess projected airfield improvements, runway configurations were derived from present and projected airport layouts. Aircraft separations used for IFR and VFR simulations were based on projected air traffic control procedures and system improvements. The estimates of annual delay took into account the yearly variations in the use of different runway configurations and weather conditions based on historical data.

For the delay analysis, the Technical Center developed traffic profiles based on the *Official Airline Guide,* historical data, and Massport forecasts. The characteristics of aircraft mix and peaking patterns were then developed for three levels of annual operations selected by the Capacity Team.

The Runway Delay Simulation Model (RDSIM)

RDSIM was used for both total capacity analysis and for analyzing delays occurring from an actual daily schedule of aircraft operations. RDSIM simulates activity for runways and exits only, and does not consider the taxiway network nor the terminal complexes. It is suitable for capacity analysis because the majority of airfield delays are runway related. RDSIM models discrete events, that is, the movement of individual aircraft over a network composed of the final approach path, the runway, and the exit taxiways for arrivals and, for departures, the departure threshold, the point of takeoff (rotation), and the initial departure flight segment. Randomness is introduced through the actual time a flight enters the simulation and its operational performance, (runway occupancy times, exit probabilities, approach speeds, etc.). Delays occur as aircraft wait at specific points along the network until sufficient separation is established from other aircraft.

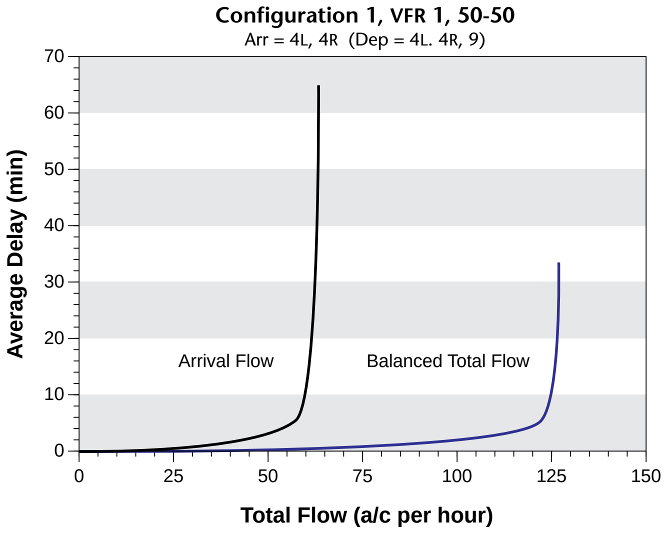
For a given demand, the model calculates the hourly flow rate and average delay per aircraft during the full period of airport operations. Arrival demand is assumed to equal departure demand, and aircraft are randomly assigned arrival and departure times. Arrivals receive priority over departures.

The experiments are replicated a minimum of 40 times, using Monte Carlo sampling techniques to introduce system variability into each run. The results are then averaged to produce the capacity and delay outputs for a given demand level. Using the same aircraft mix, computer specialists simulate different demand levels for each run to generate demand-versus-delay relationships.

Capacity figures were calculated for both an average four-minute arrival delay and for maximum throughput. Maximum throughput capacities were based on unlimited arrival and departure queues, which produced very large theoretical delays. The maximum throughput delays are included for comparison purposes only. The purpose of the model is to estimate the capacity that each runway configuration might provide for a given level of delay. It is not an analytical capacity model, which estimates a single number for capacity.

The figure to the right illustrates a typical curve showing the results of both types of calculations and illustrating the severe delay penalty associated with maximum throughput. The average arrival delay per aircraft is plotted against arrival capacity for one of the VFR runway configurations.

The maximum throughput approach provided a small increase in capacity at a severe increase in delay compared to the four-minute arrival delay. In the example illustrated above, the difference in an arrival flow rate of 54.9 versus 62.8 aircraft per hour produced a dramatic increase in average delay, from four minutes to 37 minutes per aircraft. Correspondingly, when the average total delay reaches 4 minutes, the total flow is 118 aircraft per hour.



Assumptions

In order to evaluate the 27 potential airport improvements, certain standard inputs were used to reflect the Logan operating environment. Some of these inputs were based upon observed data, and others were based on assumptions made by the Capacity Team. Details may be found in the various data packages produced by the Technical Center. The more significant details are summarized below:

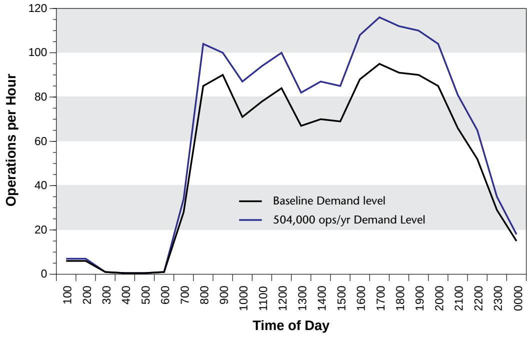
Traffic Volume. Three levels of annual operations were assumed:

412,000 -- approximating the 1987 level of demand

450,000 -- an intermediate level of demand

504,000 -- a longer-range demand level, approaching Logan's ultimate airfield capacity

(The Capacity Team did not assign forecast years to these scenarios.)



Profile of Daily Demand Hourly Distribution

Fleet Characteristics

Aircraft Class	Aircraft Types	Peak Hour		Departure Runway Occupancy Times	Approach Speeds
		Airfield Mix	Annual Fleet Mix		
Class 1	Under 12,000 lbs.	6%	3%	34 seconds	100 knots
Class 2	Commuter aircraft (turboprops)	37%	37%	34 seconds	120 knots
Class 3	Large jets <300,000 lbs.	45%	49%	39 seconds	130 knots
Class 4	Heavy jets >300,000 lbs.	12%	11%	39 seconds	140 knots

Aircraft Separation. The in-trail separations varied depending on the sequence of aircraft types, the mix of arrivals and departures, and the weather conditions. The range of separations was from an average of 2.89 nautical miles, when a small aircraft was following a small aircraft under VFR 1, to 7 nautical miles, when a small aircraft was following a heavy aircraft in an IFR approach. The separations used were a combination of FAA standards and actual observations.

Airfield Weather. The following distribution of the major weather conditions was assumed:

Weather	Ceiling/Visibility	Occurrence (percent)
VFR 1	2,500 ft./5mi and above	79.0
VFR 2	1,000 ft./3mi to 2,500 ft./5mi	8.0
IFR 1	300 ft./3mi to 1,000 ft./3mi	9.9
IFR 2	below 300 ft./3mi	3.1
		Total: 100.0

Runway Configurations. Four current runway configurations were analyzed:

	VFR 1 and VFR 2	IFR 1 and IFR 2
Configuration 1	Arrivals on 4L and 4R Departures on 4L, 4R, and 9	Arrivals on 4R Departures on 4L, 4R, and 9
Configuration 2	Arrivals on 22L, 27* Departures on 22R, 22L	Arrivals on 22L Departures on 22R, 22L
Configuration 3	Arrivals on 33L, 33R (VFR only) Departures on 27, 33L	Arrivals on 33L Departures on 33L
Configuration 4	Arrivals on 9, 15R, 15L* Departures 15R, 9	Arrivals on 15R Departures 15R, 9

* These configurations employ hold-short procedures.

Runway Utilization. Percentage Use (1987 Baseline)

Configuration	VFR 1	VFR 2	IFR 1	IFR 2	Total
1	19.8	5.2	4.6	1.9	31.5
2	26.0	2.8	1.3	0.0	30.1
3	30.0	0.0	2.9	1.2	34.1
4	3.2	0.0	1.1	0.0	4.3
Total	79.0	8.0	9.9	3.1	100.0

Discussion and Findings

This section discusses each improvement option briefly and, for those alternatives evaluated by computer model, includes an estimate of the amount of delay savings benefit if that improvement were implemented. For those alternatives that were not modeled, the benefits of the improvements are described qualitatively. The alternatives are discussed under the six strategies developed for reducing aircraft delays at Logan.

A Separate the operations of smaller aircraft from larger and heavier jet aircraft.

B Expand the number of runways on which jets can operate independently under VFR and IFR conditions.

C Improve taxiway circulation to expedite ground movement and improve departure sequencing.

D Lower minimum visibility requirements for IFR approaches.

E Adopt policies which manage demand to utilize the airfield more efficiently.

F Develop more efficient use of the airspace around Logan and Boston Approach Control.

Strategy A: Separate the operations of smaller aircraft from larger jet aircraft.

Logan serves as an international gateway for New England as well as a domestic hub airport for connections to and from many outlying areas of New England. As a result, 40 percent of the aircraft landing at Logan are the smaller Class 1 and 2 aircraft used by commuter airlines and by general aviation.

These smaller aircraft require greater separation when approaching or taking off behind heavy aircraft because of their vulnerability to wake vortices (6 miles in trail versus 3 miles). Their slower approach speed (typically 90 to 120 knots, versus 140 knots for large turbojets) also complicates controller workload and limits optimum runway utilization.

Air traffic controllers typically seek to use combinations of runways which allow for a separate arrival stream for smaller aircraft. Although Logan has a total of five runways (10 runway ends), there is not enough separation between runways to allow independent operations in IFR weather. Also, several of the configurations that are necessary in strong wind conditions and desirable for noise abatement do not provide separate arrival and departure streams, even under VFR.

Because of these constraints, a major effort of the Capacity Team was to search for alternatives that would accommodate independent operation of small aircraft and heavy jet aircraft in a variety of weather conditions.

A-1 New independent IFR Runway 14/32 fully instrumented for unidirectional operations (Arrive 32 and Depart 14).

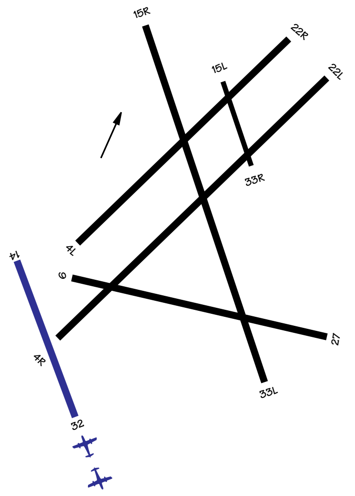
Configuration 3, with arrivals on Runways 33L and 33R and departures on Runways 27 and 33L, is the most constrained combination of runways during VFR. However, since this configuration minimizes noise exposure to adjacent residential communities, it is used 34.1 percent of the year. Runway 33R is only 1,400 feet from Runway 33L, and, during IFR, they must be treated as a single runway. During VFR operations, small aircraft departing on Runway 33L must wait 3 minutes after a heavy aircraft departs to avoid wake turbulence. Due to the short length of Runway 33R, commuter aircraft are reluctant to depart from it. Furthermore, departing aircraft have a difficult time getting to Runway 33R due to the need to cross the major arrival runway, Runway 33L.

This new Runway 14/32 is designed to expand significantly the capacity of Configuration 3 by providing for an independent approach stream for the smaller Class 1 and 2 aircraft regardless of visibility conditions. During busy departure flows, it also provides for departures from Runway 14 when Configurations 1 and 4 are in use.

Unidirectional flow was chosen to keep all aircraft operations over water and avoid any potential impact on adjacent communities, in consideration of the concerns

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	33.6	81.3	171.4



which led to the court order blocking construction of this runway. ("Unidirectional" in this context means "taking off in only one direction, i.e. to the southeast, and landing in only one direction, i.e. to the northwest.)

Results of the modeling indicated significant reductions in aircraft delays when operating in Configuration 3 due to the additional arrival stream on Runway 32 for both VFR and IFR 1 operations. The use of Runway 32 as an independent runway in IFR 1 operations provided substantial gains in reducing delays and traffic handling capabilities.

Employing Runway 14 as a departure runway in Configuration 4 resulted in an improvement in the IFR 1 case, especially for the departures, which were reduced to an average departure delay of less than six minutes for all levels of demand under study.

The introduction of Runway 14 as a departure runway in Configuration 1, i.e., arrivals on Runways 4R and 4L and departures on Runways 4R, 4L, 9, and 14, improved the departure delays slightly. The main advantage of this improvement for Configuration 1 would be greater flexibility in managing configurations at Logan and interfacing with the en route traffic environment.

The annual savings benefits in the current case were estimated to be 33,600 hours of delay. With 504,000 annual operations, the annual savings in delay were estimated to reach 171,400 hours.

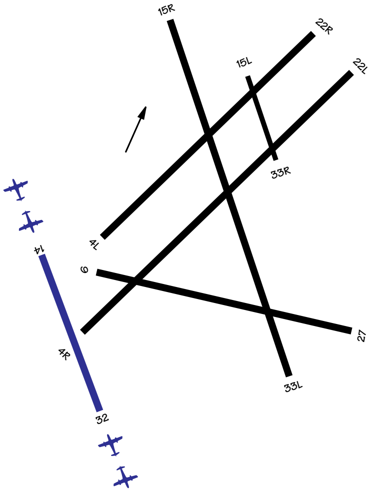
A-2 New independent IFR Runway 14/32 fully instrumented and bidirectional.

Alternative A-1 evaluated unidirectional use of new Runway 14/32. Alternative A-2 examined the same runway but used for bidirectional operations, i.e., arrivals and departures on Runway 32 for Configuration 3 and arrivals and departures on Runway 14 for Configuration 4. As expected, this additional flexibility improved the airfield operation for both configurations.

All of the benefits associated with unidirectional use of the runway are included in the benefits achieved under bidirectional use. Delays were further reduced in Configuration 3 by the addition of independent arrival and departure streams. This allowed Configuration 3 to perform as well as Configuration 1 under VFR 1 operations. Configuration 1 is currently Logan's highest capacity configuration in VFR conditions.

Estimated Savings in Delay

Ops/Yr	**412,000**	**450,000**	**504,000**
000 Hrs	34.8	86.0	193.1



Under Configuration 4, using the new runway as an independent arrival and departure runway (Runway 14) also produced an improvement over the baseline case. This alternative also improved the performance of Configuration 4 to the same level as Configuration 1 in VFR 1 operations.

The total annual savings benefit of the bidirectional use of Runway 14/32 over the baseline condition was estimated to be 34,800 hours of delay, and savings increased to 193,100 hours per year with 504,000 annual operations. This was the highest savings estimated for any of the alternatives studied.

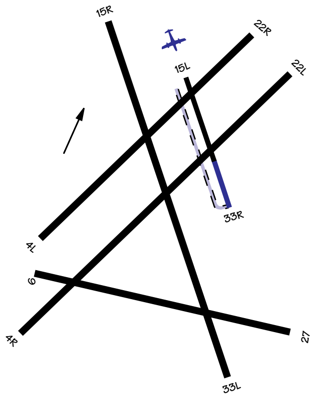
While this alternative is a clear improvement over alternative A-1, the estimated difference is only 1,200 hours of delay for the base case and 21,700 hours of delay with 504,000 annual operations. If bidirectional use of the new runway is not feasible due to obstructions or environmental considerations, this analysis suggests that about 90 percent of the benefit can be achieved with unidirectional use.

A-3 Extend Runway 15L/33R to approximately 3,500 feet and add a new parallel taxiway.

Runway 15L/33R is only 2,557' long and, as such, has very limited use. Extension of Runway 15L/33R and its associated parallel taxiway would permit expanded use of the runways in VFR 1 conditions. The analysis assumed that 100 percent of the Class 1 and 2 aircraft would be capable of operating on Runway 15L/33R.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	34.9	85.0	178.4



Delay reduction was achieved by redistributing traffic during VFR 1 conditions when using Configuration 3 (arrivals on 33L and 33R; departures on 27 and 33L). The benefit of this improvement for Configuration 4 (arrivals on 9, 15L, and 15R, hold short of 9; departures on 15R and 9) was significant during VFR 1 conditions. Annual delay savings for the improvement ranged from 34,900 hours for the base case and up to 178,400 hours for 504,000 operations.

The current land area of the airport supports an extension to only 2,850'. The benefit of the 3,500-foot extension modeled may be significantly greater than the actual benefit to be realized by an extension confined within the present limits of the airport's land area.

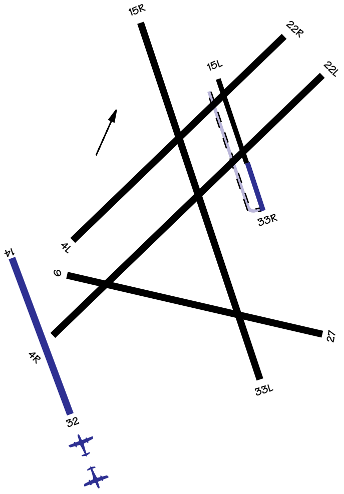
A-3a Combination of the new parallel Runway 14/32 (unidirectional) and the extension of Runway 15L/33R.

The use of the extension to Runway 15L/33R combined with the new Runway 14/32 configured for unidirectional traffic (departures on Runway 14 Configuration 4, arrivals on Runway 32 added to Configuration 3) was tested employing a different distribution of traffic. The overall effect on delay was not much better than the new Runway 14/32 improvement alone. There was a minor improvement in delay during VFR 1 conditions for Configuration 3 (arrivals on 32, 33R, and 33L; departures on 27, 33R, 33L). During IFR 1 condition, the results indicated greater departure delays due to the elimination of Runway 33R as an arrival runway and of Runway 27 as a departure runway.

There would be no compelling reason for adding an extension to Runway 15L/33R with the present airfield demand if the new Runway 14/32 were available for unidirectional use.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	34.0	84.4	178.4



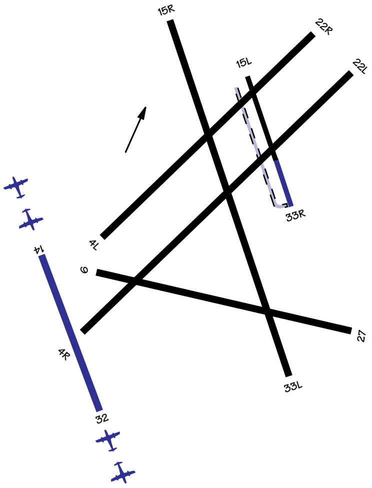
A-3b Combination of the new parallel Runway 14/32 (bidirectional) and the extension of Runway 15L/33R.

The use of the extension of Runway 15L/33R combined with the new Runway 14/32 configured for bidirectional traffic (arrivals and departures on 14 when in Configuration 4, arrivals and departures on 32 when in Configuration 3) was tested employing a redistribution of traffic. The overall effect showed some minor improvement in delay for both VFR 1 and IFR 1 conditions for Configuration 3 (arrivals on 33L and 32; departures on 33L, 33R, and 32). There were no savings in the cost of delays for the extension of Runway 15L/33R with the new bidirectional Runway 14/32 improvement in place.

As with the previous alternative, there would not appear to be a compelling reason for adding an extension to Runway 15L/33R with the present airfield demand if the new Runway 14/32 were available for bidirectional use.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	34.4	85.1	181.9

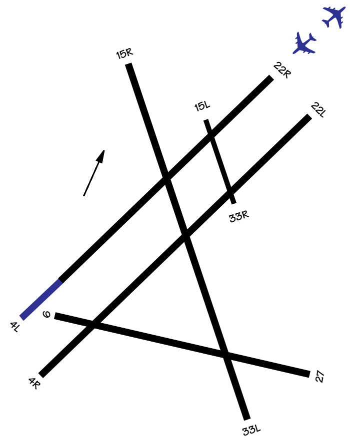


A/B-4 Remove noise restrictions on turbojet departures on Runway 4L and arrivals on Runway 22R.

Removing noise restrictions for departures on Runway 4L (Configuration 1) would permit the use of this runway by about 20 percent of the large and heavy aircraft during VFR operations and about 30 percent of the large and heavy aircraft during IFR operations. This redistribution of departures decreased the annual delays by about six hundred hours at the highest demand level.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	0.332	0.255	0.6



A/B-4a Remove Noise Restrictions and Extend Runway 4L to New Taxiway B.

An extension of Runway 4L to the new Taxiway B and removal of the noise restrictions would permit the use of 4L for departures to increase to 30 percent of the large and heavy aircraft traffic (Class 3 and 4) during VFR weather conditions. The effect of this redistribution of departures would not appreciably change the delay savings from those experienced in the previous alternative.

Estimated Savings in Delay

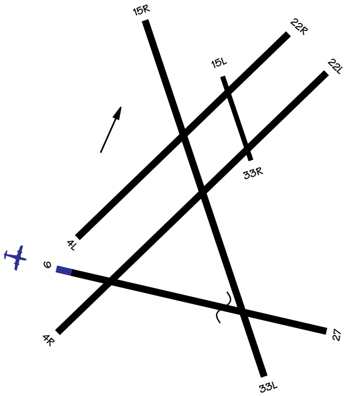
Ops/Yr	412,000	450,000	504,000
000 Hrs	0.2	0.2	0.6

A-5 Recover 400 feet of displacement of Runway 9 threshold to permit commuter aircraft landing on Runway 9 to hold short of Runway 15R during daylight VFR, wet and dry conditions.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.8	5.6	12.9

Runway 9/27 is 7,000 feet long with about 1,800 feet of additional pavement west of the Runway 9 threshold. When Configuration 4 is used, almost all arriving aircraft use Runway 15R. (Some Class 1 and 2 aircraft can land on 15L or 9). Over the past decade the commuter fleet has shifted to larger turbine engine aircraft that require a longer stopping distance. By reclaiming 125 feet of Runway 9's displaced pavement, almost all commuter aircraft could be issued approaches to Runway 9 to hold short of Runway 15R during dry VFR conditions. A 400-foot extension would encompass wet conditions as well. This configuration is presently used less than 4 percent of the time for VFR 1 conditions because of high arrival delays under normal traffic demand. It should also be noted that easterly winds occur most frequently in non-VFR 1 conditions.



Annual delay savings for the base case activity were estimated at 1,800 hours. More significant than the base year savings was the increase in savings that was realized with 504,000 annual operations, when this alternative would provide annual delay savings of 12,900 hours.

A-6/D-2 Use of Microwave Landing System (MLS) technology.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

The benefits of MLS at Boston were not quantified by the Capacity Team. MLS technology does have the potential to affect capacity in many different ways. The most frequently cited example is the use of curved approaches. The use of these approaches and the development and acquisition of the necessary aircraft avionics for them are still in the future. The advantages of these new approaches could be shorter flight paths, parallel paths of instrument guidance, obstruction avoidance, and noise mitigation. Some of these benefits may be tempered by the requirement for a straight-in final approach phase to aid the pilot in orienting to the airfield's visual aids.

The Capacity Team identified various other ways to use MLS technology that have the potential to reduce delays at Logan. These include:

- greater flexibility in siting the azimuth and elevation antennas relative to Instrument Landing System (ILS) components;
- development of parallel offset approaches to a "point in space" for independent IFR approaches which can transition to VFR on the final flight segment;
- higher glide path for commuter flights to reduce separation requirements behind larger jets (Wake vortices travel downward, and a higher approach angle keeps commuter aircraft above them); and
- more accurate missed approach guidance.

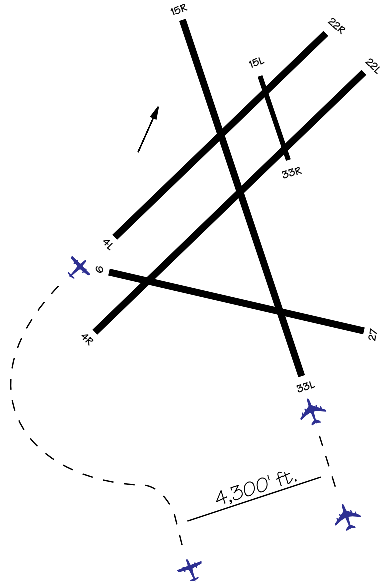
Once more specific guidance is developed from FAA's current MLS demonstration and evaluation program, additional capacity analysis should be performed on alternatives which incorporate MLS technology.

A-7 Simultaneous Localizer Directional Aid (LDA) parallel point-in-space approaches to Runway 33L, circle to Runway 4L.

This procedure is intended to provide an additional arrival stream during IFR 1 weather. During other weather conditions below IFR 1, this configuration did not have an advantage over other presently available configurations. It is restricted to use in calm wind conditions since it is proposed for crosswind runways. Nevertheless, this configuration (arrivals on 4L and 33L; departures on 4L and 4R) did demonstrate a reduction in delay when compared to the existing single stream IFR 1 configurations. Using an estimated percentage of time this new configuration could be employed at the airport, the delay savings were estimated to be 1,500 hours per year in the base year.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.5	0.0	0.0



Strategy B: Expand the number of runways on which jets can operate independently under VFR and IFR conditions.

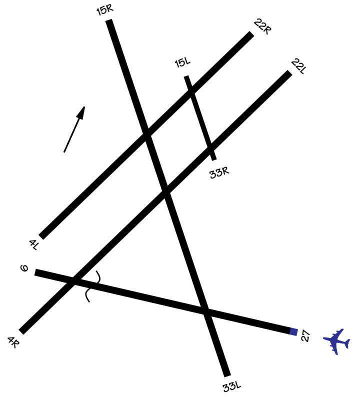
Although Logan does not have any independent parallel runways, it does have ten runway ends, which air traffic controllers use in four different configurations, with an IFR and a VFR version of each. The intent of this strategy is to seek ways to increase independence of operations on intersecting or closely spaced parallel runways.

B-1 Extend Runway 27 200 feet to the east (to allow hold-short operations).

A 200-foot extension of Runway 27 to the east would permit large aircraft arriving on Runway 27 to hold short of Runway 22L during daylight in VFR weather and under dry conditions. This improvement affects only Configuration 2, which is used approximately 29 percent of the combined time during VFR 1 and VFR 2 operations. Estimated annual savings for this improvement were only 89 hours. Even with 504,000 annual operations, this alternative would only reduce delays by 500 hours.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	0.089	0.12	0.5

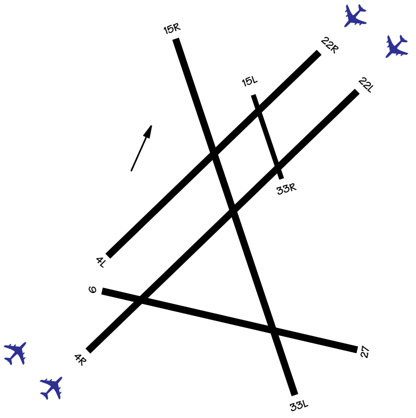


B-2 Simultaneous approaches to Runways 4R and 4L and to Runways 22R and 22L in less than VFR 1 conditions.

Simultaneous approaches to Runways 4R and 4L and 22R and 22L were tested in VFR 2 and IFR 1 operations. An arrival and departure demand distribution was selected for both configurations, and the appropriate separation standards were applied independently to each of the arrival runways. The results showed reductions in delay for each configuration, especially in IFR 1 operations. The annual delay savings were estimated to be 15,100 hours.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	15.1	30.0	30.2



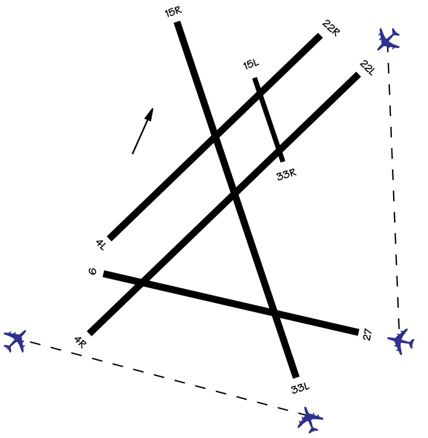
B-3 Modify ATC procedures to allow simultaneous approaches to Runways 27 and 22L and to Runways 4L and 33L under IFR conditions.

Simultaneous arrival operations were examined for IFR 1 weather conditions for approaches to Runways 22L and 27 (Configuration 2) and to Runways 4L and 33L (special Configuration 1). Both dependent staggered (2NM in-trail separation between adjacent arrivals) and independent parallel IFR approaches were included in the study.

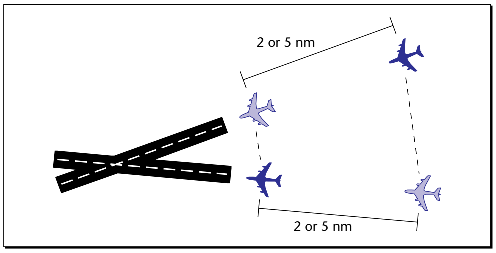
Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	2.1	4.0	4.5

Both the dependent staggered and independent parallel approaches resulted in substantial delay reduction for Configurations 1 and 2 compared to the baseline IFR 1 case. The total delay savings for dependent staggered operations at the lowest demand level was 1,603 aircraft hours. At 450,000 annual operations, the savings increased to 3,021 hours. Independent parallel approaches produced slightly greater savings in annual delay. At 504,000 annual operations, independent parallel approaches resulted in saving 4,596 hours of annual delay versus saving 4,232 hours of annual delay with dependent staggered approaches.



A/B-4 Removal of noise restrictions on Runway 4L departures and Runway 22R arrivals.



(See description under Strategy A)

A/B-4a Remove Noise Restrictions and Extend Runway 4L to New Taxiway B.

(See description under Strategy A)

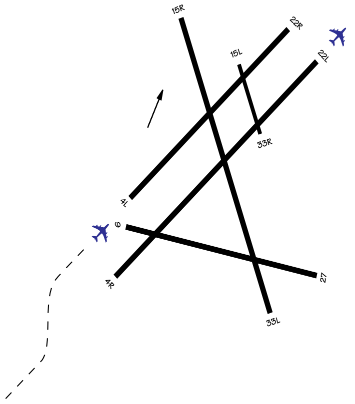
B-5 Side step approaches from Runway 4R to Runway 4L.

Side step approaches from Runway 4R to Runway 4L were applied as an improvement to Configuration 1 for the IFR 1 weather condition. It was anticipated that an overall improvement in departure delay would be realized by permitting departures on 4R immediately after an arrival on 4L. The result indicated that there was an improvement in overall delay, but the comparison depended heavily on the balance of arrival and departure delays. Adjusting the level at which departures were intentionally inserted (departure push) between successive arrivals affected the ratio of arrival to departure delay.

This alternative could result in a reduction in delay of 1,500 hours, but it should be noted that as demand grows, the increase in departure delays begins to outweigh the benefit of the decrease in arrival delay. The net effect is no delay savings for the highest demand level.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.6	0.7	0.0



B-6 Fan headings for aircraft departing Runway 22L and 22R.

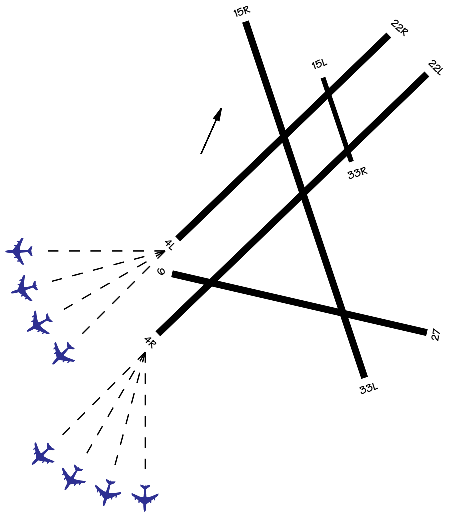
Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.9	2.7	6.2

Fanning departures onto different headings immediately after takeoff from Runways 22L and 22R (Configuration 2) would permit aircraft to depart rapidly in a carousel pattern from the airport. This improvement demonstrated a significant reduction in departure delays during all weather conditions.

The total savings over the baseline conditions were estimated to be 2,000 hours for the baseline demand level. The savings benefit increased rapidly as operations increased from the baseline, with over 6,200 hours of delay savings when Logan reached 504,000 annual operations.

Because this alternative yielded increasing benefits as demand volume grew, it should be given priority consideration. The increasing proportion of the fleet that will be using Stage III engine technology should facilitate this approach since these aircraft create a smaller noise footprint and have higher rates of climb. Future noise studies at Logan should examine the impacts of this alternative.

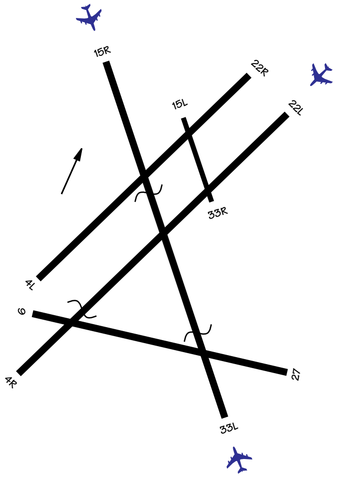


B-7 Use of hold short procedures under wet conditions (landing distances 6,000 feet or more) for turbojet aircraft on Runways 15R (hold short of 9), 22L (hold short of 27), and 33L (hold short of 4L).

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	3.2	8.3	17.9

Relief from the requirement to provide separation between arrivals on these intersecting runways in wet conditions reduced the arrival delays for each configuration. (On Runway 33L, the effect of smaller aircraft holding short of 4L was tested by constructing experiments for a special configuration, i.e., arrivals on 4L and 33L and departures on 4L and 4R.) The amount of delay savings during the day was apportioned according to the configuration's utilization and the number of days wet conditions existed at Boston during VFR 1 and VFR 2 operations. The total savings in delay costs for the baseline year were estimated at 3,200 hours. These savings grew to 17,900 hours when demand reached 504,000 annual operations.



Strategy C: Improve taxiway circulation to expedite ground movement and improve departure sequencing.

Delays of aircraft on the ground are generally not as expensive to the airlines, nor as demanding on controller workload, as airborne delays. However, time on the ground has the same cost impact on the air traveler since delays while taxiing can still cause missed connections and backups throughout the national system of airports. Well-designed ground movement surfaces should ease the proper sequencing of departure queues by providing bypass routes and hold aprons. Proper placement and geometry of exit taxiways can reduce runway occupancy times for landing aircraft.

C-1 New parallel taxiway between Runways 4L/22R and 4R/22L.

This new parallel taxiway would relieve congestion at the north end of the airport. Circulation of arrivals and departures on Runways 22R and 22L would be greatly facilitated for ground control operations. In particular, queuing of departures to both runways should be enhanced, and taxi times to and from the runways should decrease, particularly during periods of heavy demand when congestion is likely to extend back towards the ramp areas of the terminal.

This alternative was not modeled because it involved ground movement delays, which require a different simulation model, such as the Airfield Delay Simulation Model (ADSIM). Massport is about to initiate a comprehensive taxiway design study that will include modeling of taxiways.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

C-2 New south exit parallel taxiway for Runway 27.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

This improvement would permit aircraft landing on Runway 27 to exit and taxi at moderate speed to the crossing at Runway 4R. This reduces runway occupancy times and congestion caused by landing aircraft remaining on Runway 27 until they reach the intersection with Runway 4. The taxiway would also provide a benefit by expediting ground traffic to the terminal area. The current location of the glide slope facility for Runway 4R, the localizer for Runway 15R, and other navigational aids may prevent the construction of this taxiway. Maintaining minimum runway/taxiway separation would likely require some filling-in of the harbor and a slight alteration of the shoreline. Alternate locations and funding for the relocation of the affected facilities must be identified before the Capacity Team would seriously consider this improvement. It was not modeled. This is the type of taxiway improvement that requires a more comprehensive analysis to properly examine both its benefits and its costs.

C-3 Add fillets at intersection of Taxiways D and C with Runway 15R/33L.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	0.061	0.104	0.156

The addition of intersection fillets to Taxiways D and C was tested by decreasing the occupancy time on Runway 15R by 15 percent for aircraft using the exit. The results of the computer simulation showed no significant increase or decrease in delays. This indicates that, with present use of all the exits from Runway 15R, the principal benefit of the fillet would be for aircraft maneuvering off the runway. If the required separations between arriving aircraft were reduced, then runway occupancy times may become more critical, and these improvements, more beneficial.

Note: These improvements to the exit taxiway geometry have already been completed.

C-4 Add staging areas at end of Runways 15R/33L, 27, 4R, 22R, and at intersection of Taxiway G with Runway 33L.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	0.75	0.83	1.6

Staging of departures at the ends of the runways would permit the release of traffic to take advantage of diverging departure routes. This improvement was applicable to all configurations and demonstrated reductions in departure delays during IFR 1 and IFR 2 weather conditions.

The total savings of the staging concept over the baseline conditions was estimated to be 750 hours at the baseline level of operations and 1,600 hours when annual operations reach 504,000. Although the annual delay benefit is small, this is in large measure a result of the low number of hours of IFR weather. The staging areas would contribute to greater reliability of service during IFR. Therefore, this option may be considered useful for purposes other than delay reduction.

Note: The Taxiway G improvement was completed during the course of this study.

C-5 New taxiway from the end of Runway 27 to the end of Runway 33L.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

This taxiway will permit a quicker departure than at present for aircraft ready to depart from either Runway 27 or Runway 33L. If a departure clearance is withheld for any reason for an aircraft awaiting departure on either runway, the controller could use this taxiway to direct the aircraft to the alternate runway. The next departure could then proceed on the current active runway while the delayed aircraft waited for clearance on the alternate one.

The construction of this taxiway will interfere with the newly relocated VORTAC facility. Consideration of this improvement should be postponed until another opportunity (replacement or upgrade) arises to relocate the VOR and VORTAC to another suitable site.

C-6 Extend Taxiway D to Runway 4R/22L.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

The extension of Taxiway D to Runway 4R/22L would permit enhanced access both to and from Runway 27. Presently, aircraft using Runway 27 are restricted to Taxiway C or E. This restriction encourages the use of Taxiway E for exiting the runway and of Taxiway C for channeling aircraft from the entire gate complex. A greater degree of flexibility would be derived for the arrivals that exit Runway 27 at Taxiway C and proceed to the south terminal area. In addition, departures from the south complex can reach Runway 27 without using Taxiway C. Runway crossings on both 4L/22R and 4R/22L should be facilitated since they would no longer be concentrated at Taxiway C.

Strategy D: Lower minimum visibility requirements for IFR approaches.

Since low visibility weather is the prime contributor to aircraft delay, the Capacity Team investigated a number of alternatives that could lower approach minimums. This strategy would be effective primarily when aircraft are holding for higher minimums, executing missed approaches, or diverting to other airports. This strategy would not not be effective in relieving the bottleneck that results from a single approach stream into the airport during IFR conditions.

D-1 Install Category II/III ILS on Runways 15R, 22L, 27, and 33L.

The implementation of CAT II/III ILS on these runways would permit IFR 1 operations to continue into IFR 2 conditions when visibility falls below 1 mile. By recalculating the delay costs associated with the configurations affected by the improved runway performance and the percentage of use during IFR 2 conditions, the annual savings in delay was estimated to be 1,100 hours in the base year and 1,700 hours with 504,000 annual operations.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.1	1.3	1.7

A-6/D-2 Use of Microwave Landing System (MLS)

See discussion under Objective A-6 for a list of methods by which MLS technology could help reduce delays at Logan. None of these methods were evaluated by the Capacity Team since the feasibility of innovative approach procedures and the airlines' commitment to installing the requisite on-board avionics are still uncertain.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

D-3 Reduce minimums to 250 feet and 3/4 mile on Runway 22L for CAT I approaches.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	see narrative		

The minimums on this approach are higher than required due to an agreement at the time of installation between the FAA and local communities that the precision (ILS) approach minimum would not go below the minimum for the non-precision approach it was replacing. However, if the minimums could be reduced from 420/60[6] to 250/40, the use of Configuration 2 (arrivals on 22R and

---

[6] Standard notation of minimums are ceiling height or base of clouds expressed in feet above ground level and straight ahead visibility expressed in hundreds of feet, e.g., 420/60 represents base of clouds no lower than 420 feet above ground level and straight ahead visibility of 6,000 feet or more.

22L) could be increased slightly during IFR 1 weather conditions. If a shift of 0.5 percent of runway utilization is assumed between Configuration 3 (arrivals on 33L) and Configuration 2, this improvement would provide greater flexibility in managing the traffic configurations at Logan and provide a savings of 417 hours of delay per year at the baseline level of operations.

Strategy E: Adopt policies which manage demand to utilize the airfield more efficiency.

After all feasible physical improvements have been made to improve capacity, there are only two remaining options — relying upon competition among airlines and neighboring airports to adjust to constrained capacity and imposing policies aimed at taking advantage of underutilized capacity.

Without public intervention, private market adjustments can occur through peak-hour premium ticket pricing, expansion of passenger services at outlying air carrier airports, greater reliance on corporate aircraft to provide point-to-point travel on demand, passengers transferring to alternate modes for shorter length trips, etc. Underutilization of capacity can also occur through inefficient use of operations during peak hours or through unused capacity during off-peak periods. Demand management policies have historically focused on slot management to reduce peak hour congestion. Recently, greater attention has been given to increasing average aircraft size in order to increase capacity in terms of passengers rather than aircraft operations.

Demand management policies are as controversial a topic to national transportation interests as new runways are to adjacent neighborhoods. There are a few airports in this country with such programs. The approach is more common in Europe and Asia, where such policies are often interwoven with economic protection of national airlines. As with any public policy attempting to alter the activities of the private market, there are complex sets of issues regarding principles of equity and effectiveness which must be judiciously balanced.

The Capacity Team did not evaluate this option extensively, but two alternatives were developed to provide an initial evaluation of the potential for such policies to reduce delays.

E-1 Increase the percentage of large and heavy jets in the fleet mix.

Changes in fleet mix were analyzed to determine the theoretical sensitivity of delay to an increase in the percentage of large and heavy aircraft. Single-engine aircraft were eliminated and Class 2 aircraft were reduced by 5 percent, and their numbers replaced with large and heavy jets (Class 3 and 4) to produce the same overall demand level in terms of operations, but with a mix of 15 percent heavy, 53 percent large, and 32 percent commuter aircraft. The demand was held at the same level for all weather conditions (VFR 1 to IFR 2). This experiment resulted in an annual delay savings of 600 hours for the base case and 2,700 hours with 504,000 operations.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	0.6	0.8	2.7

Generally, it appears that the greater uniformity in approach speeds and reduced needs for wake vortex separation provided some reduction in delay. Further, the increase in the average aircraft size would increase the passenger capacity at Boston Logan.

E-2 Redistribute airline schedules within the hour.

This alternative examined a modest depeaking of airline schedules by redistributing scheduled arrivals more evenly throughout the hour within which they were scheduled. This was done without consideration to what mechanism might be used to effect such a redistribution or what impact this would have on connecting flights.

The simulation model predicted delay savings of 8,200 hours per year in the base case. Annual savings increase to 28,400 hours when operations increase to 504,000 per year.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	8.2	20.7	28.4

Strategy F: Develop more efficient use of the airspace around Logan and Boston approach control.

A direct determinant of the capacity of a runway is the spacing required between aircraft. Separation standards are based upon two considerations, the physical distance necessary to guarantee safe separation of aircraft and the additional physical distance necessary to avoid wake vortex interference. Airspace management not only attempts to space operations as close as possible to minimum standards but also uses other techniques to optimize the sequence of aircraft based on aircraft performance and route of flight.

F-1 Improve metering and spacing and segregate heavy jets.

This improvement was modeled by reducing the amount of variance in aircraft separation above the minimum standards. The technique simulated aircraft arriving at more precise intervals of time without violating any of the separation standards applied at the airport. For IFR 1 weather conditions, this improvement did not reduce delays because of the present proficiency of the tower during this weather condition. In this case, the improvement would simply default to the existing operation if it were introduced into the system.

Annual savings for this improvement based on present runway utilization was estimated at 1,800 hours of delay, increasing to 3,200 hours with 504,000 annual operations.

Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	1.8	2.8	3.2

F-2 Benefit of WVAS and VAS

The Wake Vortex Avoidance System (WVAS) and Vortex Advisory System (VAS) increase capacity by permitting reduced spacing between aircraft when wake vortices present no hazards to following aircraft. Under current conditions, controllers cannot detect the presence of wake vortices. Therefore, to guard against these potential hazards, they maintain increased separations between aircraft. Both WVAS and VAS decreased arrival delay over baseline conditions, but substantially increased departure delay because the reduction in spacing between arrivals did not allow sufficient intervals for intervening departures to be accommodated. Adopting a maximum departure waiting criteria of 10 minutes relieved this restriction in most cases and resulted in an overall decrease in delay. Estimated annual delay savings at the baseline level are 17,700 hours for WVAS and 12,800 hours for VAS. With 504,000 annual operations, these savings increase to 41,100 hours and 24,300 hours, respectively. Unfortunately this technology is still in the initial stages of development.

VAS Estimated Savings in Delay

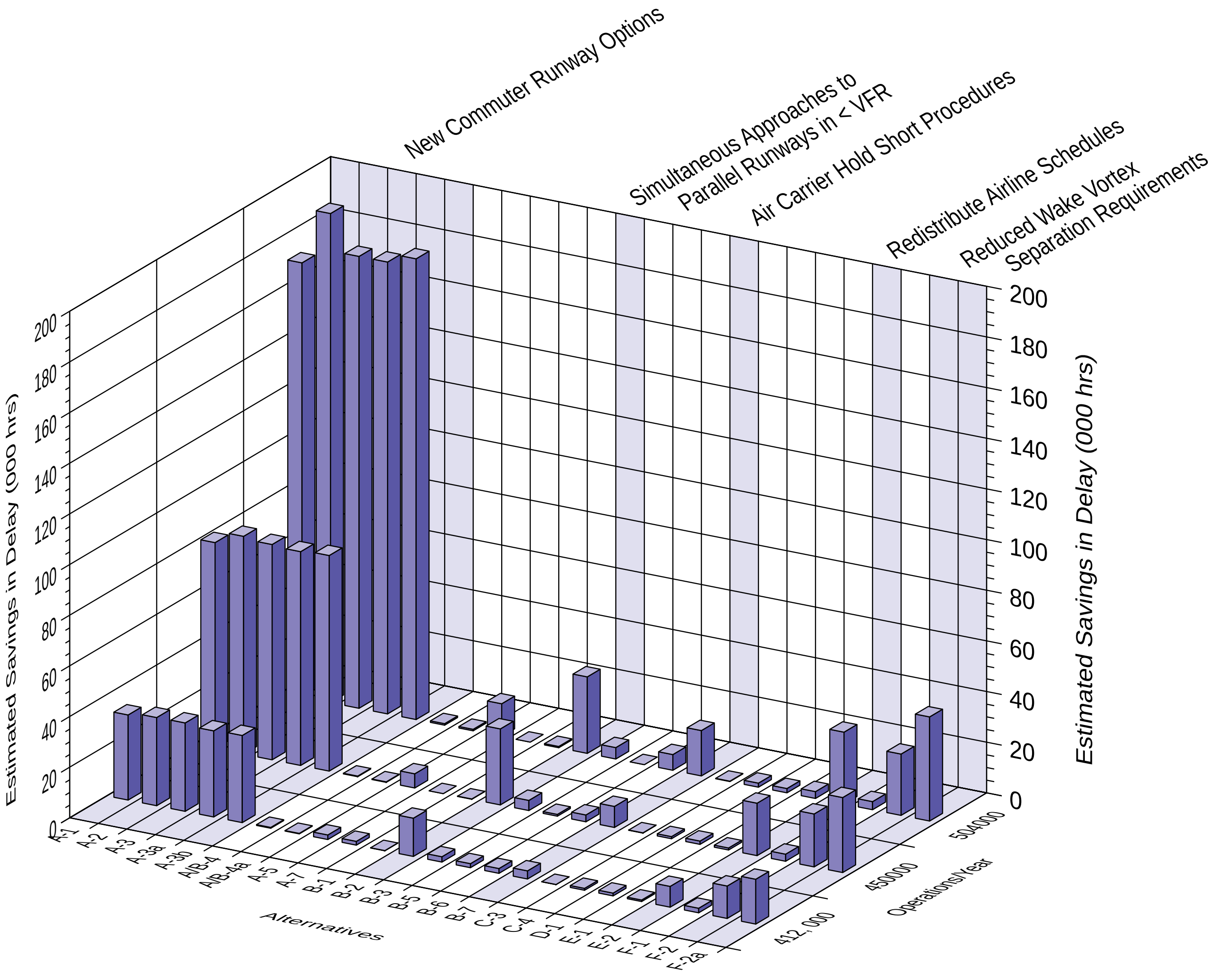
Ops/Yr	412,000	450,000	504,000
000 Hrs	12.8	20.9	24.2

WVAS Estimated Savings in Delay

Ops/Yr	412,000	450,000	504,000
000 Hrs	17.7	29.6	41.1

Summary

The delay reductions for each alternative and for each of the three levels of traffic volume (operations) are shown in the figure below. The addition of a new commuter runway or the extension of the short Runway 15l/33r give promise of the greatest relief from delays. Next in significance are the wake vortex advisory and avoidance systems, followed by the possibility of simultaneous approaches to the Runways 4R and 4L and 22R and 22L in less than VFR 1 weather conditions.



There are no delay reporting systems that produce an historical record of delay that corresponds to this estimate of Boston Logan's baseline delay. Therefore, to develop an assessment of the validity of the simulations, it is necessary to construct an estimate from national delay databases. The Standardized Delay Reporting System (SDRS) indicates that in 1987 average delays were 15.5 minutes for all phases of flight, or an average of 7.75 minutes per operation (since each flight generates an operation count at both the origin and destination airports). A conservative expectation of delay at Boston Logan would be estimated by multiplying 7.75 minutes by 412,000 annual operations for a total of 53,200 hours of delay.

From the Air Traffic Operations Management System (ATOMS), we know that in 1987 4.8 percent of operations at Boston Logan were delayed 15 or more minutes. The average delay at the 22 major airports reporting in the ATOMS was 3.2 percent in 1987. Therefore, Boston Logan's delay was 1.5 times the average. Applying this as an adjustment to SDRS national delay averages would suggest that in 1987 actual delays could have approximated 79,000 hours. This would indicate that the Technical Center's methodology is conservative in estimating baseline delay of 68,402 hours.

Therefore, as best as can be determined, the annual estimates of delay are reasonable guides to determining benefits from improvements, provided that the analysis properly simulated the effect an alternative would have on airfield operations. The delay savings benefits must also be considered for system interactions which were not modeled such as taxiway and airspace congestion.

Recommended Actions

Interpretation of the Simulations

In order to provide a set of recommended actions, the Capacity Team first had to evaluate the significance and validity of the delay savings estimated by the Technical Center's models. The team recognized that these delay savings estimates were developed from specific assumptions regarding aircraft mix, weather patterns, etc. In addition, the Technical Center's task of converting the RDSIM estimates of delay, which were based upon a set of 24-hour simulations, into a composite annual estimate of delay was not as simple as it may first appear.

The RDSIM model estimates delay resulting from a particular configuration of arrival and departure runways with the same weather conditions during a 24-hour period. This method has limitations. Weather, especially IFR conditions, rarely lasts for 24 straight hours. Typically, after a three or four hour delay, weather will improve. As a result, the capacity of the airfield increases again, and the queue of aircraft waiting to land is absorbed. This results in a shorter average delay than the model would predict. The FAA Technical Center reviewed hourly weather observations for a ten-year period at Logan. They attempted to construct a single summary statistical factor that would reflect not only the raw frequency of any weather condition, but also its duration and bias in time of day. It is difficult to evaluate the validity of this factor, because of the complexity in deriving it and the high sensitivity of delay estimates to assumptions in weather patterns.

The Technical Center's methodology produced a baseline annual estimate of 68,402 hours of delay. There are no delay reporting systems that produce an historical record of delay that corresponds to this estimate of Boston Logan's baseline delay. Therefore, to develop an assessment of the validity of the simulations, it is necessary to construct an estimate from national delay databases. The Standardized Delay Reporting System (SDRS) indicates that in 1987 average delays were 15.5 minutes for all phases of flight, or an average of 7.75 minutes per operation (since each flight generates an operation count at both the origin and destination airports). A conservative expectation of delay at Boston

Logan would be estimated by multiplying 7.75 minutes by 412,000 annual operations for a total of 53,200 hours of delay.

From the Air Traffic Operations Management System (ATOMS), we know that in 1987 4.8 percent of operations at Boston Logan were delayed 15 or more minutes. The average delay at the 22 major airports reporting in the ATOMS was 3.2 percent in 1987. Therefore, Boston Logan's delay was 1.5 times the average. Applying this as an adjustment to SDRS national delay averages would suggest that in 1987 actual delays could have approximated 79,000 hours. This would indicate that the Technical Center's methodology is conservative in estimating baseline delay of 68,402 hours.

Therefore, as best as can be determined, the annual estimates of delay are reasonable guides to determining benefits from improvements, provided that the analysis properly simulated the effect an alternative would have on airfield operations. The delay savings benefits must also be considered for system interactions which were not modeled such as taxiway and airspace congestion.

Although specific numerical estimates of annual delay savings are used throughout this report, they should be viewed only as relative estimates of a benefit. After extensive discussion and consideration of methods for estimating delay savings, the Capacity Team appreciated the variety of approaches that can be taken in defining capacity and delays at an airport. The specific numbers are not as informative as is consideration of the relative benefits of various strategies. Judgments should not be based upon summary statistics alone. Some improvements with low benefits may be important because of the reliability they provide or for their ability to ease air traffic control complexity during periods of heavy workload. All of the improvements also need to be assessed for their environmental consequences and their practicability. The Capacity Team was not formed to provide a comprehensive planning assessment of these strategies, but simply to determine which of them would provide the greatest reduction in delays. This caveat aside, there are some obvious issues regarding these strategies. These issues must be discussed as a prelude to further public consideration of the recommendations of this Capacity Team.

Conclusions

New Commuter Runway

On the basis of this analysis, either the construction of a new unidirectional[7] commuter runway or the extension of Runway 15L/33R was clearly the most significant strategy in reducing delay. Either of these alternatives provided an annual savings of at least 33,500 hours of delay at the base case level of activity, increasing to over 170,000 hours of delay when activity reaches 504,000 annual operations. This is equivalent to 72 percent of the total estimated delay.

Extension of the existing short parallel Runway 15L/33R is restricted to less than 3,500 feet total length if existing shoreline limits are maintained. The computer simulation analysis assumed that an extended runway and parallel taxiway would be used by all small (Class 1 and 2) aircraft. Given the trend towards larger and higher performance commuter aircraft, this runway length may be inadequate to provide the level of savings that was estimated. A comprehensive analysis of runway and taxiway operations would likely further erode the benefits from this extension as there are no efficient taxiway routes to this runway and a new parallel taxiway would require harbor fill. Increases in the proportion of wide body aircraft at Logan would also decrease the benefit of this runway since it is affected by wake vortices created by operations on Runway 15R/33L. Although it is premature to eliminate it as an option, it is unlikely to be as beneficial a strategy as the initial computer simulation results suggest. Any future work to develop a separate commuter runway for northwest approaches will likely focus on a new Runway 14/32.

The construction of Runway 14/32 is a highly controversial issue. Until the early seventies, there had been a tremendous expansion of the airport and of the level of jet activity, including the now banned Stage I turbojets. The defeat of the proposed Runway 14/32 became an important milestone in the history of the airport and its relationship with the surrounding communities. Over the intervening

Recommendation 1:

- Conduct comprehensive analysis of runway and taxiway interactions for a new unidirectional Runway 14/32 in order to confirm the delay savings of a new commuter runway and to test the future value of this strategy under a greater range of assumptions regarding future fleet mixes.
- Develop a noise impact analysis and a detailed description of the changes this alternative would have on the distribution of flight tracks of small and larger aircraft over the surrounding communities.
- Analyze what impact these alternatives would have on achieving the Preferential Runway Assignment Goals.
- Analyze the impact of increased commuter aircraft operations on the demand for vehicle access into Logan.
- Review the cumulative results of the above studies and provide a recommendation to Massport based upon the factual findings of such analysis.

This process should be pursued within a specified deadline (e.g., eighteen months) to develop a recommendation to Massport. The process and scope should be modified as appropriate to develop a credible and balanced re-assessment of the development of these alternatives. Given the cost, expense, and environmental impact of other off-airport alternatives to improving Logan's capacity,[8] the political controversy over the construction of a unidirectional Runway 14/32 should not preclude its evaluation on a factual basis for consideration in regional transportation planning decisions and consequent facility planning at Massport for Logan's role in regional air service.

---

[7] "Bidirectional" refers to a standard runway with departures and approaches permitted to operate off of either end of the runway. "Unidirectional" refers to aircraft arriving on the Runway 32 end and departing on the Runway 14 end. This keeps all aircraft operating over water.

years, Massport has labored extensively to maintain a balanced view between aviation objectives and community concerns regarding noise, traffic, and redevelopment of the harbor area. While there are critics challenging the appropriate level of balance on both sides of the issue, it is clear that impacts to the community have become a major consideration in the deliberation of any decision affecting operation and development of the physical facilities at Logan. Any discussion to re-awaken the project to build Runway 14/32 has symbolic implications that exceed its potential physical impact on the neighboring community.

It needs to be stressed that this runway would only service smaller, non-jet aircraft. If the runway were restricted to unidirectional operations, there would be no increase in aircraft flying over nearby neighborhoods such as Jeffries Point. More importantly, the existing Runway 33L could then be used more often and more efficiently for air carrier aircraft.

---

8. The development of a second major airport is creating considerable opposition from candidate communities. They have raised legitimate challenges to demonstrate that every alternative, including enhancement of Logan's capacity, is being pursued to avoid such an impact.

Reduce Separation for Wake Vortices

The next biggest reduction in delay resulted from the implementation of a Wake Vortex Avoidance System (WVAS) that would reduce required wake vortex separation between aircraft (41,100 hours of delay per year with 504,000 operations). Unfortunately, there are no guarantees that current research in this area will produce an effective system. This is a national research and development initiative, and there is nothing that can be done locally to reduce wake vortex separation standards prior to the promulgation of new national procedures and equipment certification.

Recommendation 2:

FAA and Massport should monitor progress of the Vortex Advisory System and the Wake Vortex Avoidance System and use whatever initiatives are practical to implement at Logan.

Simultaneous Dependent Approaches

Developing simultaneous approaches to the closely spaced parallel runways, Runways 4R/22L and 4L/22R, would provide significant savings in delay (15,000 to 30,000 hours per year). National research anticipates being able to reduce the diagonal separation required between aircraft through the use of improved radar technology. Improvements are limited by the problem of wake vortex effects on aircraft operating on parallel approaches with less than 2,500 feet lateral separation. Results of current tests in this area should be available within two years.

New radar displays with software that enhances a controller's ability to monitor aircraft with reduced separation are currently being installed at Logan. This will support the reduction of diagonal spacing on dependent converging approaches, providing an annual delay savings of 2,100 to 4,200 hours.

Recommendation 3:

Members of the Capacity Team should support the development of procedures that will reduce the separation required for simultaneous dependent approaches at Logan Airport.

Redistribution of Airline Schedules

Redistribution of airline schedules within the hour was the next most significant alternative in terms of reducing delay. It has an estimated savings of 28,400 hours of delay per year with 504,000 operations, or less than 11 percent of total estimated delay.

Depeaking within the hour attempts to reduce delays caused by the scheduling of departure times at the hour and half hour, which results, in part, from an airline marketing response to the manner in which passengers inquire about and book flights. Since implementation of the Airline Service Quality Performance system, airlines have lengthened the scheduled duration of their flights in realization that departures at peak times are often delayed. In this manner, airlines are absorbing some of the delay within their schedules.

The Air Transport Association (ATA) firmly opposes any attempt to redistribute demand. The most obvious reason is the complexity of scheduling aircraft through airports across the country. If the FAA or local airports were to regulate schedules, airlines would face enormous costs in underutilized equipment, missed connections at hub airports, inadequate baggage processing times, etc. All this could occur even from adjustments within the hour as simulated in these experiments.

The Capacity Team did not investigate any other demand management strategies during their study. However, anticipating that discussions of physical improvements to the airport to improve capacity will be rejoined by questions regarding operational improvements such as demand management, the following discussion provides background to this issue.

Generally, demand management attempts to make more efficient use of existing capacity by increasing the average number of passengers per aircraft operation and by making better use of under-utilized capacity in off-peak periods. Two popular approaches involve variation of peak-hour pricing and slot allocation.

Peak-hour pricing attempts to operate through market forces by increasing the price of using an airport when demand is highest. There is a common misconception that the purpose of peak-hour pricing is to encourage the transfer of air carrier passenger flights to off-peak hours. Because of the tremendous price differential that would be

Recommendation 4:

Given the moderate benefits from within-hour rescheduling and the stated policy of ATA opposing such an initiative, the Capacity Team does not recommend this strategy at this time.

required to induce passengers to travel off peak, this is generally not the objective of peak-hour pricing mechanisms. The intent of peak-hour pricing is to provide an economic disincentive for smaller aircraft to utilize air carrier runways during critical peak hours without creating any outright restriction. The anticipated outcome of peak-hour pricing is an increase in the average number of passengers per flight and a decrease in general aviation operations and small commuter aircraft operations.

To shift air carrier passenger flights, it is usually more practical to use slot allocations rather than pricing mechanisms. This can be a cumbersome and difficult program to execute in a manner that is both equitable and efficient. Its use within this country has been restricted to the four busiest "pacing" airports where delays have historically affected the performance of the National Airspace System (NAS). It should be noted that, as Logan approaches 504,000 operations per year, there will be very little extra capacity in the off-peak periods. At this level of demand, the only two daytime off-peak hours (less than 80 operations) occur from 9 pm to 11 pm. The noon to 3 pm period is projected to increase from an average of 68 operations per hour in the baseline to an average of 85 operations per hour with 504,000 annual operations. As operations increase, there may not be enough extra capacity in the traditional off-peak time periods to accommodate additional operations without significant delays. At this point, slot allocations will only be able to reduce delay by effectively "capping" the total number of operations at the airport.

While programs to redistribute demand may be less expensive to the airport owner than physical improvements, any action which significantly raises the cost of air travel or limits the ability of airlines to offer air service in response to passenger demand can have far-reaching implications on the region's economy. Air travel is not an economic product in itself, but a utility used for other purposes, e.g., business or pleasure. When the cost of this utility increases, or its efficiency diminishes, those economic activities that depend on air travel will be negatively affected. Therefore, any analysis of demand management strategies has to carefully consider these impacts prior to its implementation.

On the other hand, proponents of demand management cite concern for the economic inequities imposed by congested facilities. During periods of congestion, each additional flight creates delays in all other competing flights that far exceed the delay cost experienced by the passengers and airline from that one additional flight. Due to these "externalities," the rational behavior of each airline in scheduling additional flights is in conflict with the collective interests of all users. Under these circumstances, demand management is viewed as necessary to maintain reasonable levels of cost and service at an airport.

Therefore, the critical question is whether premium prices which result directly or indirectly from demand management are sufficiently offset by savings in costs associated with delay and congestion. The answer to this deceivingly simple question is usually quite complex and further complicated by the issue of who pays and who benefits.

Finally, demand management initiatives can also provide relief in a more timely manner than physical facility improvements. In that regard, they may be a useful "bridge" if, in the future, air travel demand increases at a rate that overwhelms the airport's ability to provide the requisite facilities.

Hold-Short Procedures

The other alternative which merits separate discussion is the development of additional hold-short procedures. "Hold-short" procedures allow air traffic controllers to legally separate landings on a runway from landings and takeoffs on an intersecting runway or from crossing taxiways. This, in effect, provides for an additional arrival stream. Additional use of hold-short operations on Runways 15R, 22L, and 33L under wet conditions could provide independent air carrier approaches, with a delay savings of 17,900 hours at 504,000 operations per year. Establishing hold-short procedures on Runway 9 for wet and dry conditions could provide an independent commuter arrival stream and reduce delays by 12,900 hours. Considered together, development of these hold-short procedures could provide in excess of an 11 percent reduction in delay.

Recommendation 5:

The FAA should support the necessary studies[9] to implement hold-short procedures on Runways 9/27, 15R, 22L, and 33L subject to environmental analysis and concurrence by Massport on any changes to displaced thresholds.

---

[9] See Advisory Circular 121.195 CD-1a

Improve Taxiway System

Based upon its experience in developing these strategies and in reviewing the RDSIM analysis, the Capacity Team concluded that there was a need for a comprehensive analysis of Logan's taxiway structure. Appropriate modeling of the combined taxiway and runway system could help determine if a more efficient taxiway system with more appropriate exits and high-speed turnoffs could be developed to help improve the performance of hold-short landings, departure queues, and other critical functions. Such an effort would also tie into current runway and taxiway incursion analysis at Logan.

Recommendation 6:

FAA should support a comprehensive analysis of Logan's taxiway structure to improve safety, increase operating efficiency, and support the recommendations of this Capacity Team.

Appendix A – List of Abbreviations

ADSIM	Airfield Delay Simulation Model
ASC	Office of System Capacity and Requirements
ATA	Airline Transport Association
ATC	Air Traffic Control
CAT	Category
FAA	Federal Aviation Administration
FY	Fiscal Year
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ITF	Industry Task Force
LAMP	Logan's Airport Modernization Program
LDA	Localizer Directional Aid
Massport	Massachusetts Port Authority
MLS	Microwave Landing System
NAS	National Airspace System
NAVAID	Navigational Aid
NM	Nautical Mile
RDSIM	Runway Delay Simulation Model
TACAN	Tactical Air Navigation
VAS	Vortex Advisory System
VFR	Visual Flight Rules
VOR	VHF Omnidirectional Range
VORTAC	Combined VOR and TACAN navigational facility
WVAS	Wake Vortex Avoidance System

Credits

Editorial and production support provided by MiTech Inc.
Photos supplied by Massport and Aerial Photos International, Inc., and
the FAA, Airports Division.