# EVALUATION OF THE NATIONAL AIRSPACE REDESIGN AND PRECISION RUNWAY MONITOR PROGRAMS IN THE OPERATIONAL EVOLUTION PLAN VERSION 5.0

**NAS Configuration Management and Evaluation Staff**
**Program Evaluation Branch (ACM-10)**

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# Executive Summary

The Operational Evolution Plan (OEP) represents the Federal Aviation Administration's (FAA) commitment to increase the capacity and efficiency of the National Airspace System (NAS) over a ten year period while enhancing safety and security. The OEP provides stakeholders, including the aviation community, with near, mid, and long term goals of programs that the FAA is undertaking to address current challenges in the NAS while enhancing safety.

In January 2003, the Associate Administrator for Research and Acquisitions (ARA-1) and the Associate Administrator for Air Traffic Services (ATS-1) requested that the Program Evaluation Branch (ACM-10) of the NAS Configuration Management and Evaluation Staff conduct an evaluation of the OEP with a focus on two programs – National Airspace Redesign (NAR) and Precision Runway Monitor (PRM). The final report was to provide ARA-1 and ATS-1 with the status of both OEP programs, citing whether the programs were on track to meet their current and future commitments. The report also needed to document the issues and roadblocks each program was facing, as well as measure and report any benefits from implemented initiatives.

The evaluation team focused on three main objectives: (1) determine the status of the NAR and PRM programs, showing if each would meet their current and future commitments; (2) identify roadblocks to program implementation; and (3) identify benefits, based on performance measures, that stakeholders have received from the programs.

The evaluation did not cover the entire OEP because it was not feasible in the eight-month time period set aside for this assessment. Therefore, ARA-1 and ATS-1 asked the team to focus on the NAR and PRM programs. The team gathered both qualitative and quantitative data from several locations where the programs were already implemented. Next, the team analyzed the qualitative data to determine the status of each initiative and the quantitative data to assess program benefits. Finally, the team developed findings and recommendations based on their analysis of the data.

## Findings and Recommendations

The evaluation team developed the following findings based on their analysis:

1. Many Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan milestones are behind schedule.
2. Implemented Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan initiatives are providing benefits, but expected benefits from incomplete initiatives remain uncertain.
3. Operational Evolution Plan benefits for Precision Runway Monitor and National Airspace Redesign are difficult to evaluate due to nonspecific performance measures and initiative tracking obstacles.

## Finding One: Many Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan Milestones are Behind Schedule

Although FAA has met some of its OEP milestones related to PRM and NAR, many of these milestones are behind schedule due to unresolved operational issues, budget cuts, and other implementation issues. As a result of these milestones not being met, users (i.e., air carriers, passengers, and airports) will not be able to derive benefits as promised in the OEP.

Five of the eight PRM milestones scheduled for the near- or mid-term are not being met or are not on track to be met.[1] Further, two of the three milestones that have been met (i.e., install PRM at San Francisco International Airport (SFO) and John F. Kennedy International Airport (JFK)) provide no benefits without operational implementation of the PRM capability.

Table ES-1 lists the near-term and mid-term PRM milestones in OEP version 5.0 and their status.

| Milestone | Due Date | Status |
|---|---|---|
| Install SFO PRM | Near-Term | Complete. However, no benefits accrue from installation. |
| Install JFK PRM | Near-Term | Complete. However, no benefits accrue from installation |
| Further site specific Simultaneous Offset Instrument Approach (SOIA) procedure development as new sites are approved and use PRM | Mid-Term (2006-2009) | In progress |
| Resume PRM at Minneapolis-Saint Paul/Wold-Chamberlain International Airport (MSP) by FY03 Quarter 2 | FY 2003 Quarter 2 (March 03) | Implemented FY04 Quarter 1 (December 2003) |
| Implement PRM-SOIA at Lambert-Saint Louis International Airport (STL) | FY 2004 | In progress. Several issues remain and it is unclear if commitment will be met. |
| Implement PRM-SOIA at SFO | FY 2004 | In progress. Several issues remain, and it is unclear if the commitment will be met. |
| Complete Wake Safety assessment at STL and SFO | Near-Term (by September 30, 2005) | Completed. SFO to be reassessed when updated data is available. |
| Address Enhanced Surveillance capability at Detroit Metropolitan Wayne County International Airport (DTW) and Hartsfield-Jackson Atlanta International Airport (ATL) | Mid-Term (2006-2009) | ATL approved for PRM. DTW is under consideration for PRM. |

**Table ES-1 - OEP milestones for PRM and their status**

Twenty-five of the 54 NAR initiatives[2] in the OEP are not on track to meet their milestones. According to the NAR Primary Office of Delivery, the Air Traffic Airspace Management Program, three of the 25 initiatives were published in OEP version 5.0 with incorrect milestones. The remaining 22 initiatives have been impacted by changes in project scope, the Area

1 *Although PRM is operational at Philadelphia International Airport and scheduled for implementation in Cleveland Hopkins International Airport, the OEP version 5.0 did not list milestones for these sites. Therefore, they are not discussed in this finding.*

2 *Two initiatives were expanded into 5 initiatives because they had different milestones.*

Navigation (RNAV) moratorium, budget cuts, and environmental issues. Until these issues are resolved, users will not reap the benefits associated with these initiatives in the OEP.

Causes for not meeting OEP milestones varied both between and within the PRM and NAR programs. However, unresolved operational issues were a major cause for failure to meet milestones in both programs. PRM and NAR initiatives that involve developing and implementing new operating procedures may not meet milestones in the OEP. However, these milestones may not be realistic because new procedures require the consensus of a diverse group of stakeholders. It is difficult for the group to reach consensus on new operating procedures because there is no single FAA manager ultimately responsible for delivering the new service or capability. Further, changes in project scope, the RNAV moratorium, and budget cuts have impacted many OEP NAR milestones, causing initiative schedules to slip.

***Recommendations***:

- The Federal Aviation Administration Chief Operating Officer should assign a single Federal Aviation Administration manager with ultimate responsibility for implementing a new system or solution, such as Precision Runway Monitor or Area Navigation. This manager would be responsible for coordinating with Flight Standards Service and external stakeholders when developing and implementing new operating procedures.
- The Operational Evolution Plan Office should examine Operational Evolution Plan initiatives other than Precision Runway Monitor and National Airspace Redesign to determine whether they are facing similar operational challenges related to procedural development.
- To ensure the accuracy and traceability of initiative and milestone dates in the Operational Evolution Plan, the Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should consider listing milestones as short-term, mid-term, or long-term.

## Finding Two: Implemented Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan Initiatives are Providing Benefits, but Expected Benefits from Incomplete Initiatives Remain Uncertain

Users are benefiting from PRM and NAR initiatives in the OEP that have been implemented by the FAA, but expected benefits from other initiatives remain uncertain. For instance, it is not clear that users will benefit from PRM operations at JFK because of issues related to shared airspace and pilot nonparticipation. Also, the reduction in air traffic since the events of September 11, 2001 (9/11) has limited the benefits from some initiatives already implemented. Notwithstanding the impact of 9/11, initiatives already implemented have helped users lower operating costs by increasing throughput and reducing departure and arrival delays.

**Summary of Benefits Related to Precision Runway Monitor and National Airspace Redesign Initiatives in Operational Evolution Plan**

Table ES-2 summarizes the benefits related to PRM and NAR initiatives in the OEP based on the evaluation team's analysis.

| OEP Initiative | Benefits Based on the Evaluation Team's Analysis |
|---|---|
| PRM at MSP | Based on PRM usage in summer of 2002:<br>▪ Annual average savings of $61,052<br>▪ Average of one additional aircraft arrival during a push |
| PRM at STL | PRM supported approach saved an average of 1.44 minutes of airborne delay per aircraft using PRM |
| PRM at JFK | Future benefits uncertain due to shared airspace with LaGuardia Airport and Westchester County Airport and pilot nonparticipation issues |
| Las Vegas RNAV & Four Corner Post | ▪ Decrease in average departure delay of 4.83 minutes per aircraft<br>▪ Decrease in average gate arrival delay of 3.78 minutes per aircraft |
| Choke Points 1 & 2 | Reduced departure delays between 2000 and 2002 while air traffic volume remained constant |
| Choke Point 3 | Reduced departure and arrival delays between 2000 and 2002; however, air traffic volume declined also |
| Choke Point 4 | Reduced departure delays between 2000 and 2002 while air traffic volume remained constant |
| Choke Points 5 & 6 | ▪ Reduced departure and arrival delays for Chicago O'Hare International Airport (ORD) and Cincinnati/Northern Kentucky International Airport (CVG) between 2000 and 2002 while air traffic volume increased<br>▪ Reduced departure delays for Pittsburgh International Airport (PIT) between 2000 and 2002; however, arrival delays increased. Air traffic volume increased.<br>▪ Reduced departure and arrival delays for Cleveland/Hopkins International Airport between 2000 and 2002; however, air traffic volume declined slightly also<br>▪ No benefits identified for DTW |
| Choke Point 7 | Reduced or held constant departure and arrival delays for CVG, DTW, and ORD while air traffic volume increased |
| Offshore Radar/Deep Water Sector | ▪ Based on July 2003 data, reduced Continental departure delays for Fort Lauderdale/Hollywood International Airport (FLL), Miami International Airport, George Bush Intercontinental/Houston Airport, and Orlando International Airport (MCO)<br>▪ Continental estimates annual savings of $250,000<br>▪ Based on August 2003 data, reduced Delta departure delays for FLL and MCO |

**Table ES-2 - Benefits Related to PRM and NAR Initiatives in the OEP**

Our analysis indicated that NAR initiatives in the OEP have benefited users by reducing departure and arrival delays, thereby lowering operating costs. Our analysis also showed that PRM at MSP and STL has benefited users by reducing arrival delays. However, it is uncertain that JFK will receive these same benefits. In addition, the PRM/SOIA procedures planned for STL may negatively impact the airport's operations.

***Recommendations:***

- The Federal Aviation Administration Chief Operating Officer should consider how Precision Runway Monitor can provide operational benefits at John F. Kennedy International Airport prior to implementing the system.
- The Primary Office of Delivery for Precision Runway Monitor (Air Traffic Planning and Procedures Program) should determine whether Precision Runway Monitor/Simultaneous Offset Instrument Approach procedures at Lambert-Saint Louis International Airport could negatively affect airport operations prior to implementing this new capability.

## Finding Three: Operational Evolution Plan Benefits for Precision Runway Monitor and National Airspace Redesign are Difficult to Evaluate Due to Nonspecific Performance Measures and Initiative Tracking Obstacles

OEP benefits for PRM and NAR are difficult to evaluate due to nonspecific performance measures and initiative tracking obstacles. The current OEP measures are not specific enough to adequately measure program and initiative performance. In addition, tracking PRM and NAR initiatives that are listed in the OEP is difficult and can hinder stakeholders' efforts to analyze program performance.

Each of these challenges reinforces the fact that assessing the performance of a program is currently difficult and often ineffective. The OEP and its PRM and NAR programs will not be able to effectively analyze the results of and benefits from program implementation until appropriate performance measures are established and program initiatives can be tracked.

***Recommendations:***

- The Air Traffic Organization, Operational Evolution Plan Office, Operational Evolution Plan Primary Office of Delivery, and the Office of System Capacity should work together to develop performance measures that will align high-level measures with program-specific benefits that address customer needs.
- The Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should establish a performance measures plan that includes methods and responsibilities for collecting pre-implementation data.
- The Chief Operating Officer should assign a manager and provide this individual with the appropriate resources to oversee the integration of key databases to enable the sharing of data and the alignment of strategic performance measures.
- The Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should ensure that initiatives and their milestones can be tracked in future versions of the Operational Evolution Plan.

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# Introduction

## Background

The Operational Evolution Plan, or OEP, "is the Federal Aviation Administration's (FAA) ten year plan to increase the capacity and efficiency of the National Airspace System (NAS) while enhancing safety and security."[3] The OEP provides stakeholders with the near, mid, and long term goals of programs that the FAA is undertaking to address current challenges in the NAS while enhancing safety. The OEP is divided into four sections (1) arrival and departure rates, (2) en route congestion, (3) airport weather conditions, and (4) en route severe weather. Each program in the OEP maps directly to one of these four areas.

The FAA conceived and developed the OEP as a way to address capacity and delay issues after record passenger enplanements and severe weather constrained the NAS during the summer of 2000. The FAA completed the first published version (Version 3.0) of the OEP by June 2001. That version has since been followed by two updated documents, the latest being Version 5.0 which the FAA released in December 2002.[4]

In January 2003, the Associate Administrator for Research and Acquisitions (ARA-1) and the Associate Administrator for Air Traffic Services (ATS-1) requested that the NAS Configuration Management and Evaluation Staff's Program Evaluation Branch (ACM-10) conduct an evaluation of the OEP with a focus on two programs – National Airspace Redesign (NAR) and Precision Runway Monitor (PRM). The final report was to provide ARA-1 and ATS-1 with the status of both OEP programs, citing whether the programs were on track to meet their current and future commitments. The report also needed to document the issues and roadblocks each program was facing, as well as measure and report any benefits from implemented initiatives.

## Objectives

The objectives of the evaluation were to (1) determine the status of the NAR and PRM programs, showing if each would meet their current and future commitments, (2) identify roadblocks to program implementation, and (3) identify benefits, based on performance measures, that stakeholders have received from the programs.

## Scope/Methodology

Conducting an assessment of the entire OEP was not feasible in the eight-month time period set aside for this evaluation. Therefore, ARA-1 and ATS-1 asked the team to focus on the NAR and PRM programs. The team gathered both qualitative and quantitative data, using the qualitative data to determine the status of each initiative and the quantitative data to assess program benefits. The general process that the team followed for NAR and PRM data collection is shown in Figure 1. The specific methodology used to determine the status of each program's initiatives is discussed below.

3 *Operational Evolution Plan Version 5.0*

4 *The evaluation team realizes that Version 5.1 came out in August 2003. However, the last full version of the OEP was version 5.0, which was the document used in this evaluation.*

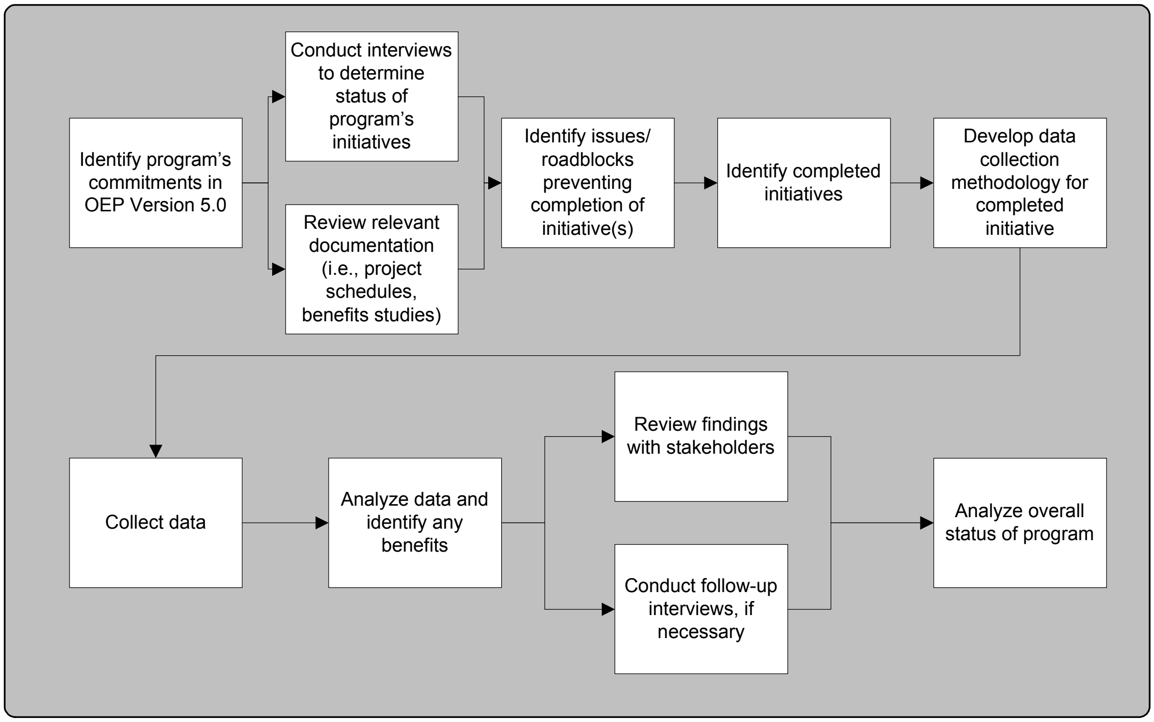


**Figure 1 - OEP Evaluation Methodology**

## Precision Runway Monitor Methodology

### *Qualitative Data Collection*

The evaluation team followed a slightly different approach for assessing the status of PRM commitments in the OEP. The team first conducted a series of interviews with Headquarters (HQ) personnel to obtain background information and an understanding of the program. The interviews included the following groups:

- FAA's Terminal Business Services – En Route Surveillance Services (ATB-450)
- FAA's Flight Standards Service (AFS)
- OEP Primary Office of Delivery for PRM - Air Traffic Planning and Procedures Program (ATP)

Next, the team determined that trips to PRM sites were necessary in order to talk with stakeholders about their PRM systems and obtain data that could be used in a benefits study. The team limited site visits to Minneapolis Saint Paul International Airport (MSP), Lambert - Saint Louis International Airport (STL), and Philadelphia International Airport (PHL) where PRM has been operational at one time or another. The team also thought it beneficial to visit John F. Kennedy International Airport (JFK), as conflicting stories regarding JFK's PRM had surfaced during early interviews. During each site visit, the team spoke with representatives from the following organizations:

- Airports
- Terminal Radar Approach Control (TRACON) facilities

- National Air Traffic Controllers Association (NATCA)
- FAA's Airway Facilities Service

In addition, the team conducted telephone interviews with representatives from the other PRM sites (i.e., Hartsfield-Jackson Atlanta International Airport (ATL), Cleveland Hopkins International Airport (CLE), and San Francisco International Airport (SFO)). Interviewees included representatives from the following organizations:

- FAA's ATP
- FAA's ATB-450
- Major airlines
- International Federation of Airline Pilots' Association
- Airline Pilot's Association
- FAA's AFS
- TRACON facilities
- FAA's NAS Implementation Program
- Airport management

The evaluation team interviewed a total of 71 stakeholders to determine the status of the PRM program and understand the challenges that the program faces as it works to meet its current and future commitments.

### *Quantitative Data Collection*

One of the evaluation team's objectives was to determine if PRM increased throughput and reduced delays at operational sites. To determine if sites realized these benefits, the team collected Traffic Management Log data at STL and MSP, the only two sites with historical PRM operations. The team then shaped the data collection methodology to fit each site's unique characteristics and requirements, using Aviation System Performance Metrics (ASPM), Post Operations Evaluation Tool (POET), the OPSNET database, and the Runway Delay Simulation (RDSIM) Model to collect, model, and analyze delay, weather, and runway configuration data. The data collection methodology and results for MSP, STL, and JFK can be found in Appendices A, B, and C, respectively. The results of the qualitative and quantitative data collection are discussed in Findings 1 and 2.

## National Airspace Redesign Methodology

### *Qualitative Data Collection*

For NAR, the team undertook an iterative process of interviewing, reviewing, and assessing data. The team initially met with the Air Traffic Airspace Management Program (ATA-1) to discuss the NAR program and to gain an understanding of the program's history and background. To determine the status of each program, the team created a detailed matrix that included each NAR initiative listed in OEP Version 5.0. The team requested that each Region provide an update of the current status for its assigned NAR programs. At the same time, ATA-1 provided the updated status of all NAR initiatives, noting changes in schedule and scope since the publishing of OEP Version 5.0. The team combined all of the data from the Regions and from Headquarters, noting any discrepancies between dates and/or roadblocks. When the team required clarification, we followed up with ATA-1 or the relevant Region to ensure that the status of each initiative was correctly documented.

***Quantitative Data Collection***

The evaluation team also identified completed NAR initiatives to determine if any data could be collected and analyzed in a benefits assessment. For each completed initiative, the team developed a separate data collection methodology and used several resources and databases to obtain relevant data. The process used to collect data is shown in Figure 2.

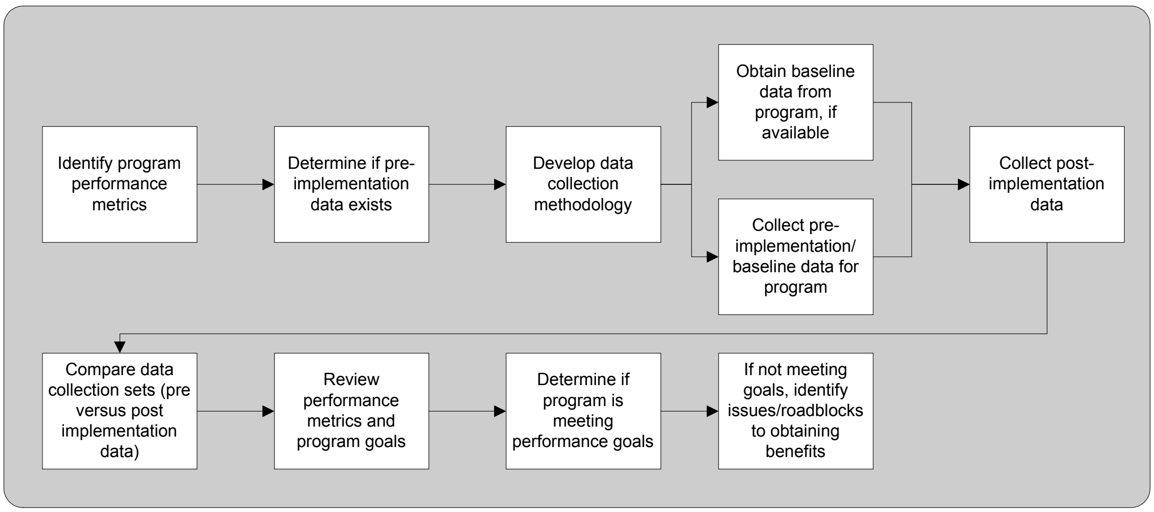


**Figure 2 - NAR Quantitative Data Collection Methodology**

The data used to assess NAR benefits came from a variety of sources including:

- POET
- Flight Explorer
- ASPM
- Air Transport Association
- Enhanced Traffic Management System (ETMS)

The data collection methodology and benefits analysis for each implemented NAR program can be found in Appendices D - F. The results of the qualitative and quantitative data collection are discussed in Findings 1 and 2.

# Constraints

The evaluation team understands that the OEP is an evolving document, designed to share the FAA's ten-year plan with stakeholders throughout the aviation industry and to be flexible in meeting the needs of stakeholders and the demands of the aviation environment. Because the document is designed to change or evolve over time, the evaluation team did not consider slight initiative changes or schedule slips to be significant. For those initiatives that significantly changed focus or milestone dates, the evaluation team used internal and external stakeholder perspectives to determine how such changes would affect other projects and negatively impact modernization.

The evaluation team was asked to assess only the PRM and NAR programs in the OEP. While evaluating two programs does not represent a significant sample of OEP initiatives, the programs can be used as case studies to illustrate the challenges and benefits that have resulted from OEP commitments through FAA programs. Other programs within the OEP and throughout the FAA are likely facing the same types of challenges and can benefit from the recommendations set forth in this evaluation.

The evaluation team attempted to obtain quantitative data on each completed initiative. In some cases, benefits could not be assessed because initiatives were not fully operational at the time of the evaluation, benefits could not be measured, or pre-implementation data was not available (e.g., PHL PRM operations). The evaluation team used various techniques and data collection methodologies to assess benefits for as many completed PRM and NAR initiatives as possible.

# Program Descriptions

The following sections provide a brief description of the PRM and NAR programs. These descriptions are to provide essential background information that will aid in understanding the evaluation team's findings and recommendations.

## Description of Precision Runway Monitor

In 1987, the FAA initiated a contract to develop, deliver, and test two prototype surveillance systems in response to the need for a Parallel/Converging Runway Monitor. The FAA determined that one test site would be Raleigh Durham International Airport (RDU) and the other site would be Memphis International Airport (MEM). The equipment was expected to increase airport acceptance rates in instrument meteorological conditions (IMC) at airports with closely spaced parallel instrument runways. The FAA installed e-scan radar at RDU and back-to-back Mode-S at MEM. By 1991, the FAA completed the testing and evaluation phases and began working to acquire the prototype tested at RDU, discontinuing the prototype tested at MEM. Shortly after, Congress directed the FAA to purchase five PRM systems. The FAA commissioned the system at RDU and installed another system at MSP. The FAA later decommissioned RDU's PRM after American Airlines closed their hub, reducing the level of operations. Final site selection included MSP, JFK, STL, PHL, SFO, CLE, and ATL.

PRM is a high-update surveillance radar that provides air traffic control the ability to conduct simultaneous approaches during IMC on parallel runways separated by less than 4300 feet. PRM radar provides an update rate of approximately one second and greater resolution when compared to the 4.8-second update rate of the Airport Surveillance Radar (ASR). Currently, PRM is installed at JFK and SFO and is commissioned at PHL, STL, and MSP.

Airports that have multiple parallel runways (two or three) with spacing between the runway centerlines of 2500 to 4300 feet can use PRM to conduct simultaneous independent parallel approaches during poor weather conditions. Without the PRM technology and necessary procedures, these airports would be required to conduct dependent parallel approaches, significantly reducing the airport's arrival rate during poor weather conditions. Independent simultaneous parallel approach procedures are dependent upon the spacing between runway centerlines.

PRM's one-second update radar is able to closely track and predict the path of each arriving aircraft. If one aircraft is predicted to cross into the 2000 foot wide No-Transgression Zone (NTZ), controllers first notify the pilot and ask him/her to return to the localizer. The NTZ is a corridor of airspace located centrally between the two runway approach paths where controller intervention is required when the airspace is penetrated by an aircraft conducting an independent simultaneous approach to the adjacent parallel runway. The localizer provides a signal that aircraft use to align their aircraft with the runway centerline on final approach. If the pilot does not respond to the controller's request and penetrates the NTZ (called a blunder), the controller will break out the opposite aircraft. This requires the break out pilot to manually turn the aircraft away from the blundering aircraft and rejoin the arrival stream.

For parallel approaches where the runways (centerline to centerline) have greater than or equal to 4300 feet of separation, PRM is not required for simultaneous/independent parallel approaches. When runway spacing falls below 4300 feet, PRM monitored approaches are required to maintain an arrival rate at or near the Visual Flight Rules (VFR) arrival rate. The straight in approach, shown in Figure 3 below, is used for runways whose centerlines are between 3400 feet and 4300 feet apart.[5]

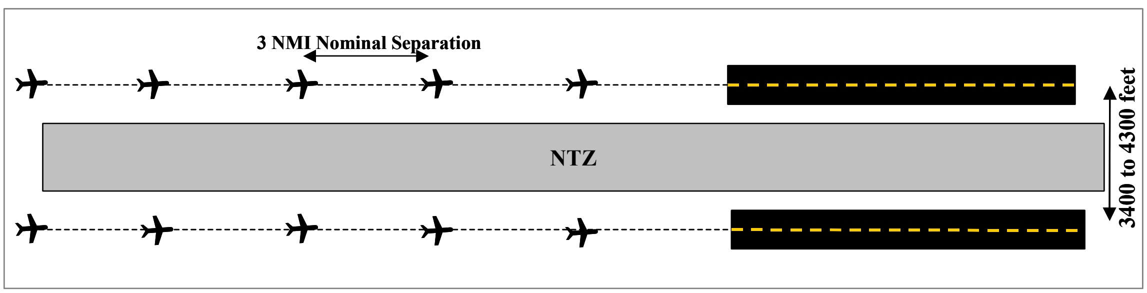


**Figure 3 - Straight In Approach Using PRM**

If this approach were not available, arrivals would be required to fly a staggered/dependent approach, shown in Figure 4.

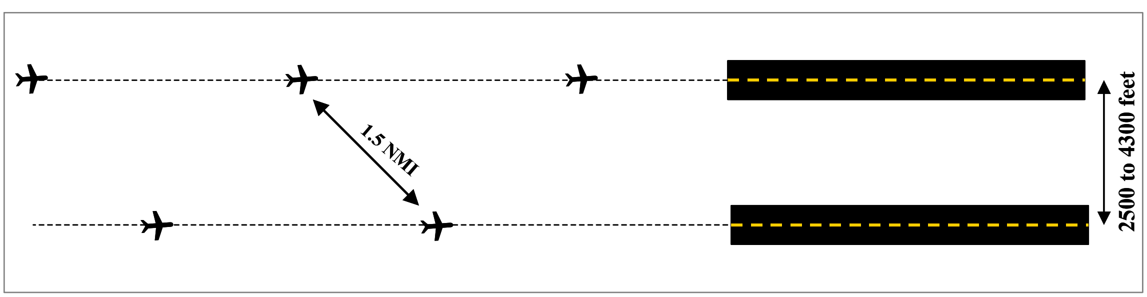


**Figure 4 - Dependent Parallel Approaches (No PRM)**

The offset Instrument Landing System (ILS) approach is used for airports where parallel runways are spaced between 3000 feet and 3400 feet apart. An offset localizer is used to provide

5 *The distance between runway centerlines at MSP is 3380 feet.*

a 2.5 degree offset signal, as shown in Figure 5. Aircraft gradually turn into the runway centerline as they approach the runway threshold.

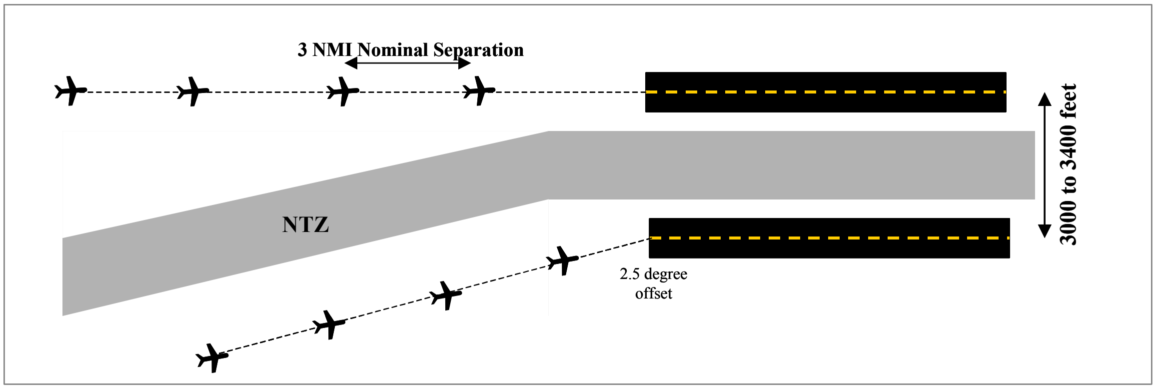


**Figure 5 - Offset ILS Approach**

At STL, a Localizer Type Directional Aid (LDA) approach is currently used to provide separation so that the airport arrival rate can be maintained during IMC. The LDA approach requires that pilots gain visual contact with the parallel aircraft at the Missed Approach Point (MAP). STL uses PRM to monitor the LDA approach up to the point where visual contact is established at the MAP. If visual contact is not established, one of the aircraft will conduct a missed approach, rejoining the arrival stream. Figure 6 depicts the approach.

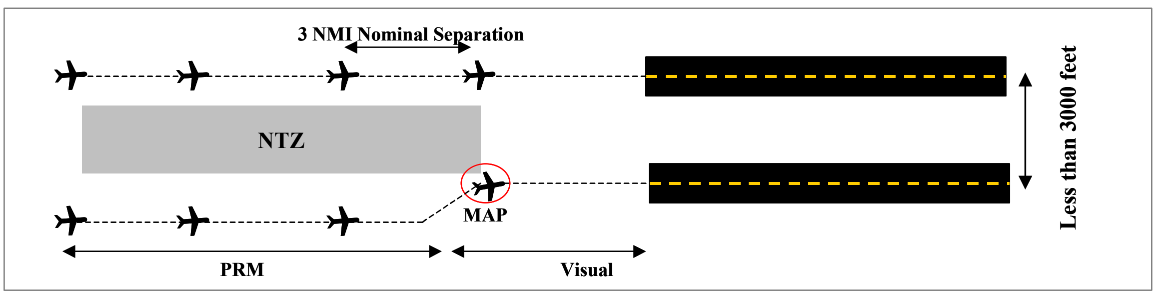


**Figure 6 - Localizer Type Directional Aid Approach**

The final PRM approach is the Simultaneous Offset Instrument Approach (SOIA) for runways that have spacing less than 3000 feet apart. Air traffic control monitors the approach on PRM monitors to required minimums at which point a visual approach is required. SOIA allows aircraft to conduct simultaneous approaches at minimums lower than the LDA approach. Figure 7 depicts the approach.

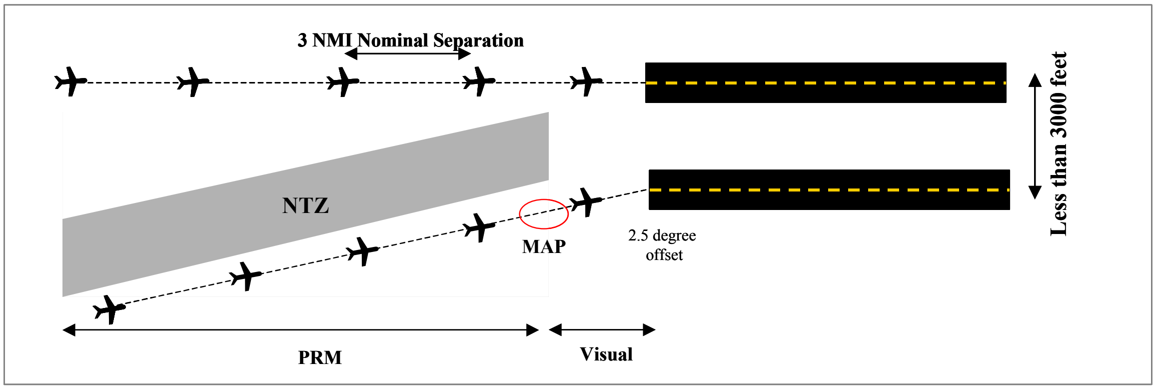


**Figure 7 - Simultaneous Offset Instrument Approach**

ATB-450 expects PRM to provide each site with specific benefits as listed in Table 1 below. Those benefits will depend on the runway spacing, approach procedures, arrival rates, and minimum weather conditions at each site.

| Site | Type of Approach | Expected Arrival Rate Per ATB-450 |
|---|---|---|
| ATL | Straight In/Triples | Up to 23 additional aircraft/hr |
| CLE | SOIA | Estimated 16 additional aircraft/hr |
| JFK | Offset | 3 additional aircraft/hr |
| MSP | Straight In | 4 additional aircraft /hr |
| PHL | Offset | Up to 17 additional aircraft/hr |
| SFO | SOIA | Estimated 13 additional aircraft/hr[6] |
| STL | LDA/SOIA | Up to 16 additional aircraft/hr[7] |

**Table 1 - Site Configuration Data**

The near term (2003 – 2005) and mid term (2006 – 2009) PRM milestones shown in OEP Version 5.0 are listed below. The OEP did not include specific milestones for PHL and CLE. PHL initiated operations in 2003, and CLE is scheduled to begin operations in 2004. Version 5.0 also contains a milestone for Detroit Metropolitan Wayne County International Airport (DTW), which has been designated a *potential* site for PRM.

Near Term Milestones

- Resume PRM at MSP by FY03 Quarter 2
- Install SFO PRM
- Install JFK PRM
- Implement PRM-SOIA at STL
- Implement PRM-SOIA at SFO
- Complete Wake Safety assessment at STL and SFO

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6 *ATP expects benefits for SFO in the range of 4 to 8 additional aircraft per hour.*

7 *STL expects benefits of 20 additional aircraft per hour.*

Mid Term Milestones

- Further site specific SOIA procedure development as new sites are approved and use PRM
- Address Enhanced Surveillance capability at DTW and ATL

## Description of National Airspace Redesign Program

NAR is a program charged with reviewing and redesigning domestic and oceanic airspace in order to provide airspace modernization. The goals of the NAR program are to reduce delays and congestion, increase the flexibility of the airspace, and provide airspace options to pilots and controllers, while maintaining or improving safety records. The program involves Regional stakeholders who are largely responsible for the airspace redesign efforts that involve their facilities and/or sectors. ATA-1 serves as the lead for all NAR initiatives including Regional efforts. NAR is the mechanism by which ATA and regions are modernizing the national airspace to meet the demands and conditions of today's needs.

NAR is a highly visible program, affecting a vast majority of aviation industry stakeholders. NAR is also a major program in the OEP, encompassing terminal and en route airspace redesign, which requires the coordination of ATA, Regional airspace coordinators, and various stakeholders throughout the NAS.

NAR requires the coordination of a vast number of aviation industry stakeholders and has required ATA to conduct formal and informal briefings, attend public meetings, and work with working groups and advisory committees. NAR uses a phased implementation approach to complete and implement initiatives. Version 5.0 splits NAR initiatives into near-term, mid-term, and long-term phases. The milestone date for each initiative is based on the level of effort and resources that are required to complete the task.

The two formally recognized national initiatives that were listed in the OEP Version 5.0 include:

- High Altitude Redesign
  - High Altitude Redesign Phase I
  - High Altitude Redesign Phase I Expansion
  - High Altitude Redesign Phase I Completion
  - High Altitude Redesign Phase II Initial
  - High Altitude Redesign Phase II Expansion/Completion
  - High Altitude Redesign Phase III
- Oceanic Redesign
  - Oakland Center (ZOA) Oceanic Airspace
  - Miami Center (ZMA)/Houston Center (ZHU) Gulf Reroutes
  - Anchorage Center (ZAN) Oceanic Redesign
  - Caribbean Reroutes

Other initiatives coordinated at the national level include:

- Choke points
- Area Navigation (RNAV)
- Potomac TRACON
- ZOA/ZAN Airspace

Regional initiatives comprise a large part of airspace redesign and require significant coordination to ensure that a region's airspace redesign initiatives do not negatively impact adjacent regions. Table 2 lists the regional initiatives discussed in OEP Version 5.0.

| Regional National Airspace Redesign Initiatives | |
|---|---|
| Bay to Basin/AWP En Route (includes Santa Barbara Expansion) | Denver South Airspace |
| Northwest 2000 / PHX Redesign | ZDV Redesign |
| SFO Dual CEDES | ZSE Redesign |
| Las Vegas 4 Corner Post | PDX Class B airspace |
| Las Vegas North Resectorization | ZLC Area Realignment |
| Honolulu Redesign | ZTL/ATL/CTL/ GSO Runway expansion and airspace redesign |
| NCT Internal Airspace Redesign[8] | CVG Runway and Terminal Redesign |
| San Diego East Arrival Project | MCO 4th Runway Airspace Redesign |
| ZOA/NCT Redesign | MIA 4th Runway |
| LAX Departure Project | ATL ARTCC North South Flows / Midwest Airspace Capacity Enhancements |
| LAX Profile Efficiency Project/Independent Flows | Houston Area Air Traffic System (HAATS) – Airspace for new runway |
| Western Alaska | Midwest Expansion |
| Southeast Alaska | Great Lakes Corridor |
| Interior Alaska | Boston Consolidated TRACON |
| Anchorage Terminal Redesign | Northern Utah Airspace/Salt Lake City 4 Corner |
| ZAN Domestic/Oceanic Airspace Redesign | SEA/PDX Terminal Redesign |
| NY/NJ/PHL Metropolitan Airspace Redesign | Midwest Airspace Plan |
| NYICC | Omaha Airspace Redesign |
| KC ARTCC east end resectorization and restratification | |

**Table 2 - NAR Regional Initiatives in OEP Version 5.0**

[8] *Part of Bay to Basin*

# Findings and Recommendations

The evaluation team, after completing data collection and analysis, found the following:

1. Many Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan milestones are behind schedule.
2. Implemented Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan initiatives are providing benefits, but expected benefits from incomplete initiatives remain uncertain.
3. Operational Evolution Plan benefits for Precision Runway Monitor and National Airspace Redesign are difficult to evaluate due to nonspecific performance measures and initiative tracking obstacles.

## Finding One: Many Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan Milestones are Behind Schedule

Although FAA has met some of its OEP milestones related to PRM and NAR, many of these milestones are behind schedule due to unresolved operational issues, budget cuts, and other implementation issues. As a result of these milestones not being met, users (i.e., air carriers, passengers, and airports) will not be able to derive benefits as promised in the OEP.

### Precision Runway Monitor

Of the eight PRM milestones scheduled for the near- or mid-term, five are not being met or are not on track to be met.[9] Further, two of the three attained milestones (i.e., install PRM at SFO and JFK) provide no benefits without operational implementation of the PRM capability.

Table 3 lists the near-term and mid-term PRM milestones in OEP version 5.0 and their status.

| Milestone | Due Date | Status |
|---|---|---|
| Install SFO PRM | Near-Term | Complete. However, no benefits accrue from installation. |
| Install JFK PRM | Near-Term | Complete. However, no benefits accrue from installation |
| Further site specific SOIA procedure development as new sites are approved and use PRM | Mid-Term (2006-2009) | In progress |
| Resume PRM at MSP by FY03 Quarter 2 | FY 2003 Quarter 2 (March 03) | Implemented FY04 Quarter 1 (December 2003) |
| Implement PRM-SOIA at STL | FY 2004 | In progress. Several issues remain and it is unclear if commitment will be met. |

[9] *Although PRM is operational at PHL and scheduled for implementation in CLE, the OEP version 5.0 did not list milestones for these sites. Therefore, they are not discussed in this finding.*

| Milestone | Due Date | Status |
|---|---|---|
| Implement PRM-SOIA at SFO | FY 2004 | In progress. Several issues remain and it is unclear if commitment will be met. |
| Complete Wake Safety assessment at STL and SFO | Near-Term (by September 30, 2005) | Completed. SFO to be reassessed when updated data is available. |
| Address Enhanced Surveillance capability at DTW and ATL | Mid-Term (2006-2009) | ATL approved for PRM. DTW is under consideration for PRM. |

**Table 3 - OEP milestones for PRM and their status**

***Minneapolis-Saint Paul/Wold-Chamberlain International Airport (MSP)***

FAA did not meet the OEP milestone for MSP to resume operations by March 2003 due to runway construction and loss of the Instrument Landing System (ILS) capability during the summer months. As a result of this delay, users were unable to reap the benefits of PRM capability at MSP. However, MSP resumed PRM operations in December 2003, nine months past the target date.

***San Francisco International Airport (SFO)***

The FAA has met the OEP Version 5.0 milestone to install PRM at SFO. However, it will be difficult for SFO to begin PRM/SOIA operations in FY 2004 as scheduled in the plan because the FAA has not resolved a number of operational issues at SFO. If SFO does not begin PRM/SOIA operations in time to meet the OEP milestone, SFO users will not be able to benefit from reduced arrival delays and increased throughput until these outstanding issues have been resolved.

The OEP version 5.0 milestone for SFO SOIA implementation is early FY 2004. SFO hopes to initiate PRM/SOIA operations sometime in the first six months of CY 2004. However, it will be difficult for implementation to occur because the FAA recently (November 20, 2003) completed negotiations on a national agreement regarding PRM/SOIA operations with NATCA. In addition, AFS is working with the International Civil Aviation Organization to make a safety case for PRM/SOIA operating procedures. Since national standards have been developed, the FAA will have to develop customized PRM/SOIA operating procedures for each site.

The following items need to be completed at SFO before the milestone can be accomplished:

- Procedures development for PRM/SOIA operations.
- Local NATCA agreement on PRM/SOIA.
- Training for pilots on PRM/SOIA procedures.
- Training for controllers on PRM/SOIA procedures.
- Commissioning the PRM. The system is installed but is awaiting flight check and commissioning.
- SFO Waiver to the SOIA order that addresses site-specific operational issues. The waiver was requested from AFS in August 2003, but it has not yet been granted. The waiver requests a change in the procedures for transferring communications from approach controllers to tower controllers for aircraft that are performing SOIA

approaches. The SOIA Order requires communications to be transferred to tower controllers about 15 miles out. SFO wants arrival controllers to continue monitoring SOIA approaches until the missed approach point at which time the transfer of communication to the tower controller would occur.

If the PRM/SOIA operation is not implemented in SFO in time to meet the milestone, users will be unable to benefit from reduced arrival delays and increased throughput that result from PRM operations. SFO estimates that PRM/SOIA will enhance capacity from the current 30-32 aircraft in poor weather conditions to 36-38 aircraft using PRM. In the 1990's, during a brief experiment with an LDA approach operating in conjunction with an ASR-9, SFO realized arrival rates as high as 45 aircraft per hour. Plans for an additional runway have been placed on hold due to environmental concerns, increasing the urgency to implement PRM. Aircraft operations are currently down since the events of September 11, 2001 (9/11), but as traffic levels increase, PRM benefits will become more important. Users at SFO are very supportive of PRM implementation.

***Lambert - Saint Louis International Airport (STL)***

It will be difficult for STL to begin PRM/SOIA operations in FY 2004 as provided in the OEP because the FAA has not resolved a number of operational issues associated with PRM/SOIA at STL. However, the impact of a delay will be minimal, since STL has increased its arrival rate and reduced arrival delay by implementing an ILS/LDA approach procedure in marginal visual meteorological conditions.

The PRM/SOIA approach may not become operational in FY 2004 because of several unresolved operational issues similar to those at SFO, including:

- Procedures development for PRM/SOIA operations.
- Local NATCA agreement on PRM/SOIA.
- Training for pilots on PRM/SOIA procedures
- Training for controllers on PRM/SOIA procedures

***John F. Kennedy International Airport (JFK)***

FAA has met the OEP version 5.0 milestone to install PRM at JFK. However, it is unclear whether JFK will achieve any operational benefits from PRM operations for two reasons: (1) the high level of expected pilot nonparticipation and (2) local FAA officials believe there are very limited opportunities to use PRM due to shared airspace with La Guardia Airport (LGA). The evaluation team's benefit assessment for JFK is discussed in more detail on pages 19 and 20 of this report.

***Hartsfield-Jackson Atlanta International Airport (ATL) and Detroit Metropolitan Wayne County Airport (DTW)***

OEP version 5.0 states that FAA will address enhanced surveillance needs at ATL and DTW by 2009 (mid-term). While ATL appears to be on schedule to commission PRM in January 2007, DTW is not currently scheduled to receive enhanced surveillance capability due to budget cuts in FY 2004. The PRM program requested $23 Million in FY 2004. This budget would enable the program office to procure systems for both ATL and DTW. However, it appears that Congress will only appropriate $6-$8 Million. Given that amount, FAA will be unable to pursue PRM at DTW.

Without a PRM in DTW, users will be unable to achieve the benefits of an operational PRM, including increased arrival rates and fewer delays. Users at DTW, including Northwest Airlines, were enthusiastic about the benefits that could be achieved at that airport.

## National Airspace Redesign

Of the 54 NAR initiatives[10] in the OEP, 25 are not on track to meet the milestones. According to the NAR Primary Office of Delivery, ATA-1, three of the 25 initiatives were published in OEP version 5.0 with incorrect milestones. The remaining 22 initiatives have been impacted by changes in project scope, the RNAV moratorium, budget cuts, and environmental issues. Until these issues are resolved, users will not reap the benefits associated with these initiatives in the OEP.

Table 4 lists the 22 NAR initiatives that were not on track to meet the milestones in OEP Version 5.0 as of June 2003, including their current estimated completion dates and the reason for schedule slips, as provided by ATA-1.

| NAR Initiative | Milestone In OEP Version 5.0 | Estimated Completion Date | Reason for Schedule Slip |
|---|---|---|---|
| Northwest 2000/PHX Redesign | 2002-2003 | March 2005 | RNAV Moratorium |
| SFO Dual CEDES | 2002-2003 | April 2006 | Scope Refined |
| Las Vegas North Resectorization | 2002-2003 | November 2004 | RNAV Moratorium, Scope Refined |
| San Diego East Arrival Project | 2002/2003 | August 2005 | RNAV Moratorium |
| LAX Departure Project | 2003 | 2005 | RNAV Moratorium and Rulemaking |
| LAX Profile Efficiency Project | 2003 | 2006 | RNAV Moratorium and Rulemaking |
| KC ARTCC East End Resectorization and Restratification | 2004 | March 2006 | Scope of project extended |
| Northern Utah Airspace/ Salt Lake City 4 Corner Post | 2003 | 2005 | Lack of funding |
| SEA/PDX Terminal Redesign | 2002-2003 | Dec 2005 | Scope refined, may be impacted by lack of funding |
| ZDV Redesign | 2003 | 2004 | Refining schedule, may be impacted by lack of funding |
| ZSE Redesign | 2004 | 2005 | Refining schedule, may be impacted by lack of funding |
| MCO 4th Runway Airspace Redesign | Oct 2003/2004 | June 2005 | Scope refined, may be impacted by lack of funding |

10 *Two initiatives were expanded into 5 initiatives because they had different milestones.*

| NAR Initiative | Milestone In OEP Version 5.0 | Estimated Completion Date | Reason for Schedule Slip |
|---|---|---|---|
| ATL ARTCC North South Flows/Midwest Airspace Capacity Enhancements | Jan 2003 | Jan 2006 | Scope refined, may be impacted by lack of funding |
| ZLC Area Realignment | 2004 | 2005 | Refining schedule, may be impacted by lack of funding |
| PDX Class B Airspace | 2004 | 2007 | No information provided |
| CLT Runway Expansion and Airspace Redesign | 2005 | 2006 | Pushed back due to airline financial problems |
| GSO Runway Expansion and Airspace Redesign | 2005 | 2008 | No information provided |
| Honolulu Redesign | 2002 | 2004/2005 | Environmental Extension |
| NCT Internal Airspace Redesign | 2002-2003 | 2005 | No information provided |
| ZOA/NCT Redesign | 2003 | 2005 | Initiative tied to Northern CA resectorization |
| Interior Alaska | 2004 | 2005 | Part of ZAN Airspace Redesign |
| Omaha Airspace Redesign | 2004 | Jan 2005 | Lack of funding |

**Table 4 - OEP NAR Milestones not on track to be met**

Overall, ATA-1 identified three major causes for the slips: (1) changes in project scope, (2) RNAV moratorium, and (3) lack of funding. Fifteen of the 22 initiatives that are not on track to meet milestones are affected by at least one of these overall issues discussed below.[11]

***(1) Changes in Project Scope***

Seven of the 22 NAR initiatives not on track to meet milestones were affected by changes in project scope. These initiatives include SFO Dual CEDES, Las Vegas North Resectorization, Interior Alaska, Kansas City (KC) Air Route Traffic Control Center (ARTCC) East End Resectorization and Restratification, Seattle-Tacoma International Airport (SEA)/Portland International Airport (PDX) Terminal Redesign, Orlando International Airport (MCO) 4th Runway Airspace Redesign, and ATL ARTCC North South Flows/Midwest Airspace Capacity Enhancements.

Since these projects were originally included in the OEP Version 5.0, many have been expanded or merged with other OEP initiatives, affecting their schedules significantly. According to ATA-1, these changes in scope resulted from the evolving nature of the initiatives, and were attempts to combine initiatives for more efficient use of resources, and to more efficiently track project benefits.

[11] *The total of the initiatives listed in the three issues does not add up to 22 because some of the initiatives are affected by more than one of these issues.*

***(2) Area Navigation (RNAV) Moratorium***

According to the OEP, six NAR initiatives associated with RNAV procedures (i.e., Phoenix Redesign, Las Vegas North Resectorization, San Diego East Arrival Project, ZOA/Northern California TRACON (NCT) Redesign, Los Angeles International Airport (LAX) Departure Project, and LAX Profile Efficiency Project/Independent Flows) were to be implemented in 2003. However, it is not likely that these milestones will be met due to the moratorium.

RNAV procedures are used to develop new routes that reduce flow complexity by permitting aircraft to fly optimum routes across terminal and transition airspace with little controller intervention. RNAV procedures were initially implemented as part of NAR's Las Vegas/Phoenix Four-Corner Post initiative. However, the FAA subsequently issued a moratorium on these procedures because they failed to meet a "predictable and repeatable" flight path. Controllers could not predict an aircraft's flight path because the flight management computer's capabilities varied from aircraft to aircraft. The RNAV moratorium included a grandfather clause that permitted Las Vegas to use its existing RNAV procedures after certain modifications had been completed.

FAA has reinstated some RNAV procedures related to Standard Terminal Arrival Routes and plans to reinstate others, such as Standard Instrument Departures, in the near future. Aircraft with minimal capability flight management computers will be able to use these basic RNAV procedures. Future RNAV procedures may require the use of advanced navigation equipment, such as a global positioning system and global navigation satellite service.

***(3) Lack of Funding***

The NAR program budget for 2003 was cut over $13 million from $37 million to less than $24 million, which has the potential to impact eight of the 22 initiatives not on track to meet their milestones. The full impact of this budget cut had not been determined during our evaluation timeframe.

## Summary

As discussed above, causes for not meeting OEP milestones varied both between and within the two programs we evaluated. However, unresolved operational issues were a major cause for failure to meet milestones in both the PRM and NAR programs. PRM and NAR initiatives that involve developing and implementing new operating procedures may not meet milestones in the OEP. However, these milestones may not be realistic because new procedures require the consensus of a diverse group of stakeholders. It is difficult for the group to reach consensus on new operating procedures because there is no single FAA manager ultimately responsible for delivering the new service or capability.

Further, changes in project scope, the RNAV moratorium, and budget cuts have impacted many OEP NAR milestones, causing initiative schedules to slip. The purpose of the OEP is to inform stakeholders of the FAA's progress and commitments in NAR and other programs. Therefore, it is important that initiatives and dates listed in the OEP are accurate and realistic so that stakeholders are able to accurately plan and schedule initiatives that depend on NAR.

***Recommendations***:

- The Federal Aviation Administration Chief Operating Officer should assign a single Federal Aviation Administration manager with ultimate responsibility for implementing a new system or solution, such as Precision Runway Monitor or Area Navigation. This manager would be responsible for coordinating with Flight Standards Service and external stakeholders when developing and implementing new operating procedures.
- The Operational Evolution Plan Office should examine Operational Evolution Plan initiatives other than Precision Runway Monitor and National Airspace Redesign to determine whether they are facing similar operational challenges related to procedural development.
- To ensure the accuracy and traceability of initiative and milestone dates in the Operational Evolution Plan, the Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should consider listing milestones as short-term, mid-term, or long-term.

# Finding Two: Implemented Precision Runway Monitor and National Airspace Redesign Operational Evolution Plan Initiatives are Providing Benefits, but Expected Benefits from Incomplete Initiatives Remain Uncertain

Users are benefiting from PRM and NAR initiatives in the OEP that have been implemented by the FAA, but expected benefits from other initiatives remain uncertain. For instance, it is not clear that users will benefit from PRM operations at JFK because of issues related to shared airspace and pilot nonparticipation. Also, the reduction in air traffic since 9/11 has limited the benefits from some initiatives already implemented. Notwithstanding the impact of 9/11, initiatives already implemented have helped users lower operating costs by increasing throughput and reducing departure and arrival delays.

## Precision Runway Monitor Benefits

### *Precision Runway Monitor Benefits at Minneapolis-Saint Paul/Wold-Chamberlain International Airport (MSP)*

While PRM operations at MSP have been sporadic since 1997, users have benefited from using this approach. The evaluation team used the FAA's Investment Analysis and Operations Research Division (ASD-400) laboratory to gather POET data for the summer of 2002 based on MSP's air traffic logs. The evaluation team then worked with the FAA's Simulation and Analysis Group (ACB-330) to reverse engineer a baseline using RDSIM. Through the simulation, the evaluation team determined that PRM operations resulted in an average of one additional aircraft arrival during a push in which PRM was used.[12] Using the Air Transport Association's cost of delay data[13], the team calculated an *average* annual savings to aircraft operators and passengers of $61,052 based on MSP's assumption that they currently use PRM during arrival pushes approximately 80 days per year.

It is important to note that these benefits accrued at a time when traffic levels continued to be lower due to the effects of 9/11, thereby limiting the potential benefits of PRM. As airport operations increase, PRM benefits will become more important. In addition, a new runway scheduled to open in 2005 will increase potential benefits by permitting separation of departures from arrivals, thus eliminating required departure gaps from the arrival stream. Since PRM operations have been resumed, these benefits should begin to accrue.

Some issues remain with respect to resuming PRM operations at MSP. According to the facility, the large number of nonparticipating aircraft was a continual problem during PRM usage in the past, and limited the benefits that could be achieved. New PRM procedures were designed to correct this problem by requiring nonparticipating pilots to request a slot time in advance during periods of PRM operations. However, facility contacts verified with airport users that a significant number of non-participating aircraft continue to use MSP, and it remains to be seen how well the new procedure will work.

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12 *The analysis was performed using RDSIM, at the WJHTC. For complete results and methodology, see Appendix A.*

13 *Cost of delay data includes aircraft operating costs, extra gates and airline personnel, traveler costs, and cargo costs.*

### *Precision Runway Monitor Benefits at Lambert – Saint Louis International Airport (STL)*

Users have benefited from an ILS/LDA approach that is supported by PRM. While the ILS/LDA approach is not an official "PRM approach," the procedure is conducted under IMC only when the PRM at STL is operational and in use. We analyzed the results of the PRM-supported approach at STL by comparing arrivals during timeframes when PRM was operational to timeframes when PRM was out of service. Results indicated that STL saved an average of 1.44 minutes of airborne delay per aircraft using PRM. In addition, arrival rates using PRM were maintained at 52 aircraft per hour, while other approaches at STL accepted between 32 and 48 arrivals per hour in less than visual conditions. Stakeholders at STL were enthusiastic about the approach and its benefits.

According to the OEP, STL will begin conducting a PRM/SOIA approach in FY 2004. This operation will entail one straight-in approach and one offset ILS approach to the parallel runways. There is no evidence that this approach will permit additional delay or throughput benefits over those already achieved in current operations. The benefits of the PRM/SOIA approach are that pilots on the offset approach will have a glide slope and will be required to perform less abrupt turns during the visual segment of the approach. The approach will be in accordance with nationally approved standards.

The STL facility believes that the proposed requirements for the PRM/SOIA approach may change the PRM-supported approach at STL significantly and result in a loss of benefits. Unresolved issues include requirements that pilots on parallel approaches be fully trained and that pilots (as opposed to controllers) be solely responsible for providing visual separation for aircraft on final approach.

### *Precision Runway Monitor Benefits at John F. Kennedy International Airport (JFK)*

While PRM has been installed at JFK, the equipment is not operational at this time. The benefits of PRM operations at JFK remain uncertain because of the high level of expected pilot nonparticipation and limited opportunities to use the approach due to shared airspace with La Guardia Airport. Unless these issues are resolved, users will not benefit from reduced arrival delays and increased throughput at JFK.

JFK's parallel runways, 22L/22R, are separated by 3000 feet. JFK could conduct operations with weather minimums as low as runway visual range for runway 22R of 4000 feet and runway visual range for 22L of 1800 feet.[14] Aircraft arriving on runway 22L will take the straight-in approach while aircraft arriving on 22R will take a 3.0 degree offset approach. PRM is projected to provide two additional arrivals per hour, regardless of the conditions. During Instrument Flight Rules (IFR) weather, PRM approaches will allow 42 arrivals per hour; without PRM, arrivals will be reduced to 40.[15] While PRM is scheduled for commissioning in Fiscal Year 2004 Quarter 2, two site-specific issues make achieving benefits with PRM at JFK uncertain.

The primary issue is proximity of airspace used by JFK, LGA, Westchester County Airport (HPN), and Farmingdale Republic Airport (FRG). There are several airspace concerns regarding the use of PRM at JFK.

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14 *Ceiling data based on JFK's reported weather minimums*

15 *Based on JFK's arrival rates*

- The use of PRM at JFK would require delegation of the surrounding airspace because PRM breakout maneuvers require airspace beyond what is allocated to JFK. This delegation would create significant delays at LGA when it is operating in one particular configuration (departing runway 31 and landing runway 22). Since creating such delays at LGA would negate PRM benefits at JFK, PRM would only be used when LGA is not in that configuration and when JFK is using the PRM runways. Personnel at New York TRACON estimated that these conditions would exist less than five days per year.
- JFK arrivals are vectored in close proximity into FRG at 2000 and 3000 feet. FRG arrival and departures that use the 2000-foot vector would be halted while PRM operations were conducted at JFK. This would have a major impact on FRG.
- HPN lands and departs on Runway 16 approximately 65 percent of the time in a calendar year. This configuration is required for JFK to establish Runway 22L/22R arrivals with the appropriate separation.

To verify the New York TRACON's estimate regarding the required runway configuration for JFK and LGA during PRM operations, we used ASPM data to analyze the number of times in a one-year period (August 2002-August 2003) when JFK and LGA operated in configurations compatible with PRM use. We were unable to collect data and verify the New York TRACON's estimates for HPN and FRG required runway configurations, as ASPM did not provide such data for either airport. We concluded that configurations compatible with PRM operations at LGA and JFK were never used together during the analysis period. Thus, during the past year, there would have been no opportunities to use PRM at JFK, regardless of weather conditions. However, with appropriate airspace changes and daily reviews of operations at JFK and LGA, JFK might find arrival periods where PRM is beneficial. For more information on this analysis, see Appendix C.

A second issue at JFK is pilot nonparticipation in PRM approaches. JFK is an international airport with more than fifty percent of its arrivals from non-United States airlines. Currently, 56 non-U.S. flag carriers provide service at JFK, as compared to 15 U.S. carriers.[16] Many non-U.S. airlines are not trained to fly PRM approaches. The International Federation of Air Line Pilots Association confirmed that the process of informing members about PRM operations is underway, but that the process would be a slow one due to the number of members and the disparity in size and resources of members. Also, a number of pilots working for international airlines make few trips per year to PRM airports, so training the pilots and keeping them current on PRM approaches could be difficult and present a significant financial burden. A large number of non-participants will negate any PRM benefits at JFK.

Unless these issues are resolved, JFK users will not benefit from reduced arrival delays and increased throughput. In addition, the FAA already has invested significant resources installing PRM at JFK and additional funding will be required for commissioning. Until these issues are resolved, no return on this investment is possible.

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[16] *The Port Authority of NY and NJ December 2002 Traffic Report*

## National Airspace Redesign Benefits

***National Airspace Redesign Benefits from Las Vegas McCarran International Airport (LAS) Area Navigation (RNAV) and Four-Corner Post Initiatives***

The FAA's implementation of the Las Vegas McCarran International Airport (LAS) RNAV and Four-Corner Post initiatives is allowing users to optimize airspace and routes for arrivals and departures. The agency accomplished this objective by designing routes around Special Use Airspace surrounding the airport, offering less restrictive climbs, and providing flight idle descents where fuel consumption is optimized through gradual altitude changes.

MITRE Corporation's Center for Advanced Aviation System Development (CAASD) reviewed delay metrics in a January 2003 benefits analysis to determine if changes to the Las Vegas airspace and implementation of a four-corner post were providing the intended benefits. MITRE-CAASD compared pre-implementation data from ASPM (January 2000-October 2001) to post implementation data (November 2001-December 2002) and determined that the number and duration of arrival and departure delays had decreased slightly after the initiatives were implemented. Since operations at LAS had returned to nearly pre-9/11 levels, the delays were related to airspace changes rather than a decrease in operations.

We performed a similar data analysis, but extended the post-implementation period an additional 8 months to August 2003. Appendix E provides a detailed summary of our analysis. Overall, our analysis supported MITRE-CAASD's results and showed that the general downward trend in delays continued over the additional 8-month implementation period.

<u>Declining Trend in Las Vegas McCarran International Airport (LAS) Average Departure Delays</u>

Figure 8 illustrates the decline in LAS average departure delays per aircraft from 17.40 minutes (pre-implementation) to 12.57 minutes (post-implementation).

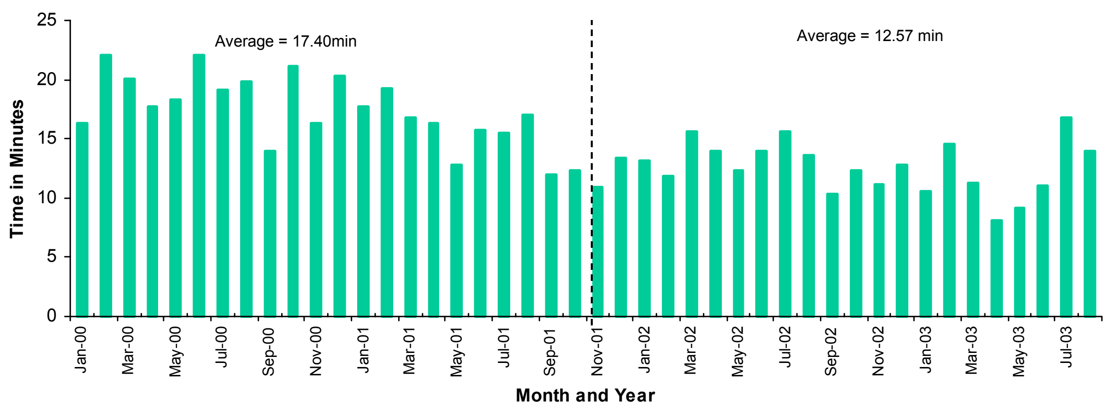


**Figure 8 - LAS Average Departure Delays Per Aircraft**

Based on Air Transport Association departure delay and airborne delay cost statistics, the decrease in departure delays resulted in average cost savings per month of approximately $1.6 million as shown in Table 5.

| | Pre Implementation Period | Post Implementation Period |
|---|---|---|
| Average Departure Delay | 17.40 min/aircraft | 12.57 min/aircraft |
| Cost per minute of Delay[17] | $22.38 | $22.38 |
| Average Number of Departures per month | 14,111 | 13,715 |
| Total Cost per Month | $5,494,992 | $3,858,257 |
| **Average Savings per Month** | **$1,636,735** | |

**Table 5 - Cost/Savings of LAS Average Departure Delays**

Our data analysis also showed that the average percentage of delayed departures decreased from 32.81 percent (pre-implementation) to 24.6 percent (post-implementation).

<u>Declining Trend in Las Vegas Average Gate Arrival Delays</u>

Figure 9 illustrates the decline in LAS average gate arrival delays per aircraft from 13.57 minutes (pre-implementation) to 9.79 minutes (post-implementation). Since the cost statistics related to gate arrival delays were not available, we could not determine the cost savings associated with this decrease in average gate arrival delays.

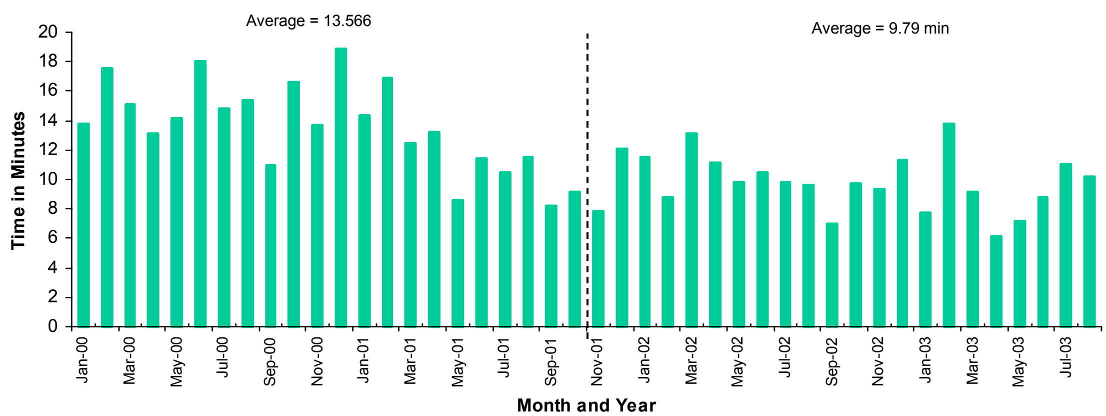


**Figure 9 - LAS Average Gate Arrival Delays Per Aircraft**

Our data analysis also showed that the average percentage of LAS delayed arrivals decreased from 24.72 percent (pre-implementation) to 19.12 percent (post-implementation).

While the LAS RNAV and Four-Corner Post initiatives have increased capacity and reduced delays, Figure 10 shows that LAS did not experience an increased demand for capacity over the post-implementation period. With the exception of September 2001, LAS operations have remained relatively stable since July 2000.

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[17] *Based on gate delay costs from Air Transport Association figures*

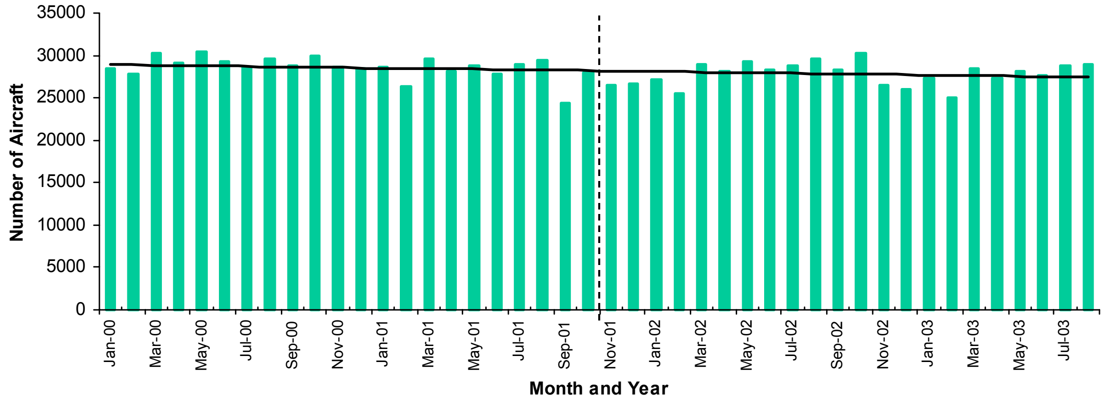


**Figure 10 - LAS Operations January 2000 – August 2003**

***National Airspace Redesign Benefits from National Choke Points Initiative***

The FAA's implementation of the national choke points initiative has resulted in reduced average departure delays in seven areas of the northeastern United States. Using ETMS data from the Airspace Analysis Laboratory and ASPM, we analyzed choke point departure and arrival data for selected dates in 2000, 2001, and 2002. Due to time and resource constraints, we limited our data analysis by selecting only: 1) clear weather days to eliminate the effect of weather on airport operations and 2) days with high air traffic volume (Thursdays from May through August). Arrival delays, departure delays, and airborne delays are calculated as the difference between the actual and scheduled times as provided by ETMS data. Below is a brief summary of our analysis related to each choke point area. Appendix F provides a detailed summary of our analysis.

<u>Choke Point Initiatives 1 and 2: Westgate and Northgate Departures from the New York Metropolitan Airports</u>

The objective of these two choke point initiatives was to implement "fixes" that would address the large volume of air traffic departing from the New York TRACON airspace. The FAA initiated a total of 10 fixes to reduce departure delays in these two choke point areas. Therefore, our analysis focused on air traffic flying over these 10 fixes on clear weather Thursdays from May through August. The analysis included a total of 23 days, 8 days in 2000 (pre-implementation), 7 days in 2001 (during implementation), and 8 days in 2002 (post-implementation).

The average departure delays for choke points 1 and 2 declined from 2000 through 2002 as shown in Figure 11. Average departure delays for choke point 1 decreased from 33.37 minutes per aircraft in 2000 to 30.9 minutes per aircraft in 2002. Similarly, average departure delays for choke point 2 decreased from 36.03 minutes per aircraft in 2000 to 31.28 minutes per aircraft in 2002.

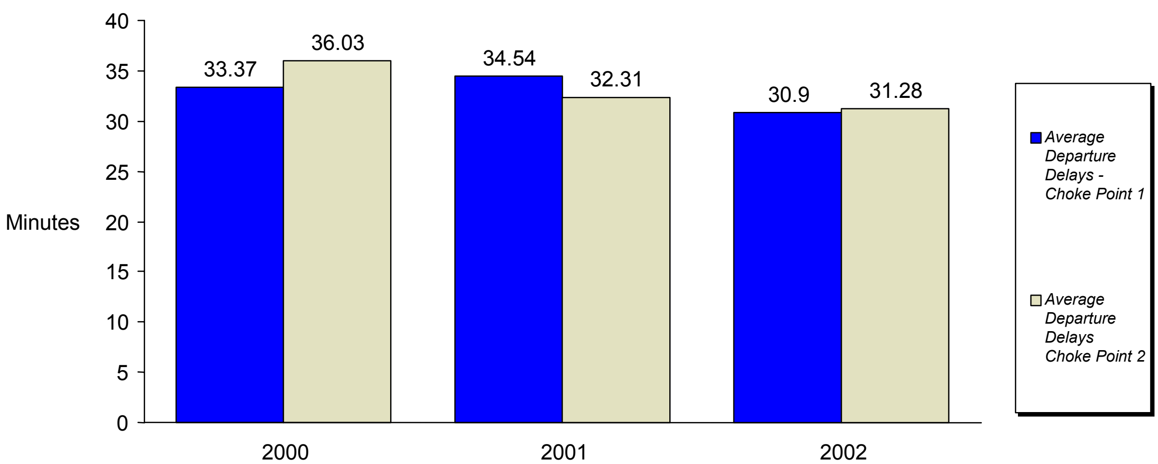


**Figure 11 - Average Departure Delays for Choke Points 1 & 2**

Since the average number of aircraft using the Westgate and Northgate fixes remained relatively constant from 2000 (pre-implementation) to 2002 (post-implementation), it is clear that choke point initiatives 1 and 2 assisted in the FAA's efforts to reduce congestion in these areas.

However, the decline in average departure delays cannot be attributed solely to these initiatives because there were other projects in the New York region, such as the Departure Spacing Program, being implemented to alleviate congestion, sequence departures, and efficiently move traffic.

Choke Point 3 Initiative: Washington ARTCC Sectors

The objective of this choke point initiative was to reduce congestion by sequencing air traffic from the Washington ARTCC that is inbound to New York. The FAA initiated fixes to reduce departure and arrival delays in four Washington ARTCC sectors. Therefore, our analysis focused on air traffic flying over these four sectors on clear weather Thursdays from May through August. The analysis included a total of 18 days, 8 days in 2000 (pre-implementation), 4 days in 2001 (during implementation), and 6 days in 2002 (post-implementation).

The average departure delays and average arrival delays for choke point 3 declined from 2000 through 2002 as shown in Figure 12. The average departure delays for choke point 3 declined from 27.88 minutes per aircraft in 2000 to 19.67 minutes per aircraft in 2002. Average arrival delays also decreased for choke point 3 from 39.5 minutes per aircraft in 2000 to 21.83 minutes per aircraft in 2002.

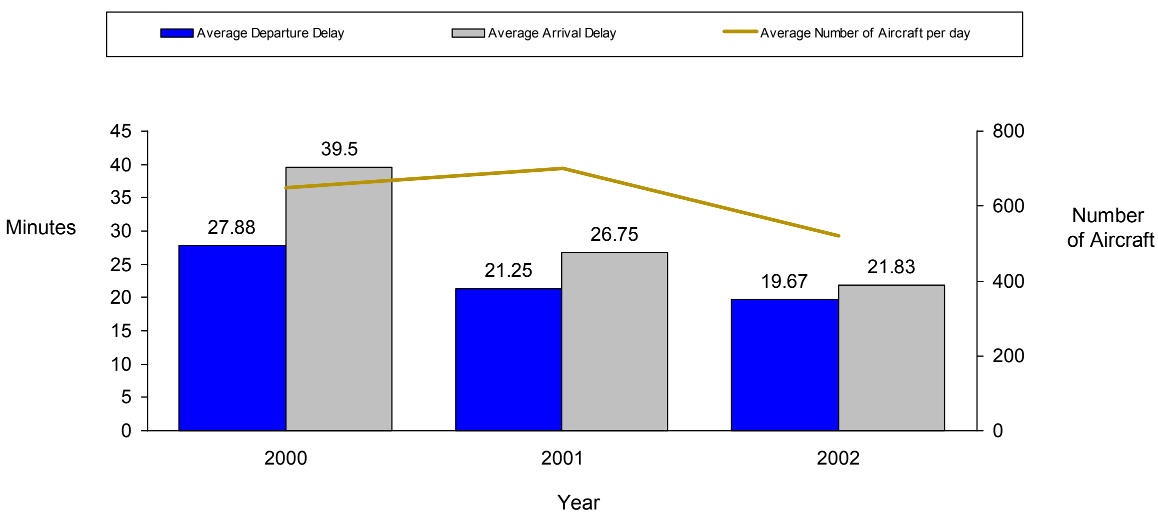


**Figure 12 - Average Departure and Arrival Delays for Choke Point 3**

While average departure and arrival delays decreased from 2000 to 2002, the average number of aircraft using the Washington ARTCC sectors also declined to below the pre-implementation level. However, there is an indication that the choke point 3 initiative assisted the FAA in reducing congestion. Average departure and arrival delays continued to decline significantly between 2000 and 2001 while the average number of aircraft using these sectors actually increased 8 percent.

Choke Point 4 Initiative: West Departures Over Jet Route 547 (J547) From the Northeast

The objective of this choke point initiative was to reduce congestion on the major westbound airway from Boston ARTCC to Chicago O'Hare International Airport (ORD), Chicago Midway International Airport (MDW), Detroit, Cleveland, and Cincinnati. The FAA initiated various fixes to reduce arrival delays for flights using the J547 flight path. Therefore, our analysis focused on traffic using this flight path on clear weather Thursdays from May through August. Our initial analysis of the average number of aircraft using the J547 flight path included a total of 32 days, 10 days in 2000 (pre-implementation), 12 days in 2001 (during implementation), and 10 days in 2002 (post-implementation).

Due to time constraints, however, we limited our analysis of delay statistics to one day per month from May through August for years 2000 through 2002. For each month, we selected the date that had the highest number of flights with complete flight data. We did not include July 2001 because we did not have complete data.

The average difference in actual versus planned departure and arrival times declined from 2000 to 2002 as shown in Figures 13 and 14, respectively. When the 2000 and 2002 average departure delays, shown in Figure 13, were averaged, the evaluation team found a decline in average departure delays. Aircraft using choke point 4 averaged 30.18 minutes of departure delay per aircraft in 2000 and 18.13 minutes of departure delay per aircraft in 2002.

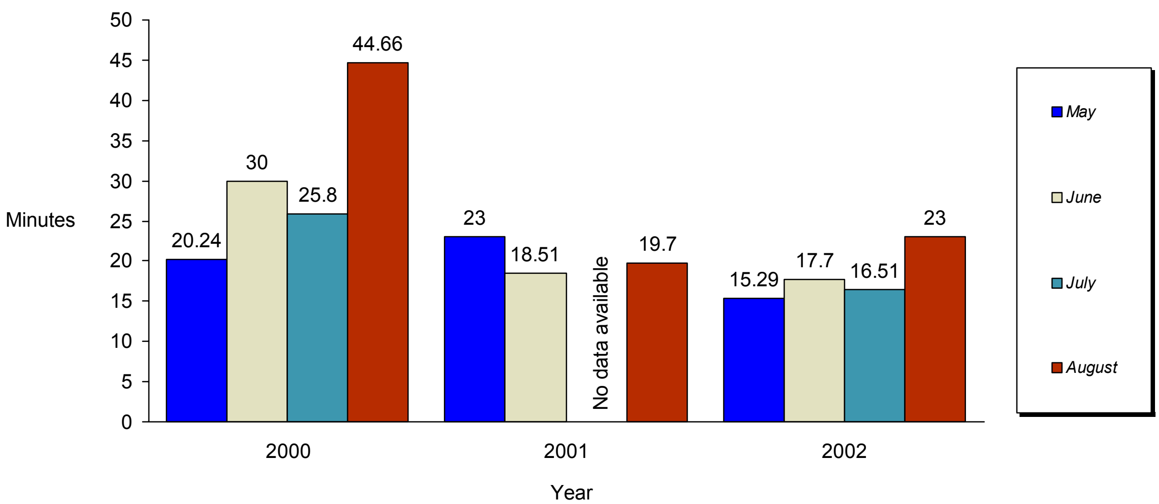


**Figure 13 - Average Departure Delays for Choke Point 4**

As shown in Figure 14, average arrival delays declined over the 2000 to 2002 period. Aircraft using choke point 4 averaged 12.33 minutes of arrival delay in 2000. In 2002, aircraft using choke point 4 arrived, on average, 10.87 minutes early.

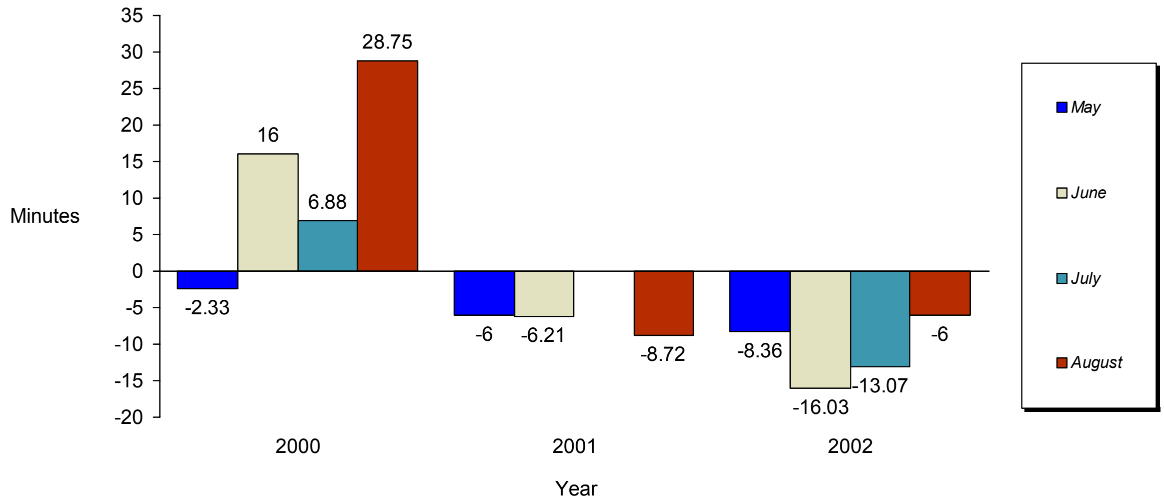


**Figure 14 - Average Arrival Delays for Choke Point 4**

Since the average number of aircraft using J547 remained relatively constant from 2000 through 2002, it is clear that choke point 4 reduced departure and arrival delays along this route.

<u>Choke Point Initiatives 5 and 6: Great Lakes Corridor and High Altitude En Route Holding of East Coast Arrivals</u>

The objective of these two choke point initiatives was to reduce the congestion and complexity of the airspace in the Chicago, Cleveland, and Indianapolis ARTCCs related to aircraft moving into and out of New York and within the geographic boundaries of the Great Lakes centers. The objective of the High Altitude En Route Holding of East Coast Arrivals was to reduce departure and arrival delays caused by high altitude holding restrictions related to the starts and stops of arrivals at east coast airports. These holding patterns resulted in delays for ORD, DTW, CLE, PIT, and Cincinnati/Northern Kentucky International Airport (CVG). The FAA implemented various fixes to reduce congestion along the Great Lakes Corridor.

Our analysis focused on flights originating at ORD, DTW, CLE, PIT, and CVG and passing through sectors Chicago Center (ZAU), Cleveland Center (ZOB), and/or Indianapolis Center (ZID) on clear weather Thursdays from May through August. Our initial analysis of the average number of aircraft using these sectors included a total of 139 days from the five airports, 48 days in 2000 (pre-implementation), 36 days in 2001 (during implementation), and 55 days in 2002 (post-implementation).

Due to time constraints, however, we had to limit our analysis of delay statistics to one day per month from May through August for years 2000 through 2002. Also, we had to substitute three clear-weather Fridays for Thursdays at CVG due to poor weather conditions.

Table 6 shows the percentage of change in the average number of departures, departure delays, and arrival delays for ORD, DTW, CVG, CLE, and PIT from 2000 (pre-implementation) to 2002 (post-implementation).

| Airport | Change in Average Departure Delays 2000 v. 2002 | Change in Average Arrival Delays 2000 v. 2002 | Change in Average Number of Departures 2000 v. 2002 |
|---|---|---|---|
| ORD | -13.0% | -50.0% | +15.5% |
| DTW | +8.0% | +3.3% | +4.7% |
| CVG | -4.8% | -24.0% | +10.3% |
| PIT | -5.3% | +3.9% | +0.7% |
| CLE | -10.5% | -17.4% | -2.8% |

**Table 6 – Percentage of Change in Average Number of Departures, Departure Delays, and Arrival Delays for Choke Points 5 and 6**

The results of choke point initiatives 5 and 6 are mixed:

- ORD, DTW, CVG, and PIT average departures increased between 2000 and 2002; however, both average departure and arrival delays decreased only for ORD and CVG. This decline was significant for average arrival delays (more than 20 percent).
- DTW average departure and arrival delays increased, although the increase in arrival delays was slight (less than 5 percent).
- PIT average departure delays decreased while arrival delays increased slightly (less than 5 percent).
- CLE average departures declined slightly (less than 5 percent), while average departure and arrival delays decreased noticeably (more than 10 percent).

In summary, ORD, CVG, and CLE seem to have received the most benefits from choke point initiatives 5 and 6.

Choke Point 7 Initiative: Departure Access to Overhead Streams

The objective of this choke point initiative was to reduce congestion for aircraft north and eastbound from CVG, east and southbound from DTW, and eastbound from Chicago by providing access to overhead streams. The FAA implemented various fixes to reduce departure delays from CVG, DTW, and ORD to specific city pairs by providing access to overhead streams.

Our analysis focused on flights between specific city pairs on clear weather Thursdays from May through August. However, we had to substitute three clear-weather Fridays for Thursdays at CVG due to poor weather conditions.

- CVG to ORD, CLE, PIT, Newark Liberty International Airport (EWR), and PHL
- DTW to CLE, LGA, EWR, PHL, CVG, Memphis International Airport (MEM), ATL, and Nashville International Airport (BNA)
- ORD to Ronald Regan Washington National Airport (DCA), Boston's Logan International Airport (BOS), LGA, EWR, and PHL

Our analysis included a total of 106 days from the three airports, 27 days in 2000 (pre-implementation), 23 days in 2001 (during implementation), and 29 days in 2002 (post-implementation).

The average departure and arrival delays for CVG, DTW, and ORD decreased from 2000 to 2002 as shown in Figure 15.

The average departure delays for CVG and DTW decreased as follows:

- CVG – from 22 minutes per aircraft in 2000 to 17.5 minutes in 2002
- DTW – from 24 minutes per aircraft in 2000 to 22 minutes in 2002

The average departure delay for ORD increased slightly from 25 minutes per aircraft in 2000 to 25.75 minutes in 2002

The average arrival delays for CVG, DTW, and ORD decreased as follows:

- CVG – from 26 minutes per aircraft in 2000 to 19.5 minutes in 2002
- ORD – from 50 minutes per aircraft in 2000 to 29.75 minutes in 2002
- DTW – from 30.75 minutes per aircraft in 2000 to 28.25 minutes in 2002

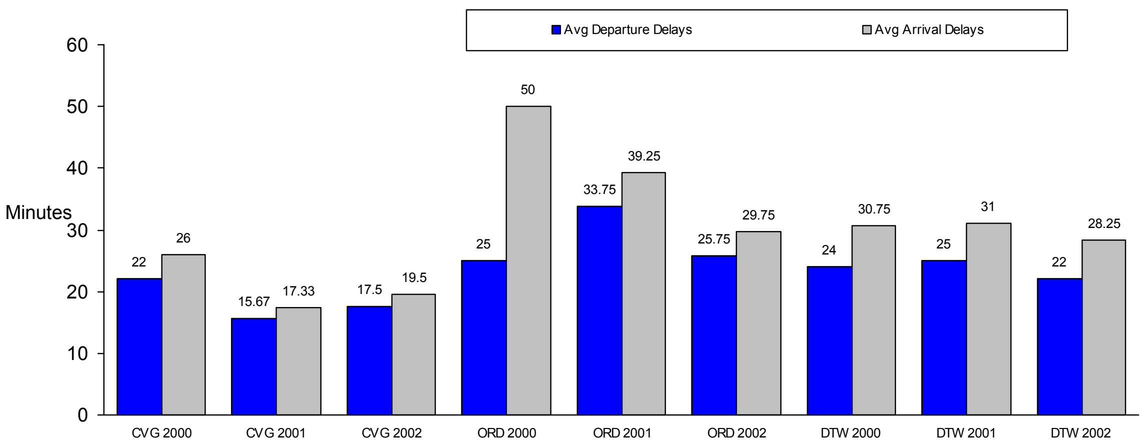


**Figure 15 - Average Arrival and Departure Delays per Aircraft CVG, ORD, and DTW for Choke Point 7**

With the average number of aircraft between the CVG, DTW, and ORD city pairs increasing from 2000 through 2002 and average departure and arrival delays decreasing or holding constant, it is clear that the choke point 7 initiative reduced departure and arrival delays between these routes.

*National Airspace Redesign Benefits from Offshore Radar/Deepwater Sector Initiative*

The FAA's implementation of the northeast offshore radar/deepwater sector initiative is providing users new routing options to avoid the heavily traveled eastern corridor. Several airlines, including Continental, Delta, and Jet Blue, have used these routes to reduce their departure delays. Using data from ASPM and POET, we analyzed Continental and Delta's usage of these routes in July and August of 2003, respectively. Appendix D provides a detailed summary of our analysis.

Continental uses the offshore/deepwater routes for volume offloads as well as severe weather avoidance when traveling from the northeast to several southern destinations. Continental estimates that it has saved in excess of $250,000 a year in reduced taxi-out times using the offshore/deepwater routes. In addition, these routes have improved the airline's overall on-time performance and helped maintain schedule integrity.

Based on our analysis of Continental flights from EWR to Ft. Lauderdale/Hollywood International Airport (FLL), Miami International Airport (MIA), George Bush Intercontinental/Houston Airport (IAH), and MCO during July 2003, the airline reduced operating costs by reducing its average departure delays as shown in Table 7 below:

| Destination | Average Minutes Delay Per Delayed Departure-Normal Route | Cost of Average Departure Delay[18]-Normal Route | Average Minutes Delay Per Delayed Departure-Offshore Route | Cost of Average Departure Delay-Offshore Route |
|---|---|---|---|---|
| ***FLL*** | ***45.88*** | ***$1,139*** | ***3.62*** | ***$ 90*** |
| ***MIA*** | ***56.27*** | ***$1,397*** | ***20.33*** | ***$ 505*** |
| ***IAH*** | ***55.26*** | ***$1,372*** | ***40.67*** | ***$1,010*** |
| ***MCO*** | ***54.31*** | ***$1,349*** | ***16.46*** | ***$ 409*** |

**Table 7 - Cost of Average Departure Delays, Continental Airlines Offshore and Deepwater Sectors**

Based on our analysis of Delta flights from EWR to FLL and MCO during August 2003, the airline reduced operating costs by reducing its average departure delays as shown in the table below:

| Destination | Average Minutes Delay Per Delayed Departure-Normal Route | Cost of Average Departure Delay-Normal Route | Average Minutes Delay Per Delayed Departure-Offshore Route | Cost of Average Departure Delay-Offshore Route |
|---|---|---|---|---|
| ***FLL*** | ***69.07*** | ***$1,715.01*** | ***48.33*** | ***$1,200.03*** |
| ***MCO*** | ***68.65*** | ***$1,704.58*** | ***10.00*** | ***$ 248.30*** |

**Table 8 - Cost of Average Departure Delays, Delta Airlines Offshore and Deepwater Sectors**

[18] *Cost data based on Air Traffic's estimate that gate plus taxi out delays cost airlines $24.83 per minute.*

## Summary of Benefits Related to Precision Runway Monitor and National Airspace Redesign Initiatives in the Operational Evolution Plan

Table 9 summarizes the benefits related to PRM and NAR initiatives in the OEP based on the evaluation team's analysis.

| OEP Initiative | Benefits Based on the Evaluation Team's Analysis |
|---|---|
| PRM at MSP | Based on PRM usage in summer of 2002:<br>▪ Annual average savings of $61,052<br>▪ Average of one additional aircraft arrival during a push |
| PRM at STL | PRM supported approach saved an average of 1.44 minutes of airborne delay per aircraft using PRM |
| PRM at JFK | Future benefits uncertain due to shared airspace with LGA and HPN and pilot nonparticipation issues |
| Las Vegas RNAV & Four Corner Post | ▪ Decrease in average departure delay of 4.83 minutes per aircraft<br>▪ Decrease in average gate arrival delay of 3.78 minutes per aircraft |
| Choke Points 1 & 2 | Reduced departure delays between 2000 and 2002 while air traffic volume remained constant |
| Choke Point 3 | Reduced departure and arrival delays between 2000 and 2002; however, air traffic volume declined also |
| Choke Point 4 | Reduced departure delays between 2000 and 2002 while air traffic volume remained constant |
| Choke Points 5 & 6 | ▪ Reduced departure and arrival delays for ORD and CVG between 2000 and 2002 while air traffic volume increased<br>▪ Reduced departure delays for PIT between 2000 and 2002; however, arrival delays increased. Air traffic volume increased.<br>▪ Reduced departure and arrival delays for CLE between 2000 and 2002; however, air traffic volume declined slightly also<br>▪ No benefits identified for DTW |
| Choke Point 7 | Reduced or held constant departure and arrival delays for CVG, DTW, and ORD while air traffic volume increased |
| Offshore Radar/Deep Water Sector | ▪ Based on July 2003 data, reduced Continental departure delays for FLL, MIA, IAH, and MCO<br>▪ Continental estimates annual savings of $250,000<br>▪ Based on August 2003 data, reduced Delta departure delays for FLL and MCO |

**Table 9 - Benefits Related to PRM and NAR Initiatives in the OEP**

Based on our analysis, the NAR initiatives in the OEP have benefited users by reducing departure and arrival delays, thereby lowering operating costs. Our analysis also showed that PRM at MSP and STL has benefited users by reducing arrival delays. However, it is uncertain that JFK will receive these same benefits. In addition, the PRM/SOIA procedures planned for STL may negatively impact the airport's operations.

*Recommendations:*

- The Federal Aviation Administration Chief Operating Officer should consider how Precision Runway Monitor can provide operational benefits at John F. Kennedy International Airport prior to implementing the system.
- The Primary Office of Delivery for Precision Runway Monitor (Air Traffic Planning and Procedures Program) should determine whether Precision Runway Monitor/Simultaneous Offset Instrument Approach procedures at Lambert - Saint Louis International Airport could negatively affect airport operations prior to implementing this new capability.

# Finding Three: Operational Evolution Plan Benefits for Precision Runway Monitor and National Airspace Redesign are Difficult to Evaluate Due to Nonspecific Performance Measures and Initiative Tracking Obstacles

OEP benefits for PRM and NAR are difficult to evaluate due to nonspecific performance measures and initiative tracking obstacles. The current OEP measures are not specific enough to adequately measure program and initiative performance. In addition, tracking PRM and NAR initiatives that are listed in the OEP is difficult and can hinder stakeholders' efforts to analyze program performance.

## Precision Runway Monitor Performance Measures

The OEP provides four general measures to gauge PRM program benefits. Those measures include increased throughput, decreased delays, decreased fuel consumption, and increased runway acceptance rates.

The OEP does not provide specific performance measures for the PRM program or its individual sites. For example:

- The OEP's current PRM performance measures do not address the site-specific benefits that should occur after operational implementation of PRM. Measures such as increased capacity and reduced delay are too generic and not properly constrained to meet site-specific goals and requirements. Performance measures should help stakeholders identify the point at which a site experiences actual benefits from program implementation. Each PRM airport has a different target at which benefits, in terms of increased capacity and reduced arrival delays, are achieved. Stakeholders must be able to measure performance and work towards those goals for program success.
- Site-specific benefits based on system expectations, level of operations, and cost are neither addressed nor documented in the OEP.
- In assessing the benefits of PRM, the evaluation team found that none of the PRM sites collected pre-implementation data that could be compared to post-implementation data. Pre-implementation data was not collected prior to the implementation of MSP, STL, and PHL PRM operations because performance measures were not established for the sites, nor was pre-implementation information requested.
- The OEP does not provide program or site-specific data requirements that future sites could use as guidance for collecting pre-implementation data. Sites are not responsible for establishing pre-implementation data collection efforts for programs because sites are required to implement and maintain numerous programs. However, some sites collected small amounts of data at the TRACON or Tower for program office assessment.

## National Airspace Redesign Performance Measures

The OEP lists a number of high-level performance measures for NAR. In the en route environment, OEP performance measures for NAR include:

- Reduce en route delay
- Reduce the difference between flight plan time and time as flown
- Reduce the difference between flight plan distance and distance flown
- Increase the percentage of time on filed flight plan versus route flown
- Increase the percentage of time on requested cruise altitude versus altitude flown
- Reduce the time to obtain requested altitude
- Reduce the number of potential conflicts
- Reduce restrictions used to manage sector complexity and congestion

In the terminal environment, OEP performance measures for NAR include:

- Reduce arrival and departure delays
- Increase airport capacity and utilization effectiveness
- Reduce excess gate times (duration and/or occurrence)
- Improved predictability

The OEP does not provide specific performance measures for NAR. For example:

- Current performance measures are not mapped to specific NAR initiatives in the OEP, making it difficult to ensure that stakeholders are receiving their anticipated benefits.
- The OEP does not state how each of the NAR performance measures will be used to calculate aggregate benefits. NAR initiatives are currently assessed independently, which can result in the double counting of benefits. For example, benefits resulting from individual choke points should be reviewed and analyzed at an aggregate level (across all seven choke points) because several choke points helped to relieve congestion at the same airport or sector.
- The current performance measures do not enable ATA-1 to measure the extent at which NAR is meeting external customer needs. ATA-1 is currently working to redefine performance measures to determine if customer needs are being met by current initiatives. Because each customer has different and changing needs, this is a complicated and difficult task.
- In assessing the benefits of NAR, the evaluation team found that NAR stakeholders are not collecting pre-implementation data. However, ATA-1 and MITRE have worked together to assess the benefits of completed initiatives, gathering data from various sources to compare the pre-implementation period with the post-implementation period.

## Precision Runway Monitor and National Airspace Redesign Data Analysis

The lack of specific performance measures and pre-implementation data created challenges for the evaluation team when attempting to assess benefits resulting from PRM and NAR. These same challenges have been or will be experienced by other stakeholders as the FAA moves towards an Air Traffic Organization that will be based on measuring performance.

The first challenge the evaluation team faced was that the FAA does not have a central repository of all of the information needed to gather performance measures. Data resides in number of databases and applications including POET, ASPM, OPSNET, and Traffic Management Logs. None of these applications are able to provide all of the information necessary to merge operational data, weather data, flight/airspace restriction data, and traffic log information. For example, to assess the benefits of PRM at STL, the evaluation team used ASPM to obtain weather data and historical operations data, POET to obtain current operational data, and STL Traffic Management Logs to determine the weather, approaches, and flight restrictions. Piecing this data together to develop an accurate benefits assessment was extremely difficult.

The data that the evaluation team was able to gather often had missing data elements. For example, the evaluation team had to delete flight data from the MSP and choke points benefits analyses due to incomplete or null data sets. The team also could not determine the change in throughput that resulted from the use of the ILS/LDA approach at STL because the team was unable to obtain data on the traffic demand. Stakeholders generally do not have the resources or time to undertake such efforts to obtain and evaluate data.

## Tracking Operational Evolution Plan Initiatives

In attempting to collect and analyze data for PRM and NAR, the evaluation team spent considerable time tracking the status and benefits of each program. Tracking the benefits of the PRM program was difficult because OEP version 5.0 did not include specific milestones for PHL and CLE. PHL initiated PRM operations in 2003, and CLE is scheduled to begin PRM operations in 2005. Without the inclusion of OEP milestones for these sites, it will be difficult to measure the progress of PRM site implementation and the overall benefits of the PRM program to stakeholders.

NAR initiatives were also difficult to track and measure because initiatives identified in the OEP have changed significantly since Version 4.0, including changes in the total number of initiatives/ initiative names and milestone dates. These revisions were due to new program strategies, initiative consolidations, and budget fluctuations. While these changes may have been warranted, it is difficult for stakeholders to track the progress and measure the benefits of NAR initiatives from one version of the OEP to the next.

- *Total Number of Initiatives* - The NAR program office has consolidated and changed the names of many initiatives since Version 4.0. Between Version 4.0 and Version 5.0, five initiatives were consolidated and between 5.0 and 5.1, eight initiatives were consolidated. In some cases, the NAR program office consolidated initiatives to avoid duplicative counting when measuring benefits tied to multiple initiatives.

- *Milestone Dates* - HQ and the Regions did not agree on the implementation status of 7 of 31 NAR initiatives in the OEP being managed by the Regions.[19] Most differences seemed to be miscommunications between HQ and the Regions. While HQ was responsible for determining the implementation status of NAR initiatives in the OEP, stakeholders may have received conflicting information about the implementation status of initiatives managed by the Regions. According to the Primary Office of Delivery, ATA-1, HQ provides the actual implementation status of all NAR initiatives, including those managed by the Regions. However, several Regions (Northwest Mountain Region, Western Pacific Region (AWP), Alaskan Region, and Central Region) did not agree with the implementation status provided by HQ. For all but one of the initiatives, most of the discrepancies related to milestone differences of one year or less. However, the implementation status for the SFO Dual CEDES initiative varied by several years. While most of these discrepancies did not appear to be substantial, internal and external stakeholders were confused about the actual implementation status of NAR initiatives in the OEP.

Each of these challenges reinforces the fact that assessing the performance of a program is currently difficult and often ineffective. The OEP and its PRM and NAR programs will not be able to effectively analyze the results of and benefits from program implementation until appropriate performance measures are established and program initiatives can be tracked.

*Recommendations:*

- The Air Traffic Organization, Operational Evolution Plan Office, Operational Evolution Plan Primary Office of Delivery, and the Office of System Capacity should work together to develop performance measures that will align high-level measures with program-specific benefits that address customer needs.
- The Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should establish a performance measures plan that includes methods and responsibilities for collecting pre-implementation data.
- The Chief Operating Officer should assign a manager and provide this individual with the appropriate resources to oversee the integration of key databases to enable the sharing of data and the alignment of strategic performance measures.
- The Operational Evolution Plan Office, in conjunction with the Primary Office of Delivery, should ensure that initiatives and their milestones can be tracked in future versions of the Operational Evolution Plan.

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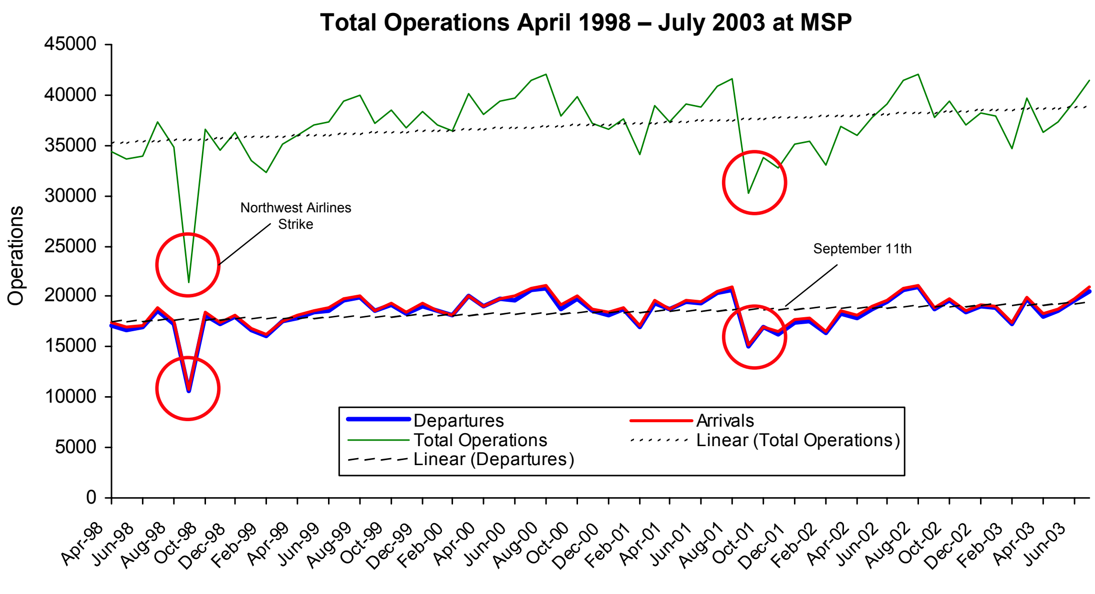
[19] *There were 8 other initiatives being managed by the Regions, but they did not provide implementation dates for these initiatives.*

# Appendix A:  Methodology and Data Collection Results for Minneapolis-Saint Paul Precision Runway Monitor Benefits Assessment

## Background of Minneapolis – Saint Paul International Airport (MSP) Precision Runway Monitor Operations

MSP relies on a high level of operations to obtain the full benefits of their PRM system.  The *Minneapolis Capacity Enhancement Plan*, published in 1993, calculated that MSP would reach an annual delay savings from PRM of $20 million[1] when annual operations totaled 530,000. When MSP reached 600,000 annual operations, the airport would see $66 million in annual delay savings.  ASPM reported that 2002 operations at MSP totaled 453,757, well below the 530,000 operations projected in the Plan (the Plan did not project the dates that MSP would reach these levels of operation).

MSP operations have returned to pre – 9/11 levels with the trend in arrivals and departures continuing upward, as shown in Figure A.1.  However, MSP will be well short of the 530,000 to 600,000 annual operations for the foreseeable future based on the current rate of growth.

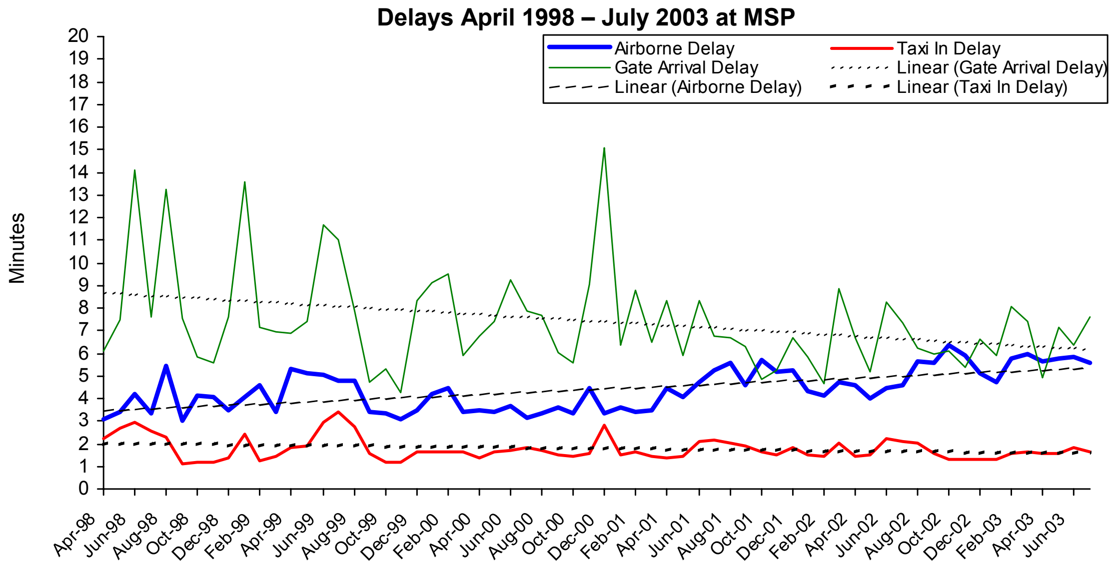



*Source:  ASPM*

**Figure A.1 - Total Operations at MSP from April 1998 through July 2003**

Figure A.2 shows that gate arrival delays have been declining (see trendlines) and that taxi in, airborne, and gate arrival delays have recently seen less fluctuation.  Based on data from the *Minneapolis Capacity Enhancement Plan,* the current levels of operation, and the decline in delays over the past few years, the evaluation team did not expect to see *significant* delay savings resulting from the use of PRM during the summer of 2002.

[1] *These figures are in 1992 dollars.*




*Source: ASPM*

**Figure A.2 - MSP Delays from April 1998 through July 2003**

# Data Collection

The objective of reviewing MSP pre and post PRM data was to determine if stakeholders had received the intended benefits – increased throughput and decreased delays – from the use of PRM approaches. To do so, the team needed baseline and post implementation data from MSP logs. The goal was to compare the pre-implementation data to post-PRM implementation data, to determine if MSP received increased throughput and decreased delays when PRM was in use.

## Post Implementation Data

Through our initial interviews, the evaluation team found that MSP recorded their use of PRM during the summer of 2002. Beginning April 27, 2002, MSP supervisors required that the TRACON record *daily* information on PRM – if PRM was not used, the TRACON was to record the reason for non-usage. The compiled information included:

- Date
- Local PRM start/stop times
- PRM Airport Arrival Rate (AAR)
- Instrument Landing System (ILS) AAR
- Arrival demand
- Reason why PRM was not in use, if applicable[2]
- Actual number landed
- Departure demand
- Actual number departed
- Total daily number of rushes

Using the 2002 data, the evaluation team determined the levels of delay and capacity occurring during periods of PRM use. The team collected data from the Post Operations Evaluation Tool (POET). The data included:

[2] *Note that most of the days that PRM was not in use were due to clear weather.*

- Planned and actual departure times
- Planned and actual arrival times
- Planned and actual air miles
- Call signs/Flight plans

In comparing the actual v. planned arrival times, air miles, departure times, and air time, we found that MSP experienced 20.84 minutes of additional airtime, 19.05 minutes of arrival delay, 38.58 miles of additional miles flown, and 3.13 minutes of delay *during periods of PRM use*. The evaluation team assumed that if the level of non-participants was too high, MSP would discontinue the use of PRM during that period.

Table A.1 shows the average delays per aircraft *per day*, including times when PRM was not in use.

*Source: POET and MSP logs*

| Date | Total Minutes of PRM Use for Day | Number of Flights during PRM Period | Number of flights (Source: POET) | **Average Arrival Delay -** (Actual - Planned Arrival Time, in minutes) per aircraft | **Average Airtime Delay -** (Actual - Planned Airtime, in minutes) per aircraft | **Average Additional Distance Traveled -** (Actual - Planned Distance, in miles) per aircraft | **Average Departure Delay (from origin airport)** (Actual - Planned Departure Time, in minutes) per aircraft |
|---|---|---|---|---|---|---|---|
| 27-Apr-02 | 262 | 172 | 494 | 15.57 | 20.23 | 34.56 | 0.46 |
| 28-Apr-02 | 230 | 199 | 530 | 14.92 | 16.71 | 20.26 | 2.75 |
| 29-Apr-02 | 50 | 30 | 607 | 18.71 | 21.37 | 23.09 | 1.38 |
| 6-May-02 | 249 | 89 | 628 | 20.05 | 22.37 | 29.30 | 2.45 |
| 9-May-02 | 40 | 17 | 477 | 24.95 | 22.47 | 31.01 | 6.63 |
| 11-May-02 | 254 | 225 | 523 | 15.96 | 19.97 | 32.21 | -0.72 |
| 12-May-02 | 129 | 73 | 539 | 20.01 | 21.37 | 20.62 | 3.50 |
| 22-May-02 | 173 | 154 | 648 | 17.73 | 20.03 | 34.47 | 3.02 |
| 28-May-02 | 30 | 28 | 613 | 20.41 | 20.10 | 29.36 | 5.13 |
| 3-Jun-02 | 213 | 105 | 493 | 24.93 | 23.07 | 27.55 | 6.68 |
| 4-Jun-02 | 261 | 218 | 643 | 27.52 | 23.00 | 29.75 | 8.50 |
| 10-Jun-02 | 261 | 235 | 668 | 22.22 | 21.93 | 36.41 | 5.36 |
| 11-Jun-02 | 94 | 76 | 684 | 19.07 | 19.07 | 9.46 | 4.16 |
| 12-Jun-02 | 121 | 97 | 687 | 20.17 | 22.13 | | 2.74 |
| 28-Jun-02 | 138 | 109 | 673 | 21.13 | 20.90 | 33.61 | 4.53 |
| | | | **Average** | **20.22** | **20.98** | **27.98** | **3.77** |

**Table A.1 - Results of POET data collection**

Once the evaluation team had data for the post-PRM implementation period, we needed baseline, or pre-implementation, data. This data would be used to compare non-PRM dates/periods with PRM dates/periods to determine if MSP experienced reduced delays and increased throughput during periods of PRM use. To conduct the data comparison, the team had two options:

- Obtain and compare MSP data for the summer of 2002 (PRM) to 2003 (non-PRM)
- Reverse engineer a non-PRM baseline using a modeling and simulation tool

### *Pre-Implementation Data*

The evaluation team looked for a tool or method to collect/obtain MSP pre-PRM data. The team ran into several setbacks when attempting to collect the data:

- POET data unavailable for most of the pre-implementation time period, except for a short period during the summer of 2002 when PRM was in use
- Unable to get pre-PRM implementation Traffic Management Logs
- Unable to determine when PRM was/wasn't in use

However, when the evaluation team conducted a site visit to MSP, the team found that because PRM was currently unavailable due to construction on the ILS, it was possible to use 2003 data as a baseline. The team received the log files from MSP for the summer of 2003 (June 15, 2003 through July 31, 2003) along with the minimum ceiling/visibility for PRM approaches (3,300 feet/8 miles). The team then reviewed the logs to determine the dates when MSP reported ILS conditions. ILS conditions occurred on the following dates from June 15, 2003 through July 31, 2003:

- June 23
- June 25
- June 26
- July 3
- July 7
- July 9
- July 10
- July 14

The team then obtained operations data from POET and weather data from ASPM for each date listed above. The evaluation team reviewed the data looking for dates where the AAR equaled 56 per hour or 14 for every quarter hour (rather than 60, the Airport Arrival Rate (AAR) achieved using PRM). The team also reviewed the data to ensure that the ceiling and visibility were approximately 3300 feet and 8 miles, respectively. Based on this analysis of the original eight dates, four dates remained.

*Comparison of Post-Implementation and Pre-Implementation Data*

Next, the team attempted to match the 2002 and 2003 dates based on similar weather conditions, runway configurations, arrival counts, and periods of arrival pushes. None of the attempts to compare the PRM and non-PRM dates proved justifiable. This could be due to a number of factors including:

- Changing weather conditions
- Different traffic flows
- Low level of operations
- Able to land more aircraft than the published AAR
- Worse weather conditions during periods of PRM use

The team struggled to find dates and time periods where similar conditions occurred in 2003 that matched PRM periods in 2002. Therefore, the team could not conclusively state that any increase in capacity or decrease delay could be attributed to the use of PRM.

## Runway Delay Simulation Model Data and Results

The evaluation team engaged the Simulation and Analysis Group (ACB-330) to reverse engineer a PRM baseline using the 2002 POET data discussed above. ACB-330 reviewed the request and considered a number of simulation tools, deciding on RDSIM, a tool used to simulate runways, runway exits, and adjacent airspace, serving as a delay analysis tool. The model replicates each experiment using sampling techniques to introduce system variability, which occurs on a daily basis in actual airport operations. The results are averaged to produce the output statistics. ACB-330 and the evaluation team decided that the best way to capture the benefits of PRM was to run each chosen day (listed in Table A.1[3]) for 100 iterations, alternating the separation values to mimic the changing weather and associated procedures for those given days. This would provide a statistical average, which gives a better measure of the benefit of PRM for the days identified. ACB-330 was able to alternate the aircraft separation values to mimic the changing weather and procedures (i.e., PRM separation values are less than non-PRM/ILS separation values). Average arrival delays per aircraft, average departure delays per aircraft, and average total delays per aircraft during non-PRM and PRM simulations are shown in Table A.2.

*Sources: POET (Source data)/RDSIM (Simulation results)* *100 Iterations*

| Date | Number of Arrivals during PRM period | Average Arrival Delay per Aircraft | Average Departure Delay per Aircraft | Average Total Delay per Aircraft |
|---|---|---|---|---|
| **April 27 – PRM** | 172 | 2.1 minutes | 2.5 minutes | 2.3 minutes |
| **April 27 – No PRM** | 172 | 2.3 minutes | 2.4 minutes | 2.4 minutes |
| **May 6 – PRM** | 89 | 2.9 minutes | 3.5 minutes | 3.2 minutes |
| **May 6 – No PRM** | 89 | 3.0 minutes | 3.5 minutes | 3.3 minutes |
| **May 22 – PRM** | 154 | 3.1 minutes | 3.8 minutes | 3.5 minutes |
| **May 22 – No PRM** | 154 | 3.3 minutes | 4.1 minutes | 3.7 minutes |
| **May 28 – PRM** | 28 | 1.5 minutes | 2.3 minutes | 1.9 minutes |
| **May 28 – No PRM** | 28 | 1.5 minutes | 2.3 minutes | 1.9 minutes |
| **June 3 – PRM** | 105 | 2.1 minutes | 3.0 minutes | 2.5 minutes |
| **June 3 – No PRM** | 105 | 2.1 minutes | 3.0 minutes | 2.6 minutes |
| **June 11 – PRM** | 76 | 2.5 minutes | 3.5 minutes | 3.0 minutes |
| **June 11 – No PRM** | 76 | 2.7 minutes | 3.5 minutes | 3.1 minutes |
| **June 12 – PRM** | 97 | 3.0 minutes | 4.5 minutes | 3.7 minutes |
| **June 12 – No PRM** | 97 | 3.1 minutes | 4.4 minutes | 3.8 minutes |

**Table A.2 - RDSIM Results – Delays at MSP**

The total impact of PRM – or the minutes of delay *prevented* by using PRM – can be gathered from the *total number of arrivals* multiplied by the *average difference in arrival delay* between PRM and Non-PRM results. For example, MSP had 172 arrivals on April 27 during PRM periods, according to POET. Those flights arrived, on average, 0.2 minutes later without PRM. Therefore, the PRM saved MSP 34.4 minutes (172 x 0.2) of delay on April 27, 2002 (see Table A.3). This information can be calculated into daily and annual delay savings.

| Date | Minutes of Delay Prevented with the use of PRM | Cost of Savings of Delay Per Day[4] | Average Number of Days PRM in Use[5] | Average Cost of Delay Savings per year |
|---|---|---|---|---|
| April 27, 2002 | 34.4 minutes | $1856.22 | 80 | $148,497.92 |
| May 6, 2002 | 8.9 minutes | $480.24 | 80 | $38,419.20 |
| May 22, 2002 | 30.8 minutes | $1661.97 | 80 | $132,957.60 |
| May 28, 2002 | 0 minutes | 0 | 80 | 0 |
| June 3, 2002 | 0 minutes | 0 | 80 | 0 |
| June 11, 2002 | 15.2 minutes | $820.19 | 80 | $65,615.20 |
| June 12, 2002 | 9.7minutes | $523.41 | 80 | $41,872.96 |
| Average | 14.14 minutes | $763.15 | 80 | $61,051.89 |

**Table A.3 - Cost savings from reduced delay at MSP**

RDSIM was also able to provide the total arrival flow (by hour) into MSP. Since an increase in throughput is one of the key performance measures for PRM, it was important to determine if

3 *The dates listed in Table A.1 were chosen based on having a sufficiently high traffic volume, similar arrival/departure counts, and longer periods of PRM usage*

4 *Based on Air Transport Association's airborne delay cost of $53.96 per minute*

5 *MSP provided the average number of days they believe that PRM could be used based on average weather conditions*

PRM is helping MSP achieve a higher arrival rate during poor visibility and/or weather. Although RDSIM provided a slightly different result if a departure push was entered as an input to the model, we have only included the values for throughput without the departure push in Table A.4. To calculate the throughput, the team calculated the difference between the throughputs during PRM with the throughput without PRM. The resulting difference in throughput is shown in the last column of Table A.4. These seven dates averaged approximately 1 additional aircraft gained with the use of PRM.

| Date | Minutes of PRM Use | Throughput during PRM | Throughput (during the same times) without PRM | Difference in throughput (in number of aircraft) |
|---|---|---|---|---|
| April 27, 2002 | 262 | 268.7 | 267.2 | 1.5 |
| May 6, 2002 | 249 | 156 | 154.5 | 1.5 |
| May 22, 2002 | 173 | 155.1 | 152.1 | 3 |
| May 28, 2002 | 30 | 16.5 | 16.3 | .2 |
| June 3, 2002 | 213 | 169 | 168.1 | .9 |
| June 11, 2002 | 94 | 171.7 | 172 | -0.3 |
| June 12, 2002 | 121 | 162.4 | 162.3 | .1 |
| Average | 163 | 157 | 156 | 1 aircraft |

**Table A.4 - RDSIM Results – Throughput at MSP**

The comparison of PRM days with non-PRM days based on the simulation shows that MSP should be seeing slightly reduced delays and increased throughput. Although a much greater benefit in reduced delays and increased capacity was desired, the low level of operations at MSP negates most of the need for the increased capacity from PRM.

## Conclusions

- Simulation data showed slightly decreased arrival delays and increased capacity on PRM dates.
- The total impact of PRM, based on the simulation results, can be used as an indicator of how much delay savings PRM provides to MSP.
- The increased throughput of four additional aircraft per hour was not reached largely due to the low level of operations. An MSP benefits study showed that the airport would realize the additional four aircraft per hour throughput when annual operations reached 530,000.
- MSP has been able to maintain an AAR of 60 per hour, rather than 56 per hour, using PRM. This increased capacity will become very important when operations increase.

# Appendix B: Results from Lambert – Saint Louis International Airport (STL) Precision Runway Monitor Benefits Analysis

## Background of Lambert – Saint Louis International Airport (STL) Precision Runway Monitor Operations

In 1998, STL commissioned their PRM, integrating it into the airport's operations and procedures. At the time of commissioning, pilots were already using ILS/LDA approaches that required an offset approach to parallel runways using ASR radar for monitoring. PRM was identified as the technology that would provide high update radar with improved resolution for monitoring the ILS/LDA approaches. Since the commissioning, STL will no longer conduct ILS/LDA approaches without PRM, making PRM an essential piece of equipment at STL.

OEP Version 5.0 lists four intended benefits that stakeholders should receive from PRM: reduced delays, increased throughput, fuel reduction, and runway operations sustained at a higher rate during IFR. The evaluation team focused on reduced delay and increased throughput/ higher rate of sustained operations for the PRM benefits assessment of STL. To conduct the study, the team needed pre-implementation and post-implementation data for operations at STL to determine if the system has provided any benefits to stakeholders.

During the site visit to the STL Terminal Radar Approach Control facility, Gateway TRACON, the evaluation team learned that PRM was out of service in the late fall/early winter of 2002, providing a period of time that could be used in place of pre-implementation data. The evaluation team requested the Traffic Management logs from Gateway TRACON for 2002 and 2001 (post-implementation data) for the benefits analysis. The team would use the logs to compare delay and capacity between periods of PRM use (2001) and non-PRM use (2002).

After reviewing the Traffic Management Logs, the evaluation team noted that PRM was listed as being out of service starting November 27, 2002 for approximately one month. Therefore, the evaluation team limited our comparison and analysis to December 2001 (PRM in service) versus December 2002 (PRM out of service). Prior to beginning the analysis, the team thought it was important to review the total operations for 2001 and 2002. The result of that review is shown below in Figure B.1.

Although the difference in total operations between months in 2001 and 2002 is somewhat significant during the spring and summer months, arrivals and departures in 2001 are most similar to those in 2002 from October through December, as shown in Figure B.1.  This is the period that we are using for our analysis.

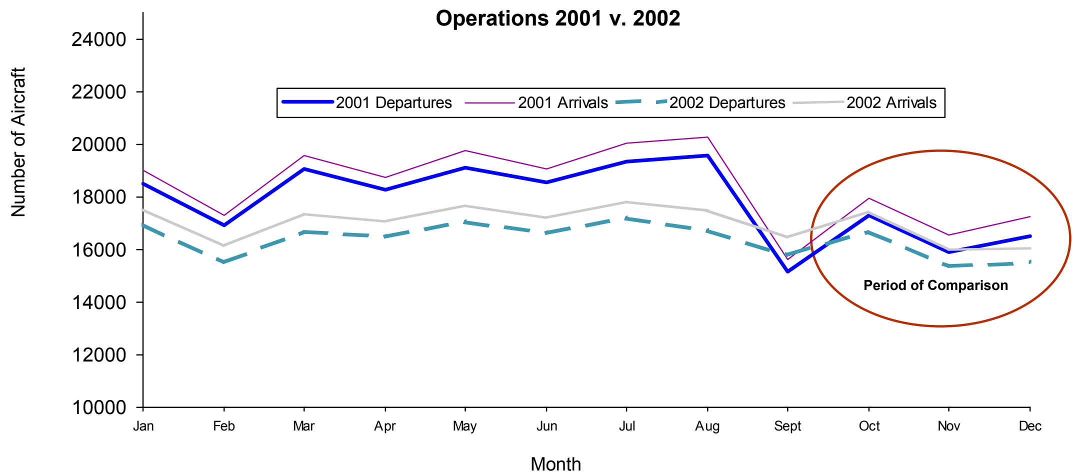



**Figure B.1 - STL Arrivals in December 2001 and December 2002**

The evaluation team also decided to take a close look at the difference in arrivals at STL for December 2001 and 2002.  Although arrivals fluctuate throughout December, there are a number of periods where arrivals in 2001 and 2002 match.  In Figure B.2, some of the most significant gaps between arrivals in 2001 and 2002 account for a difference in approximately 100 arrivals. The impact of those 50 arrivals would depend on their arrival times (i.e., whether the aircraft arrived during a peak period).

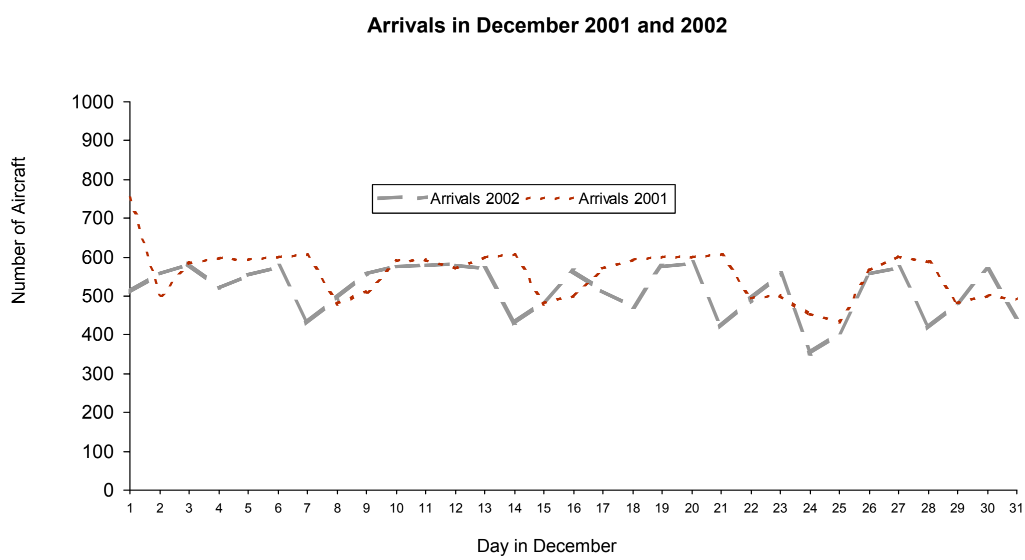



**Figure B.2:  Arrivals and Departures 2001 v. 2002**

## Arrival Procedures at Lambert – Saint Louis International Airport (STL)[6]

Understanding the arrival procedures at STL was an essential part of comprehending the approaches listed in the Traffic Management logs. STL uses a number of configurations and approaches that are dependent on weather conditions. Although the published minimums for these approaches help to determine when each would be used, the actual data from ASPM shows that there is flexibility in those minimums.

### *Approach #1 – Dependent Converging Instrument Approach (DCIA)*

DCIA uses the Converging Runway Display Aid or CRDA, which relies on ghosting to maintain aircraft stagger on approach. This is used when conditions are poor (ceiling at or below 600 feet) to increase capacity. If DCIA were not used, the airport would be restricted to arriving on one runway. For STL, the AAR using DCIA is between 32 – 38 arrivals per hour (maximum AAR = 52).[7]

### *Approach #2 – Independent Converging Instrument Approach (ICIA)*

ICIA, sometimes called simultaneous converging instrument approach, is used during IMC and requires no dependency between the two landing aircraft. Missed Approach Points (MAPs) are moved away from the runway thresholds to increase separation and result in higher decision heights for pilots and controllers. The ceiling must be above 600/650 feet, and visibility must be greater than 2 miles for ICIA use. The published AAR for this procedure in STL is approximately 42 AAR[8] at the poorest conditions.

### *Approach #3 – ILS/LDA Approach*

At STL, the ILS/LDA approach uses the PRM high update radar to bring aircraft onto the parallel 12s or 30s. One aircraft takes an LDA approach (offset from the runway) while the other takes the straight ILS approach. LDA approaches require at least 1200-foot ceilings and 4 miles of visibility. With the use of PRM, the LDA approach AAR can match the maximum AAR at 52.

### *Approach #4 – ILS approach*

The ILS approach is used when flow and weather conditions restrict the use of other approaches. The ILS approach can require arrivals to land in a single stream of traffic to one runway, affecting capacity and delays by reducing the AAR.

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[6] *Approach descriptions from* 1993 Aviation System Capacity Plan *Chapter 3*

[7] *Based on Traffic Management (TM) Logs at Gateway TRACON*

[8] *Based on TM Logs at Gateway TRACON*

# Results

## 1. Use of PRM to monitor ILS / LDA approaches

The evaluation team first wanted to determine how frequently STL uses PRM. To do so, the team counted the number of days, in the Traffic Management logs, where PRM was in use October – December 2001 and in October through November 27,2002. December 2002 was omitted because PRM was out of service. The team did not count PRM use for the entire year of 2001 and 2002 because we did not have the full logs for each year.

Based on the Gateway TRACON logs for 2001, ILS/LDA approaches were used for a period of time on 19 different days. Out of 31 days in December 2001, the ILS/LDA approach was used 11 days for one or more periods of time.[9] Those dates are listed below in Table B.1.

| Month | Date |
|---|---|
| October 2001 | 5, 12, 23 |
| November 2001 | 1, 8, 16, 26, 30 |
| December 2001 | 3, 6, 8, 13, 14, 15 17, 19, 22, 23, 31 |

**Table B.1 - Dates when PRM in use at STL**
**October – December 2001**

The ILS/LDA approaches were also used in October and November 2002 prior to PRM becoming out of service on November 27, 2002, as shown in Table B.2.

| Month | Date |
|---|---|
| October 2002 | 3, 4, 10, 11, 12, 26, 27, 28, 29, 30, 31 |
| November 2002 | 5, 6, 9, 11, 12, 14, 21, 24, 26 |

**Table B.2 - Dates when PRM in use at STL**
**October – November 2002**

The purpose of this analysis was not to compare the frequency of PRM usage in October and November 2001 with October and November 2002. The analysis simply shows that PRM is used frequently when conditions warrant an ILS/LDA approach.

## 2. Comparison One: December 2002 versus December 2001 (when ILS / LDA used)

The evaluation team compared airborne delay data in October, November, and December 2001 v. 2002. The purpose of this comparison was to use October and November as controls – if average airborne delays remained constant from 2001 to 2002 in October and November, then the team could likely attribute any increases in average airborne delay for December 2002 to the lack of PRM and the ILS/LDA approach.

Table B.3 shows no significant change between the 2001 and 2002 airborne delay statistics for any of the three months listed in the table. Although the average airborne delay in December 2002 was 1.27 minutes greater than December 2001, October and November 2002 also show increased airborne delays of 0.91 minutes and 1.12 minutes, respectively. Therefore, the evaluation team cannot attribute the increase in the average airborne delay in December 2002 to the unavailability of ILS/LDA.[10]

Figure B.3 compares the average daily airborne delay in December 2001 with December 2002. Table B.3 shows that average airborne delay was higher in 2002 for all months regardless of whether ILS/LDA approaches were being used.

| | October | November | December |
|---|---|---|---|
| **Average Airborne Delay (2001)** | 3.45 minutes (ILS/LDA) | 3.05 minutes (ILS/LDA) | 2.43 minutes (ILS/LDA) |
| **Average Airborne Delay (2002)** | 4.36 minutes (ILS/LDA) | 4.17 minutes (ILS/LDA) | 3.7 minutes (No PRM) |

**Table B.3 - Average Airborne Delays October – December 2001/2002 at STL**

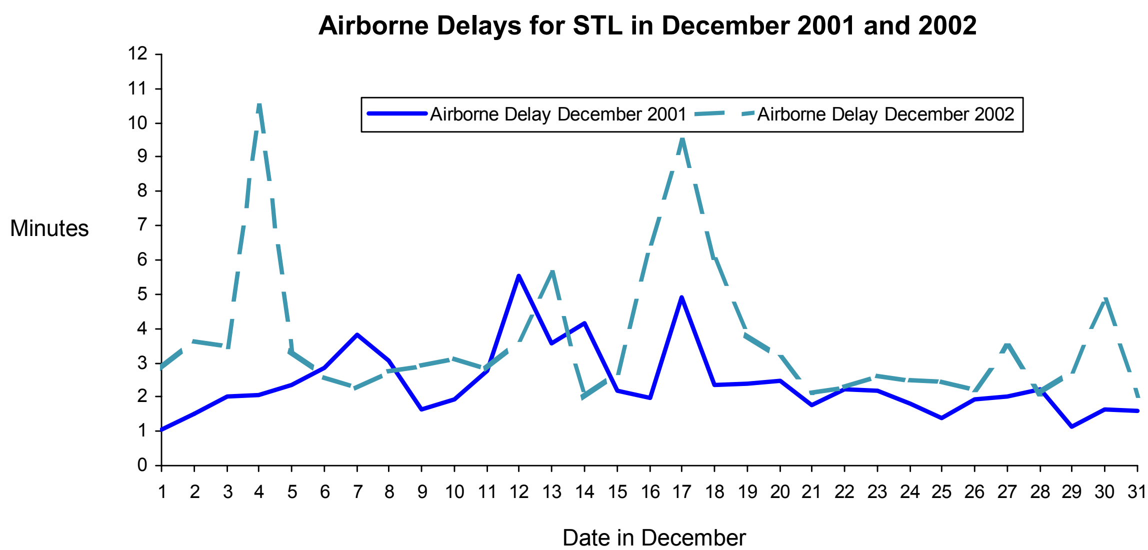


**Figure B.3 - Comparison of Airborne Delays, December 2001 and 2002**

10 *ASPM does not provide average arrival delay information. Therefore, we used average airborne delay data from ASPM.*

## 3. Comparison Two: ILS / LDA time periods in December 2001 v. December 2002

### *December 2001 Data Collection (PRM in use)*

The team began by collecting weather conditions, runway configurations, approaches, and arrival rates for all approaches in December 2001 based on the TM logs.[11] The team placed all of the December 2001 dates and times into Excel and sorted the worksheet based on the type of approach conducted. This was used to determine if certain winds, ceiling, and visibility requirements were evident for each type of approach. Table B.4 shows the average conditions for each approach during December 2001:[12]

| Approach | Rate | Ceiling Range | Range of Visibility |
|---|---|---|---|
| DCIA | 42 | 500 – 800 ft | 3 – 10 mi |
| ICIA | 42 – 52 | 800 – 3100 ft | 4 – 10 mi |
| ILS | 28 – 32 | 400 – 5500 ft | 2 – 10 mi |
| ILS/LDA | 52 | 1100 – 6500 ft | 5 – 10 mi |
| Simultaneous Visual | 52 | Up to Unlimited | Up to 10 |

**Table B.4: December 2001 Conditions and Approaches**

The team recorded the average airborne delays and number of arrivals (per quarter hour period) for those ILS / LDA periods during December 2001 when PRM was in use. The team discarded any times when the arrival demand was less than the airport's capacity, which is less than 13 per quarter hour or 52 per hour. This would allow us to compare peak arrival periods in December 2002 with peak arrival periods in December 2001.

Table B.5 shows the average airborne delay during the noted time period on ILS/LDA approaches in December 2001. The average airborne delay (aggregate) for these periods in December 2001 was 2.8 minutes.

| Date | Local time | Runway | Approach | Rate | Ceiling | Visibility | Average Airborne Delay | Arrivals |
|---|---|---|---|---|---|---|---|---|
| 6-Dec-01 | 1145 | 12R/12L | ILS/LDA | 52 | 1400 | 10 | 1.94 | 17 |
| 6-Dec-01 | 1215 | 12R/12L | ILS/LDA | 52 | 1400 | 10 | 1.76 | 17 |
| 13-Dec-01 | 1145 | 30R/L | ILS/LDA | 52/MIT | 2000 | 10 | 4.39 | 18 |
| 13-Dec-01 | 1920 | 30R/L | ILS/LDA | 52/MIT | 1900 | 7 | 2.79 | 14 |
| 14-Dec-01 | 1630 | 30R/L | ILS/LDA | 52/MIT | 1600 | 10 | 4.69 | 13 |
| 14-Dec-01 | 1800 | 30R/L | ILS/LDA | 52/MIT | 2800 | 10 | 6.72 | 18 |
| 14-Dec-01 | 1930 | 30R/L | ILS/LDA | 52/MIT | 3100 | 10 | 1.76 | 21 |
| 22-Dec-01 | 745 | 12R/L | ILS/LDA | 52 | 5500 | 6 | 1.7 | 20 |
| 22-Dec-01 | 1305 | 12R/L | ILS/LDA | 52 | 1300 | 9 | 1.07 | 14 |
| 31-Dec-01 | 1155 | 30R/L | ILS/LDA | 52 | 2300 | 10 | 3.14 | 14 |
| 31-Dec-01 | 1210 | 30R/L | ILS/LDA | 52 | 2300 | 10 | 3 | 16 |
| 31-Dec-01 | 1300 | 30R/L | ILS/LDA | 52 | 2300 | 10 | 0.85 | 13 |
| 31-Dec-01 | 1325 | not provided | ILS/LDA | 52 | 2300 | 10 | 2.63 | 19 |

**Table B.5 - December 2001 ILS/LDA Approach Average Airborne Delays**

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11 *Source for weather conditions, runway configurations, arrival rates: ASPM; Source for type of approach: Gateway Traffic Management Logs*

12 *The team reviewed the wind speeds and angles but could not find a consistent trend between the approach, wind speed, and wind angle.*

*December 2002 Data Collection (PRM Out of Service)*

Based on the information in Table B.4, the evaluation team's criteria for selecting the comparison periods of non-PRM use was as follows:

- ILS-warranted conditions
- Ceiling above 1100 feet
- Visibility greater than 4 miles
- AAR less than 52 per hour

Once the team had established the criteria, data collection and analysis began. The methodology for data collection was as follows:

1. The team collected approach, runway configuration, and weather data for those dates in December 2002 where the TM logs noted that STL conducted ILS approaches. (No DCIA and ICIA approaches)
2. The team matched December 2002 dates with the ceiling, visibility and arrival rates listed above. This narrowed the list of comparison dates in December 2001 to five.
3. The team used ASPM to find the average airborne delay per aircraft and number of arrivals during that period.
4. If the arrival demand did not meet or exceed 13 arrivals per quarter hour, the team eliminated the time period.

Table B.6 shows the resulting four dates/8 periods where ILS/LDA approaches might have increased the arrival rates at STL and/or reduced the average airborne delay.

| Date | Local time | Spacing | Runway | Approach | Rate | Ceiling | Visibility | Wind Angle | Wind Speed | Average Airborne Delay Per quarter hour | Number of Arrivals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-Dec-02 | 1415 | MIN | 30R | ICRDA | 45 | 3600 | 10 | 180 | 6 | 5.55 | 20 |
| 12-Dec-02 | 1550 | MIN | 30R | ICRDA | 45 | 3200 | 9 | 140 | 5 | 4.22 | 18 |
| 12-Dec-02 | 2040 | MIN | 12R | ILS | 45 | 2800 | 7 | 120 | 8 | 5.87 | 15 |
| 16-Dec-02 | 1410 | MIN | 12R/L | RRV/LDV | 48 | 0 | 10 | 110 | 14 | 6.19 | 16 |
| 16-Dec-02 | 1730 | MIN | 12R | ILS | Not in log | 1500 | 8 | 90 | 9 | 10.88 | 16 |
| 17-Dec-02 | 2000 | MIN | 12R | VIS | 42 | 4900 | 10 | 150 | 12 | 4.27 | 15 |
| 19-Dec-02 | 1250 | MIN | 30L/R | LDV/RRV | Not in log | 4800 | 8 | 300 | 7 | 1.94 | 17 |
| 19-Dec-02 | 1410 | 4MIT | 30R/24 | LDV/RRV | Not in log | 5000 | 9 | 300 | 9 | 3.24 | 17 |

**Table B.6: Average Airborne Delays December 2002 – Final Data Selection**

The average airborne delay per aircraft during these time periods was 4.24 minutes per aircraft. The use of ILS/LDA approaches might have saved 1.44 minutes of airborne delay per aircraft if PRM was in service.

In order for the evaluation team to determine if ILS/LDA approaches would have increased the airport's throughput, the team needed airport arrival demand data. Such information was not available in the TM logs. Therefore, the team could not conclusively state that ILS/LDA approaches, using PRM, increase throughput by a specific number of aircraft. However, Table B.6 shows that only 42-48 arrivals were landing per hour without ILS/LDA approaches available. The use of ILS/LDA approaches would have likely increased the AAR, providing increased throughput.

## Conclusions

- STL uses the ILS/LDA approaches frequently and does not use the approaches when the PRM is out of service.
    - In October through December 2001, STL used the ILS/LDA approaches a total of 19 days out of 92 days or 20.7 percent of the days.
    - In October and November 2002 (up until PRM logged as permanently out of service on November 27, 2002), ILS/LDA approaches were used a total of 20 days out of 57 days or 35 percent of the days.
- PRM was out of service beginning November 27, 2002 and stayed out of service through December 2002 (as noted in the TM logs). ILS/LDA approaches were not used during this time.
- Using TM Logs and ASPM, the team found that average airborne delay in December 2002 (when ILS/LDA approaches were unavailable) was 4.24 minutes per aircraft. The comparison data for December 2001 showed an average of 2.8 minutes per aircraft of airborne delay. When comparing similar days in 2002 and 2001 (based on runway configuration, weather, arrival rushes, arrival demand, etc.), the data showed that STL might have saved 1.44 minutes of airborne delay if PRM was in service by using ILS/LDA approaches.
- ILS/LDA approaches allow STL to maintain a higher arrival rate. TM Logs and ASPM data showed that during periods of ILS/LDA approach use, the AAR maintained a rate of 52 arrivals per hour while other approaches at STL accept between 32 and 48 arrivals per hour in less than visual conditions.
- American Airlines' recent reduction in operations at STL will impact the level of operations during arrival rushes and may reduce the need to maintain an arrival rate of 52 arrivals per hour.

# Appendix C: Analysis of Aviation System Performance Metrics Runway Configuration Data to Determine Potential Precision Runway Monitor Usage at John F. Kennedy International Airport

## Purpose

The purpose of this analysis was to identify the frequency with which the PRM could be beneficial at JFK by analyzing ASPM data on runway configurations from January 2002 to August 2003. Because changes in procedures at JFK affects LGA airport, the evaluation team also collected and reviewed ASPM data for LGA. The objective of the analysis was to determine if and how often JFK and LGA's runway configurations match the configurations required for the use of PRM.

## Methodology

JFK provided the runway configuration required for the use of PRM approaches. For JFK to use PRM approaches, aircraft would need to be arriving on 22R and 22L *and* departing on 31L.

JFK also provided the runway configurations at LGA that are required for the use of PRM approaches at JFK. At LGA, aircraft need to be:

- Arriving and departing on Runway 4
- Arriving and departing on Runway 22
- Arriving on 4 and departing on Runway 31

For each airport, the evaluation team needed to: (1) identify the frequency of use for each runway configuration and then (2) identify the runway configurations in use for instrumental approaches and visual approaches.

Once the data collection and initial analysis was complete, the team would compare JFK and LGA data.

- Identify the dates when the appropriate runway configurations were in use at each airport
- Compare the JFK and LGA dates to identify any matches
- If dates match, review weather conditions on that date

# Results

Figure C.1 shows the results of the JFK runway configuration data for January 2002 through August 2003. The runway configurations required for PRM use at JFK are for aircraft to arrive on 22L and 22R and depart on 31L. As the figure shows, there were no instances, based on ASPM data, where JFK used either of these runway configurations. The evaluation team called JFK tower to confirm the data, and the tower stated that they do not currently use either of the runway configurations required for PRM approaches.

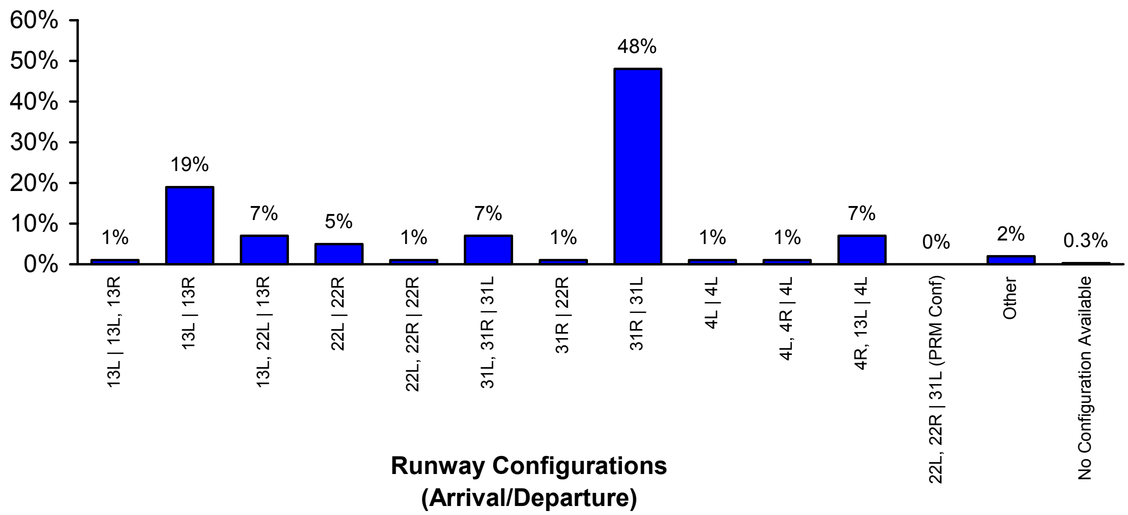


**Figure C.1 - Runway Configurations Used at JFK for 20 Month Period (01/01/02-08/31/03)**

Figure C.2 shows the results of the data collection for runway configurations at LGA. For JFK to use PRM without an airspace redesign, LGA would need to have flights arriving and departing on runway 4, arriving and departing on runway 22, or arriving on runway 4 and departing on runway 31. As the data shows, the majority (93.6 percent) of current LGA runway configurations would not allow for JFK to conduct PRM approaches without adversely impacting operations at LGA.

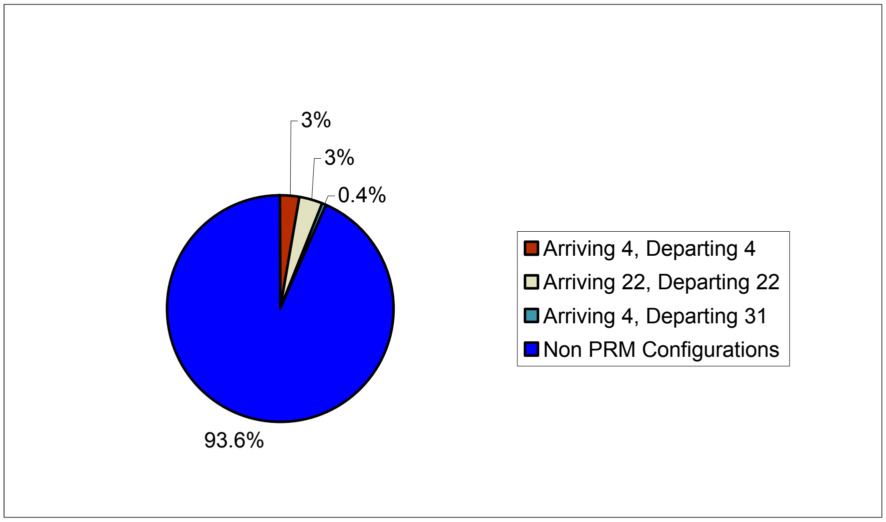


**Figure C.2 - Runway Configuration for LGA for Summer 2002 and 2003**

Although Figure C.1 showed that JFK does not currently use the runway configurations required for PRM approaches, the evaluation team reviewed the runway configurations used during instrument approaches, shown in Figure C.3.

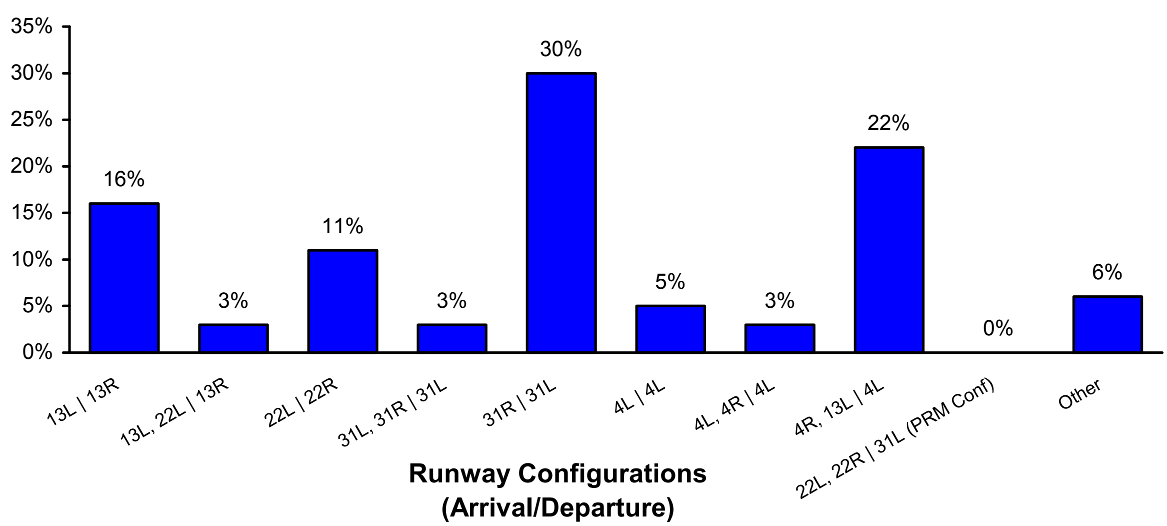


**Figure C.3 - JFK Runway Configurations for Instrument Approach Data January 2002 – August 2003**

Figure C.4 shows the JFK runway configurations used during visual approaches.

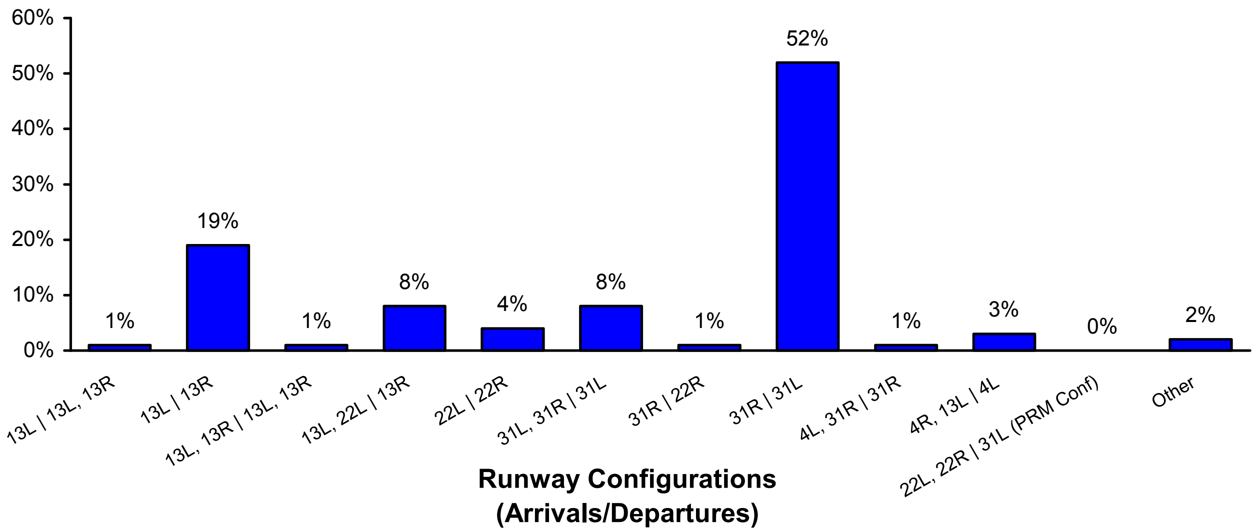


**Figure C.4 - JFK Runway Configurations for Visual Approach**
**January 2002 – August 2003**

# Conclusions

The analysis of the JFK data showed that the necessary runway configurations **were not used** during the period in question, regardless of the weather conditions. The data in Figure C.2 also showed that LGA prefers to use other approaches for much of their arrival and departure operations. Therefore, JFK is correct in stating that, based on historical data, they rarely use the runway configuration required for PRM approaches. JFK is also correct in their assessment that LGA's runway configuration would not be conducive to PRM operations. Changes in operations, procedures, and possibly airspace will be required for JFK and LGA to benefit from the use of PRM.

The evaluation team is aware that traffic arriving into and departing from White Plains (HPN) is also affected by JFK procedures. The team was unable to obtain the runway configuration data for HPN because ASPM did not have data for the runway configuration. During the team's site visit to JFK, stakeholders stated that HPN uses the runway configuration required for JFK's PRM approaches about 65% of the time. However, the team did not contact HPN to discuss their runway configuration since the JFK and LGA data already showed numerous roadblocks to PRM approach implementation at JFK.

# Appendix D: Results of Offshore Radar/Deepwater Sector Data Collection

## Background

Due to delays in the New York area, Continental Airlines has been using Offshore and Deepwater Sectors for aircraft departing out of Newark Airport (EWR). The Offshore Sectors are New York Center (ZNY) 82, 83, and 86. Deepwater Sectors include ZNY 87 and ZNY 88. Flights using deepwater sectors are limited to aircraft that have water safety features such as floatation devices. Continental routes southbound flights through these sectors to Florida and, at times, Houston International (IAH) to avoid the heavily traveled eastern corridor. Continental now schedules some of its flights for the Offshore/Deepwater routes in anticipation of heavy traffic and/or delays, particularly in the summer when the Severe Weather Avoidance Plans (SWAP) are in effect.

The evaluation team used the following sources to collect the offshore/deepwater route data:

- POET
- ASPM Data

## Results

The table below lists the major destinations that Continental uses for its Offshore and Deepwater routes. The data collection set begins with July 1, 2003 and ends with July 31, 2003 due to the SWAP and POET data available at the time of data collection. July had a total of seventeen days that included a SWAP session. Those dates were July 2, 4 – 12, 16, 18, 21 – 24, and 27th. The average SWAP session lasted 576 minutes, the longest SWAP session lasting 1450 minutes.[13]

| Data Set = July 1, 2003 - July 31, 2003 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination | No. of Flights / Day | Sample No. of Days | Total No. of Flights during Data Sample | No. of Flights Using Offshore Sectors | Percentage of Flights Using Offshore Routes | Flights using Offshore Sectors during July SWAP | Average Daily Departure Delay in July for Flights from EWR to Destination (min) | Average Departure Delay for COA Offshore Flights in July (min) | Average Arrival Delay in July for Flights from EWR to Destination (min) | Average Arrival Delay for COA Offshore Flights in July (min) |
| FLL | 5 | 31 | 155 | 21 | 13.55% | 9 | 45.88 | 3.619 | 44.11 | 4.714 |
| MIA | 5 | 31 | 155 | 3 | 1.94% | 3 | 56.27 | 20.333 | 54.86 | 25.333 |
| IAH | 8 | 31 | 248 | 3 | 1.21% | 0 | 55.26 | 40.667 | 58.6 | 23.667 |
| TPA | 6 | 31 | 186 | 1 | 0.54% | 0 | 67.85 | -15 | 65.63 | -23 |
| MCO | 8 | 31 | 248 | 22 | 8.87% | 11 | 54.31 | 16.455 | 45.21 | 11.86 |
| Total/Average | | | 992 | 50 | 5.04% | 23 | | | | |

**Table D.1 - Continental's Use of Offshore and Deepwater Sector Routes**

Table D.1 shows that Continental is benefiting from the use of Offshore/Deepwater flights. The average departure and arrivals delays for flights using these sectors were significantly lower than July average departure and arrival delay for flights originating in EWR and landing at the listed

13 *Source: Computer Science Corporation and New York Center SWAP Activity Report July 2003*

destination. If we were to associate cost with each of these delays, we would find the following:[14]

| Destination | Average Daily Departure Delay in July for Flights from EWR to Destination (min) | Cost of Avg Daily Departure Delays in July | Average Departure Delay for COA Offshore Flights in July (min) | Cost of Average Departure Delay for COA Offshore Flights in July |
|---|---|---|---|---|
| FLL | 45.88 | $ 1,139.20 | 3.619 | $ 89.86 |
| MIA | 56.27 | $ 1,397.18 | 20.333 | $ 504.87 |
| IAH | 55.26 | $ 1,372.11 | 40.667 | $ 1,009.76 |
| MCO | 54.31 | $ 1,348.52 | 16.455 | $ 408.58 |

**Table D.2 - Departure Delays and Delay Cost – Continental Offshore/Deepwater Routes**

Table D.2 shows the departure delays as they relate to cost. For example, the average flight from EWR to FLL was delayed 45.88 minutes in July 2003. This cost the airline $1,139.00 per delayed aircraft. Continental flights that used the Offshore/Deepwater sectors experienced an average of 3.619 minutes of departure delay for a July 2003 flight from EWR to FLL. This cost Continental $89.96. By using the Offshore and Deepwater routes, Continental is able to reduce both departure delays and arrival delays.[15]

The following tables show the daily flight schedule of Continental to destination airports. Screen shots of the offshore and/or deepwater routes are provided for select routes.

| Daily Flight Number | Daily Flight Time (local) | Mileage published by carrier | Number of flights that took offshore routes |
|---|---|---|---|
| 1201 | 735 | 1073 | 0 |
| 1801 | 925 | 1073 | 0 |
| 1401 | 1325 | 1073 | 5/21 |
| 1601 | 1545 | 1073 | 4/21 |
| 201 | 1905 | 1073 | 12/21 |

**Table D.3 - EWR to FLL**

[14] *Tampa International Airport is not included in the table because only one TPA flight used the Offshore routes. In addition, airlines do not save or make money by departing/arriving early*

[15] *Cost data based on the Air Transport Association estimate that gate plus taxi out delays costs airlines $24.83/minute*

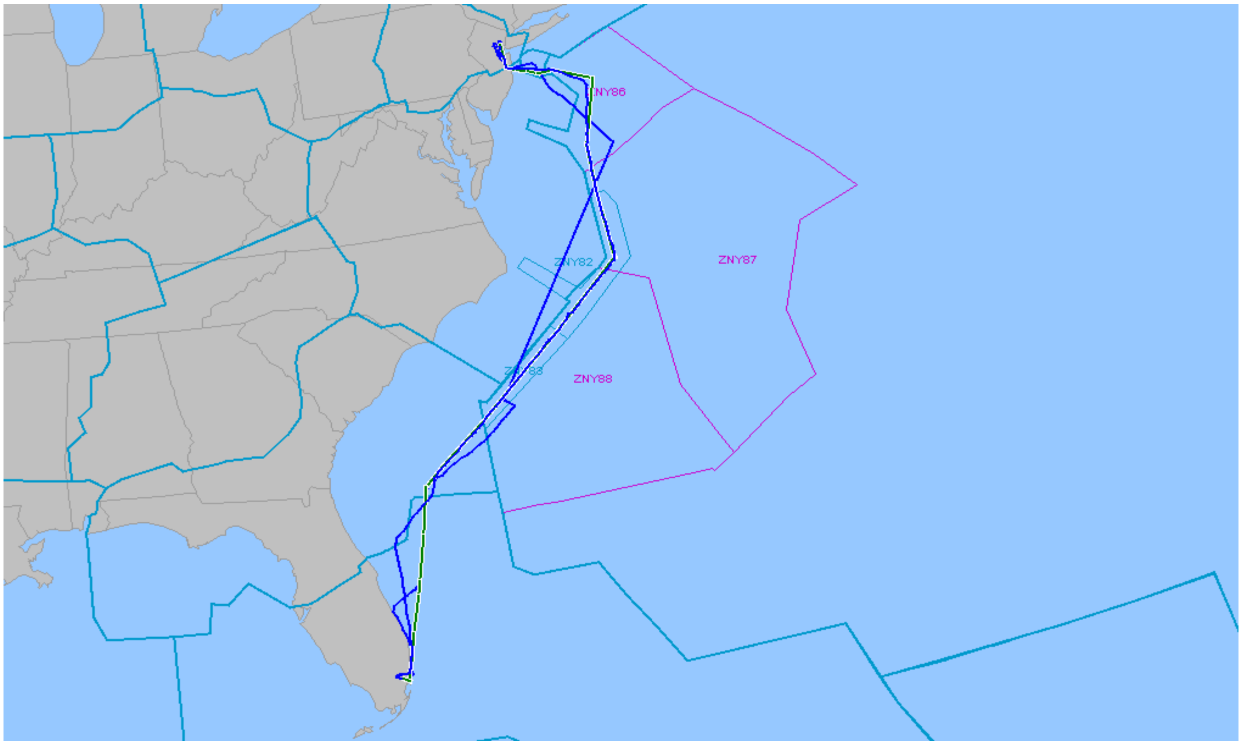


**Figure D.1 - EWR to MIA**

| Daily Flight Number | Daily Flight Time (local) | Mileage published by carrier | Number of flights that took offshore routes |
|---|---|---|---|
| 1638 | 705 | 1092 | 0 |
| 238 | 900 | 1092 | 1/3 |
| 438 | 1200 | 1092 | 0 |
| 45 | 1540 | 1092 | 2/3 |
| 638 | 1910 | 1092 | 0 |

**Table D.4 – EWR to MIA**

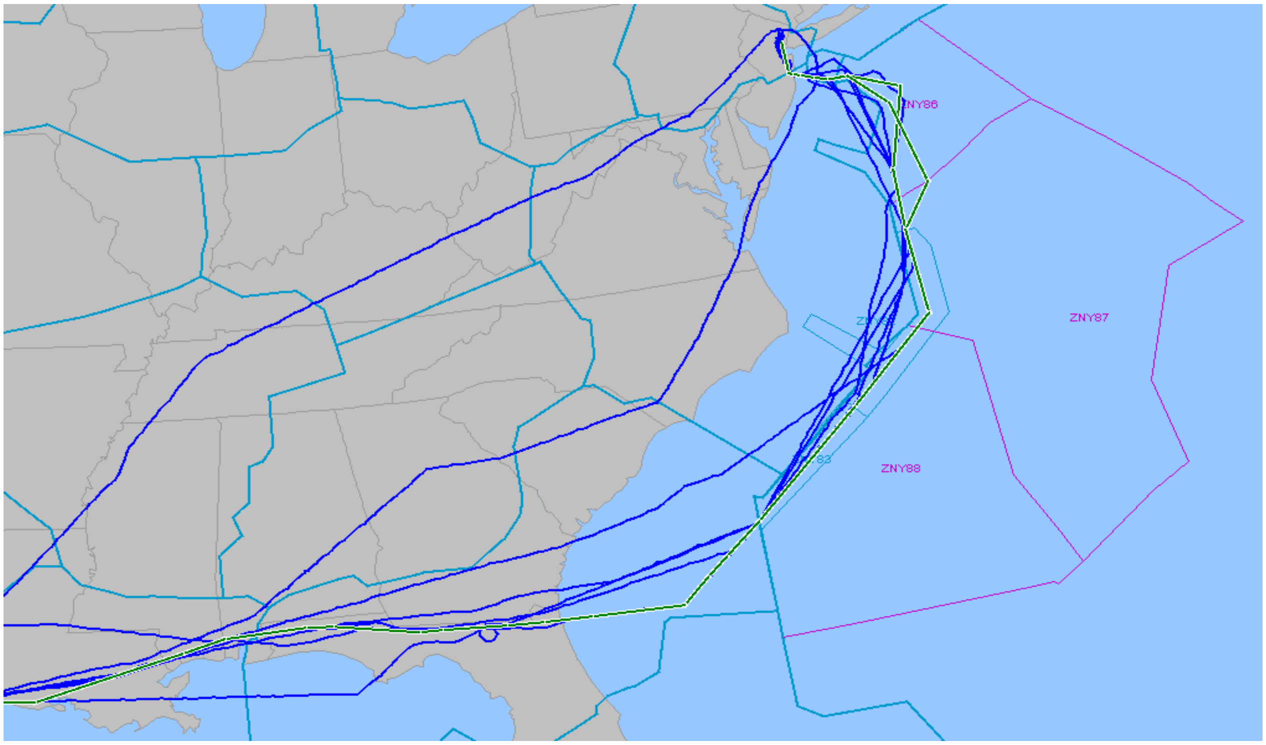


**Figure D.2 – EWR to IAH**

| Daily Flight Number | Daily Flight Time (local) | Mileage published by carrier | Number of flights that took offshore routes |
|---|---|---|---|
| 111 | 605 | 1415 | 0 |
| 211 | 805 | 1415 | 0 |
| 1011 | 935 | 1415 | 0 |
| 311 | 1040 | 1415 | 0 |
| 411 | 1410 | 1415 | 0 |
| 63 | 1505 | 1415 | 0 |
| 51 | 1655 | 1415 | 3/3 |
| 611 | 1955 | 1415 | 0 |

**Table D. 5 – EWR to IAH**

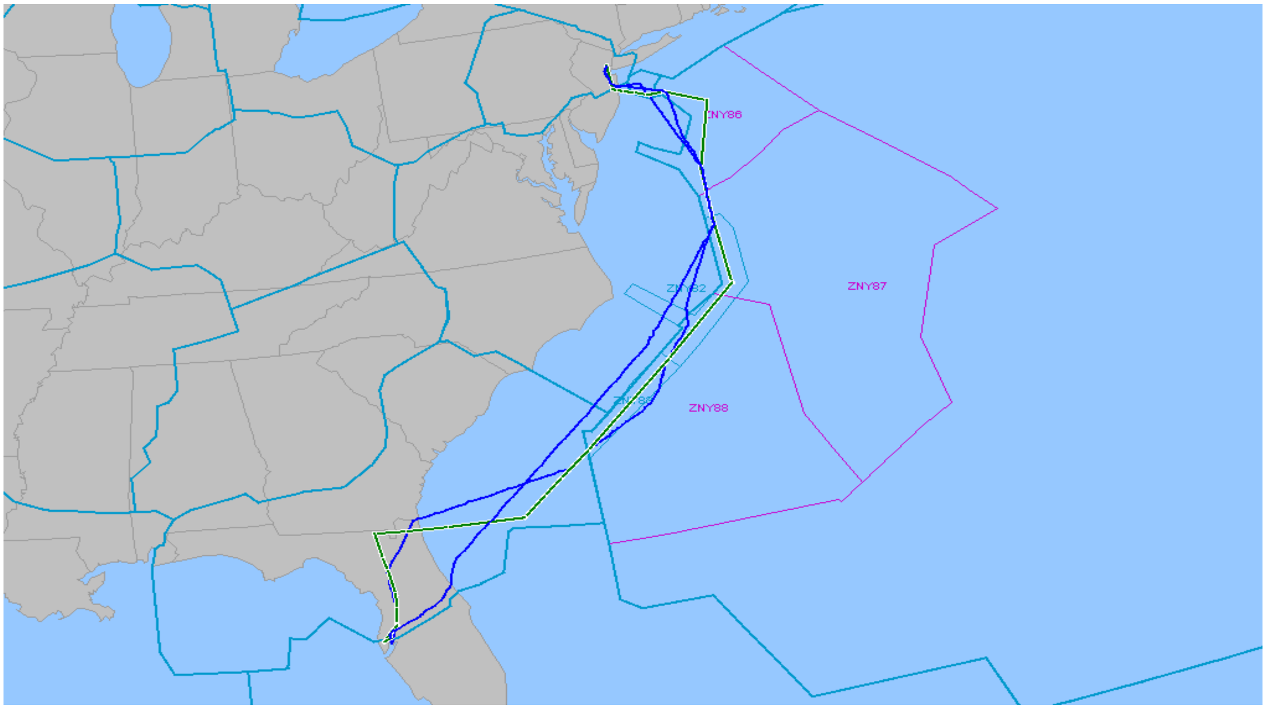


**Figure D.3 – EWR to TPA**

| Daily Flight Number | Daily Flight Time (local) | Mileage published by carrier | Number of flights that took offshore routes |
|---|---|---|---|
| 1418 | 0815 | 1010 | 0 |
| 118 | 1000 | 1010 | 0 |
| 218 | 1145 | 1010 | 0 |
| 1618 | 1250 | 1010 | 0 |
| 1218 | 1650 | 1010 | 0 |
| 1718 | 1950 | 1010 | 1/1 |

**Table D. 6 – EWR to TPA**

| Daily Flight Number | Daily Flight Time (local) | Mileage published by carrier | Number of flights that took offshore routes |
|---|---|---|---|
| 1892 | 745 | 938 | 0 |
| 1592 | 0900 | 938 | 0 |
| 792 | 1025 | 938 | 1/22 |
| 192 | 1220 | 938 | 1/22 |
| 21 | 1400 | 938 | 1/22 |
| 392 | 1615 | 938 | 5/22 |
| 1692 | 1900 | 938 | 10/22 |
| 292 | 2040 | 938 | 4/22 |

**Table D.7 – EWR to MCO**

## Offshore Data for Delta Airlines

When collecting the data on Continental's use of offshore routes, the evaluation team also wanted to determine if any other carriers were using the routes. We found that Delta Airlines is using offshore routes for their flights from EWR to MCO and FLL. In July, Delta Airlines used Offshore routes for 1 of its flights to FLL. In August 2003, Delta used the Offshore sectors for 4 flights to MCO and 3 flights to FLL. Based on these eight flights, Delta departed an average of 24.6 minutes late and arrived 10.6 minutes late.[16]

As shown in the table below, the delays for those Delta flights that used Offshore routes were significantly less than the average delays per delayed departure. The second table shows the savings realized due to the reduced departure delays from offshore routes.

| Date/Destination | Average minutes of delay per delayed departure | Average minutes of delay per delayed departure – Delta flights using Offshore Routes | Average minutes of delay per delayed arrival | Average minutes of delay per delayed arrival – Delta flights using Offshore Routes |
|---|---|---|---|---|
| **July Flights to FLL** | 45.88 | 11.0 | 44.11 | -5.0 |
| **August Flights to FLL[17]** | 69.07 | 48.33 | 56.05 | 31.33 |
| **July Flights to MCO** | 54.31 | No Flights | 45.21 | No Flights |
| **August Flights to MCO** | 68.65 | 10.0 | 68.49 | -1.0 |

**Table D.8 - Delta Airlines Delays on Flights using Offshore/Deepwater Sector Routes**

16 *POET Data*

17 *August data includes August 1, 2003 through August 18, 2003 – the dates available in POET at time of data collection*

| Date/Destination | Average minutes of delay per delayed departure | Cost of Average Daily Departure Delays | Average minutes of delay per delayed departure – Delta flights using Offshore Routes | Cost of Average Daily Departure Delays - Offshore Flights |
|---|---|---|---|---|
| **July Flights to FLL** | 45.88 | $ 1,139.20 | 11 | $ 273.13 |
| **August Flights to FLL** | 69.07 | $ 1,715.01 | 48.33 | $ 1,200.03 |
| **July Flights to MCO** | 54.31 | $ 1,348.52 | No Flights | Not Applicable |
| **August Flights to MCO** | 68.65 | $ 1,704.58 | 10 | $ 248.30 |

**Table D.8 - Cost of Delay on Delta's Flights using Offshore/Deepwater Sector Routes**

# Conclusions

- Continental is scheduling flights for offshore sector routes.
- Continental experienced significantly shorter departure delays in July 2003 when compared to other aircraft leaving Newark and traveling to Florida or Houston. This led to delay and cost savings.
  - For example, the average flight from EWR to FLL was delayed 45.88 minutes in July 2003. This cost the airline $1,139.00 per delayed aircraft. Continental flights that used the Offshore/Deepwater sectors experienced an average of 3.619 minutes of departure delay for a July 2003 flight from EWR to FLL. This cost Continental $89.96 per delayed aircraft.
- Other airlines are beginning to use the offshore routes (Delta and Jet Blue) and are also seeing cost savings due to reduced delays.
- Offshore and deepwater sector routing is providing users with new routing options that have been successful in reducing departure delays for aircraft that choose those routes.

# Appendix E: Data Collection Results for Las Vegas McCarran International Airport (LAS) Area Navigation/Four Corner Post

## Background

LAS needed to take full advantage of their airfield after a new terminal was constructed in 2000. To do so, LAS required airspace improvements that would optimize the flow of traffic at the airport by designing routes around the Special Use Airspace (SUA) that surrounds the airport. LAS predicted that future traffic could see delays increase by more than 60 percent, based on the future growth of tourism in the LAS area. LAS needed less restrictive climbs that were on course. The airport also needed flight idle descents that would optimize operations. Based on these requirements, the purpose of LAS redesign including the use of RNAV and the creation of a four corner post was to: reduce delays, increase the airport capacity, and reduce the amount of air miles flown. Optimizing the airspace and routes for arrivals and departures would provide LAS with these benefits. The four-corner post initiative was completed in November 2001.

MITRE-CAASD reviewed delay metrics in a 2003 benefits analysis of LAS to determine if the changes to airspace and implementation of a four-corner post were helping to provide the intended benefits. The evaluation team decided to use the information that MITRE-CAASD provided and extend the post implementation period out from December 2002 to August 2003, incorporating eight additional months of data.

## Results

### Reduction in Delays

The evaluation team used the ASPM database to determine the average arrival delays (using airborne delays), average departure delays, percentage of delayed arrivals, and percentage of delayed departures per month. Averages for pre-implementation and post-implementation data are provided in the graphs below.

Figures E.1 – E.4 show a decrease from pre-implementation to post-implementation in average departure delays, percentage of delayed arrivals, and percentage of delayed departures, and average arrival delays. The general downward trend in delays continued for the eight additional months of data the evaluation team added to the original study, as shown in the post-implementation averages.

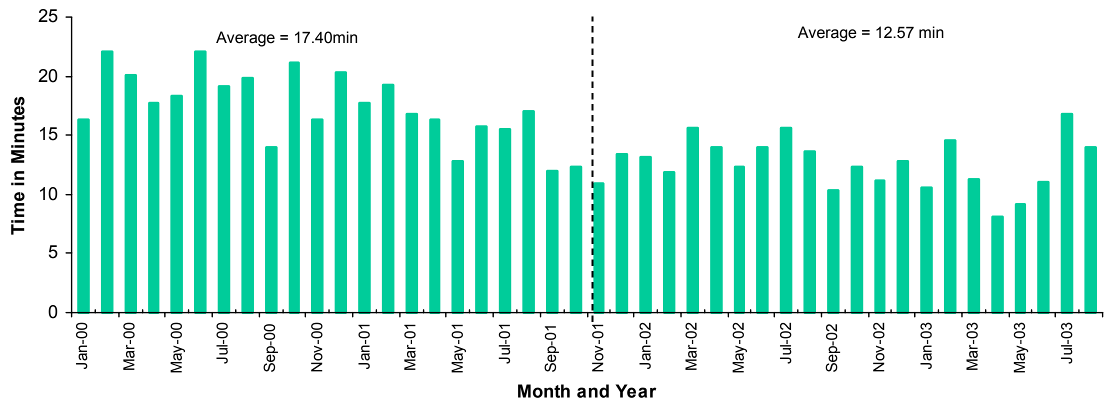


**Figure E.1 - Average Departure Delays for LAS per Aircraft**

Because the Air Transport Association provides departure delay and airborne delay cost statistics, the evaluation team was able to calculate the average delays shown in Figure E.1 into dollar averages. The pre-implementation period average departure delay from LAS was 17.40 minutes per aircraft, as shown in Table E.1. The cost per minute of departure delay is $22.38. The average number of departures, per month, from January 2000 through October 2001 was 14,111 departing aircraft. Multiplying all of these figures gives a cost of approximately $5.5 million per month due to departure delays. The cost of delays during post-implementation was $3.8 million, giving an average savings per month of just over $1.6 million.

| | Pre Implementation Period | Post Implementation Period |
|---|---|---|
| Average Departure Delay | 17.40 min/aircraft | 12.57 min/aircraft |
| Cost per minute of Delay[18] | $22.38 | $22.38 |
| Average Number of Departures per month | 14,111 | 13,715 |
| Total Cost per Month | $5,494,992 | $3,858,257 |
| Average Savings per Month | $1,636,735 | |

**Table E.1 - Cost/Savings of Average Departure Delays for LAS**

Although Air Transport Association does not have dollar figures related specifically to gate arrival delays, Figure E.2 shows that the average gate arrival delay decreased by 38% when comparing the pre-implementation period with the post-implementation period. Figures E.3 and E.4 also show a decrease in the percentage of delayed departures and arrivals at LAS.

[18] *Based on gate delay costs from Air Transport Association*

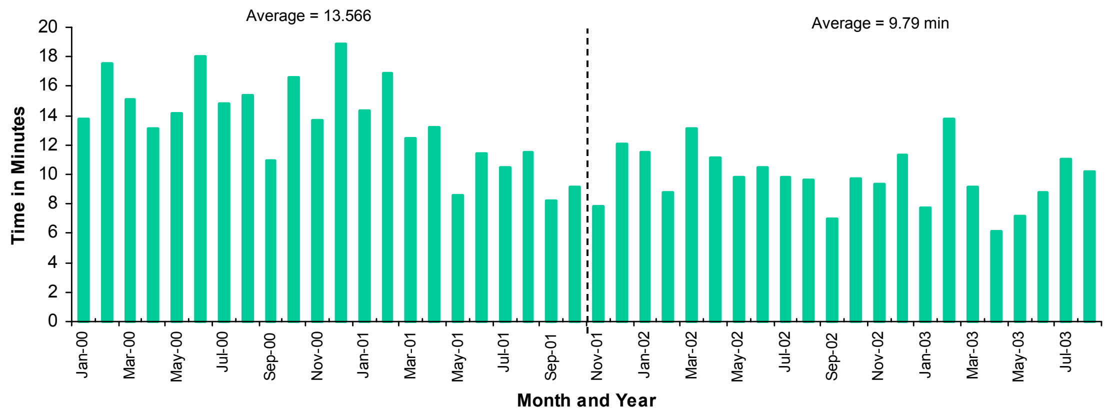


**Figure E.2 – Average Gate Arrival Delays for LAS per Aircraft**

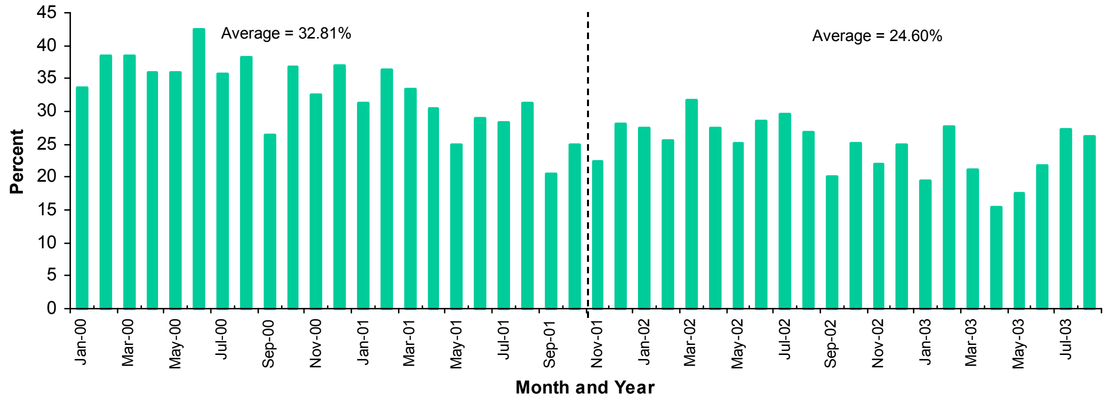


**Figure E.3 - Average Percentage of Delayed Departures for LAS**

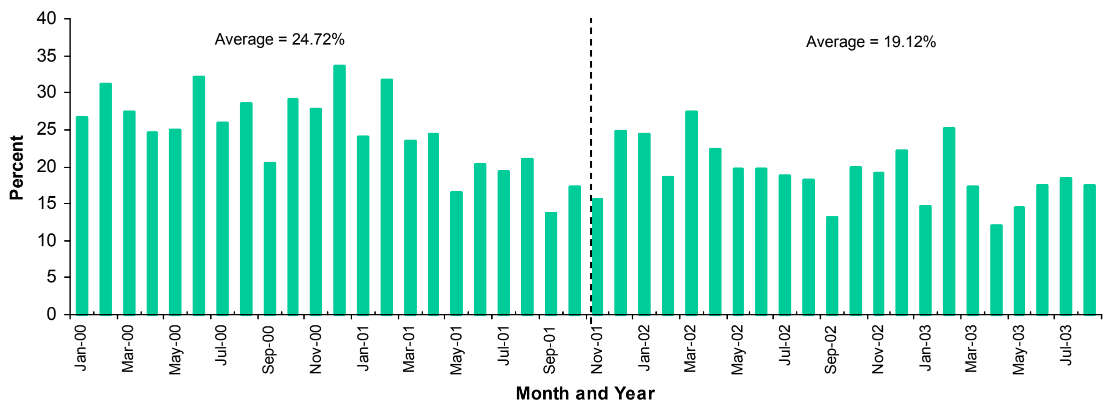


**Figure E.4 - Percentage of Delayed Arrivals at LAS**

Although RNAV and Four Corner Post procedures do not directly affect taxi in and taxi out times, it is important to consider taxi in/out delays when discussing the overall delays for arriving and departing aircraft.

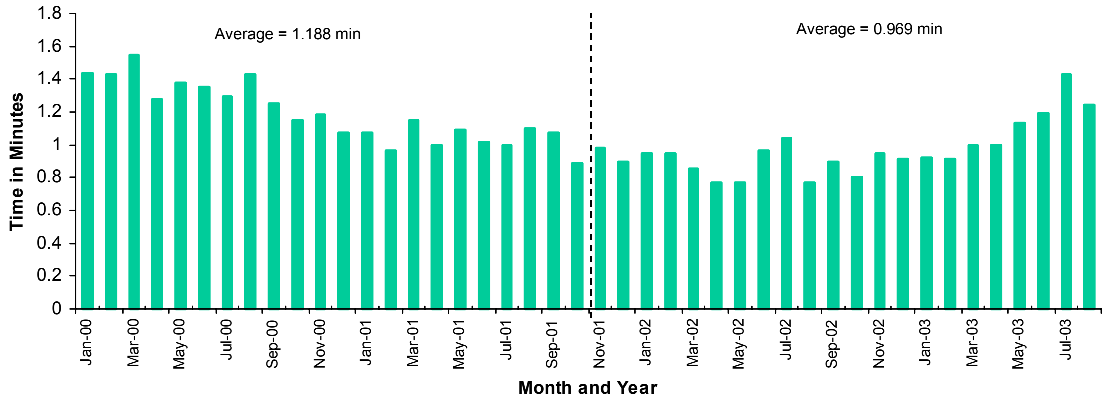


**Figure E.5 - Average Taxi In Delays at LAS**

Average taxi in delays, just like average gate arrival delays, have decreased, on average, from January 2000 through August 2003. The average taxi in delay fell 22 percent from 1.188 minutes to 0.969 minutes between pre-implementation and post-implementation. The average gate arrival delay fell 38 percent from 13.566 minutes to 9.79 minutes between pre-implementation and post-implementation.

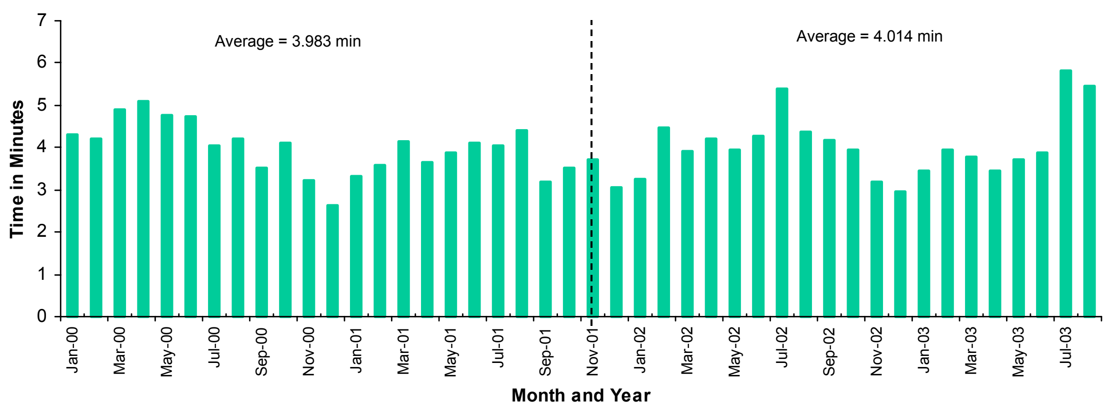


**Figure E.6 - Average Taxi Out Delays at LAS**

Average taxi out delays per aircraft increased slightly while overall airport departure delays decreased from pre-four corner post implementation to post implementation. Average taxi out delays per aircraft increased by less than one percent (.77 percent) while average airport departure delays decreased by approximately 38 percent. Neither taxi out delays nor taxi in delays had a significant impact on gate arrival or airport departure delays.

### Reduction in air miles flown

The evaluation team was unable to obtain air miles data from ASPM or OPSNET. Because the comparison period is 2000 and 2001, POET data was not available for review.

### Increase in airport capacity

LAS Four Corner Post and RNAV routes were put into place to provide increased capacity and reduced delays as the airport saw increased traffic. Although the implementation of the four-corner post and RNAV may increase LAS' capacity, the increase in capacity is not currently needed as LAS operations have remained constant, shown by the trend line in Figure E.7.

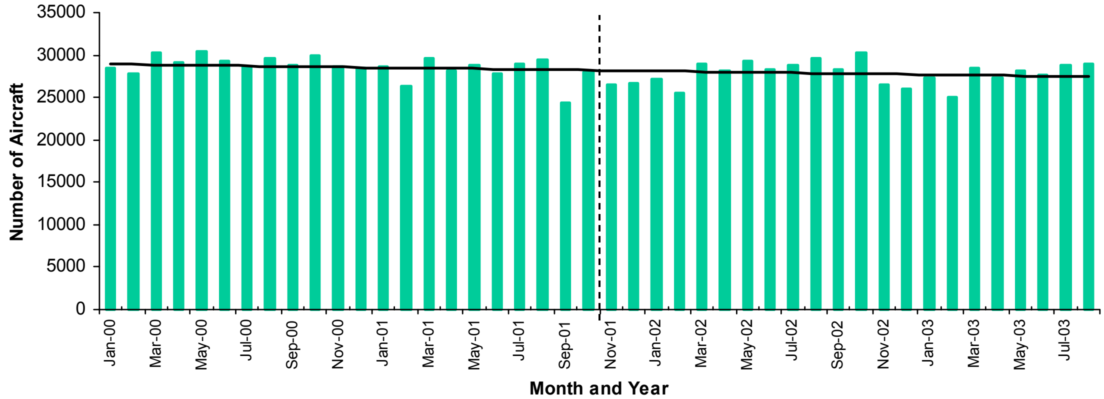


**Figure E.7 - Total Operations at LAS**

## Conclusions

- The results show a decrease from pre-implementation to post-implementation in average departure delays, average arrival delays, percentage of delayed arrivals, and percentage of delayed departures, which matches MITRE-CAASD's study.
  - The evaluation team extended MITRE-CAASD's data set to include January through July 2003 data**.** The trend in decreased departure delays and arrival delays, decreased percentage of delayed arrivals, and decreased percentage of delayed departures continued through this period.
  - The savings from a decrease in average departure delays between RNAV/4 Corner Post pre-implementation and post-implementation was $1.6 Million
- LAS Four Corner Post and RNAV routes were put into place to provide increased capacity and reduced delays as the airport saw increased traffic. Currently, LAS has experienced a decrease in average operations. Although the implementation of the four-corner post and RNAV may increase LAS' capacity, the increase in capacity is not urgent due to the reduced number of operations.

# Appendix F: Choke Points Benefits Assessments

## Background

In the summer of 2000, FAA representatives from regional and headquarters' offices met to identify and address the key bottlenecks in the national airspace, focusing on the Eastern, Great Lakes, New England, and Southern Regions' airspace. The outcome of the meeting was the identification of seven choke points. The seven choke points that the group identified and addressed were as follows:

1. Westgate departures from the New York metropolitan airports
2. Northgate departures from the New York metropolitan airports
3. Washington ARTCC sectors
4. West departures over Jet Route 547 from the northeast
5. Great Lakes Corridor
6. High altitude en route holding of east coast arrivals
7. Access to overhead streams for select city pairs

In order for National Airspace Redesign to effectively address these choke points, the choke points team identified 21 action items, mapping each action item to the relevant choke point. The objective was to reduce congestion and delays at the seven choke points by implementing all 21 Choke Point Actions. Those action items were as follows:

1. New York Terminal Radar Approach Control (TRACON) Reroute/Altitude Restrictions on Westbound Turbo Propeller Departures
2. Reroute/New Route for East Arrivals into the Washington Area Airports
3. Establish a Liberty Coordinator
4. ROBRT/HYPER Holding
5. Create Magio Super High Sector
6. New York Air Route Traffic Control Center (ZNY) National Route Program Analysis
7. Restrictions
8. Altitude Restrictions on Pittsburgh Arrivals into Flight Level 28,000 feet (FL280)
9. ARD/RBV Flip-Flop and EWR Final Vector Position for Runway 4L/R
10. NRP Traffic Impact on ZDC
11. Review of Boston Air Route Traffic Control Center's (ZBW) 1994 Airspace Redesign Team's findings
12. Air Traffic Control Assigned Airspace (ATCAA) Redesign Proposal
13. Utilization of Canadian Routes
14. Automation Interface with Canada
15. Test Changes to National Route Program (NRP)
16. Smoothing
17. Design and implement new sectors
18. Tactical Altitude Assignment
19. Collaborative Routing and Coordination Tools (CRCT)
20. Develop Area Navigation Departure Procedures
21. Reduce restrictions during ground delay program (+ / - 3 minutes)

Table F.1 lists the Choke Point Actions that NAR and its stakeholders used for each choke point.

| Action Items | Choke Point 1 | Choke Point 2 | Choke Point 3 | Choke Point 4 | Choke Point 5 | Choke Point 6 | Choke Point 7 |
|---|---|---|---|---|---|---|---|
| 1 | ✔ | | | | | | |
| 2 | ✔ | | | | | | |
| 3 | ✔ | | | | | | |
| 4 | ✔ | | | | | | |
| 5 | | ✔ | | | | | |
| 6 | | ✔ | | | | | |
| 7 | | ✔ | | | | | |
| 8 | | ✔ | | | | | |
| 9 | | | ✔ | | | | |
| 10 | | | ✔ | | | | |
| 11 | | | | ✔ | | | |
| 12 | | | | ✔ | | | |
| 13 | | | | ✔ | ✔ | | |
| 14 | | | | | ✔ | | |
| 15 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 16 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 17 | | | | | | | ✔ |
| 18 | | | | | ✔ | | ✔ |
| 19 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 20 | | | | | | | ✔ |
| 21 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

**Table F.1 - Choke Point Actions**

The choke point initiatives were completely implemented in 2002, with a number of the initiatives completed in 2001.

## Data Collection Methodology and Results

As one of the objectives for the Evaluation of the OEP's National Airspace Redesign program, the evaluation team was to identify completed initiatives and determine if any benefits had accrued from implementation. The evaluation team identified choke points as a recently completed NAR initiative. The team met with ATA and MITRE to discuss the benefits analysis that had been previously undertaken (in September 2001) and decided that an updated benefits assessment would provide valuable information and insight into the NAR program's choke points initiatives.

The evaluation team contacted ATA's Airspace Analysis Laboratory to obtain ETMS data for each choke point. The evaluation team provided laboratory analysts with a list of specific routes, fixes, airports, and/or sectors that matched each choke point, as well as a list of specific data collection points. The evaluation team limited the comparison periods to clear weather days in the summer months (May through August) of 2000, 2001, and 2002. Clear weather days were defined by the following conditions:

- Ceiling = 2500 feet or greater
- Visibility = 5 miles or greater
- Wind Speed = 20 knots or less
- Visual Conditions

The team focused on Thursdays between 0700 and 2200 local time because Thursdays during the summer typically see the highest level of traffic. The Airspace Analysis Laboratory collected the data for each choke point and provided the data to the evaluation team for analysis. The analysis and results for are discussed below.

## Choke Points 1 and 2: Westgate (Choke Point 1) and Northgate (Choke Point 2)

Westgate (choke point 1) and Northgate (choke point 2) departures out of New York TRACON handle large volumes of traffic, creating a highly complex airspace. Due to that increased congestion, choke points 1 and 2 see increased departure delays. The evaluation team identified the fixes for New York TRACON Westgate departures (ELIOT, PARKE, LANNA, BIGGY, and ARD) and Northgate departures (GAYEL, NEION, COATE, HAAYS, and SAX). Figure F.1 shows the Westgate and Northgate fixes for westbound and northbound traffic originating from the New York metro airports.

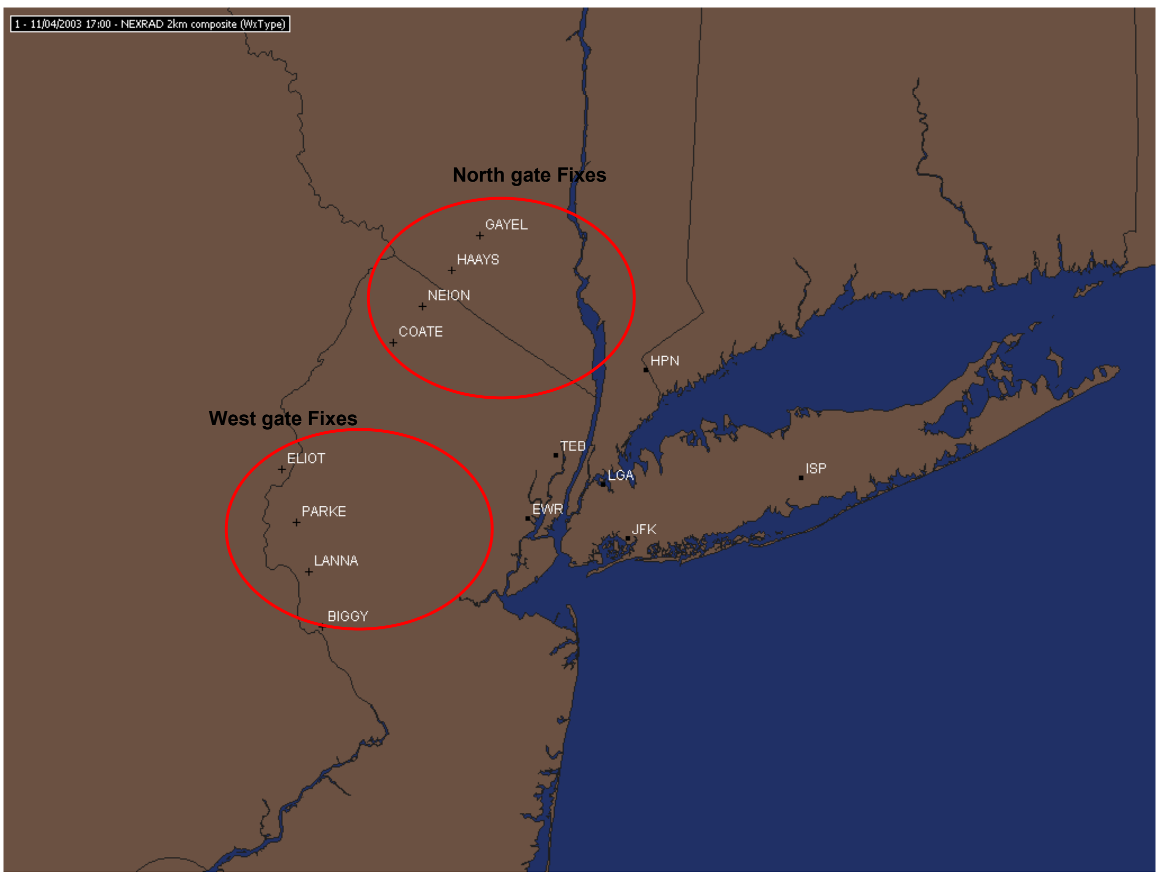


**Figure F.1 - Northgate and Westgate Fixes**[19]

To alleviate these departure delays, industry representatives undertook eight initiatives for each choke point.

[19] *Note that Figure F.X does not include ARD nor SAX, as Flight Explorer was unable to display these fixes.*

*Westgate Departures:*

- NY TRACON Rerouting/Altitude Restriction on Westbound Turbo Propeller Departures
- Reroute/New Route East Arrivals into the Washington Area Airports
- Establish a Liberty Coordinator
- ROBRT/HYPER Holding
- Test changes to NRP
- Smoothing
- CRCT
- Reduce Restrictions during Ground Delay Program to (+ / - 3 minutes)

*Northgate Departures:*

- Create Magio Super High Sector
- ZNY NRP Analysis
- Restrictions
- Altitude Restrictions on Pittsburgh Arrivals to FL280
- Test changes to NRP
- Smoothing
- CRCT
- Reduce Restrictions during Ground Delay Program to (+ / - 3 minutes)

For each of the flights that flew over these fixes on the clear weather days listed in Table F.2, the evaluation team obtained the following ETMS data:

- Flight number
- Departure and arrival airports
- Departure fix
- Time across departure fix
- Filed flight plan
- Actual route flown
- Planned and actual departure times
- Planned and actual airtimes
- Planned and actual airmiles
- Planned and actual arrival times

| Year | Month | Date |
|---|---|---|
| 2002 | May | 16, 23 |
| | June | None |
| | July | 11, 18, 25 |
| | August | 1, 8 |
| 2001 | May | 3[20], 10, 31 |
| | June | 7, 28 |
| | July | None |
| | August | 16, 30 |
| 2000 | May | 4 |
| | June | 1, 8, 29 |
| | July | 6, 13, 20 |
| | August | 17 |

**Table F.2 - Clear Weather Dates**

20 *May 3, 2001 was not used for Choke Point 1 due to an unusually low number of departures*

The evaluation team first reviewed the number of aircraft using the Northgate or Westgate fixes. The number of operations per date is shown in Figure F.2.

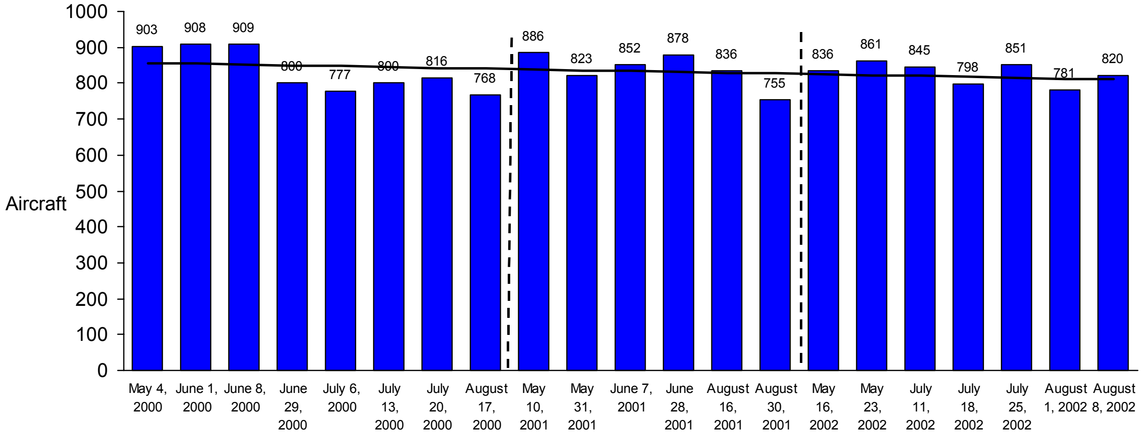


**Figure F.2 - Number of Departures for Choke Point 1**

Figure F.2 shows that the overall number of departures west bound from the New York metropolitan area have remained fairly constant during the summer months of 2000 – 2002.

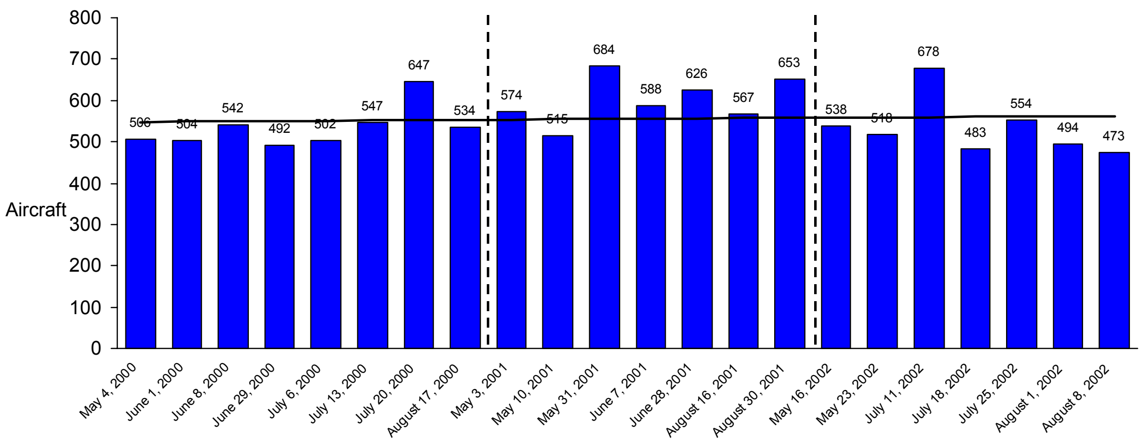


**Figure F.3 - Number of Departures for Choke Point 2**

Figure F.3 shows that the number of departures north bound from the New York Metropolitan area have also remained fairly constant during the summer months of 2000 – 2002. The annual average departure delay per aircraft and average arrival delay per aircraft (based on the summer months of May through August) for each choke point are shown in Figure F.4.

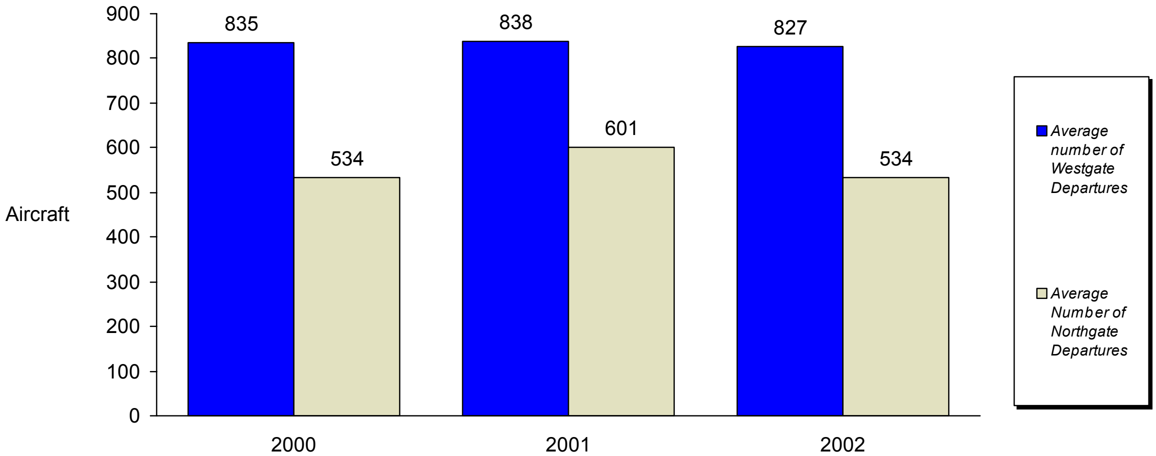


**Figure F.4 - Average Number of Departures for Choke Points 1 & 2**

Figures F.5 through F.7 show the results of our departure delay analysis for flights originating in the New York metropolitan area and heading westbound (choke point 1) or northbound (choke point 2).

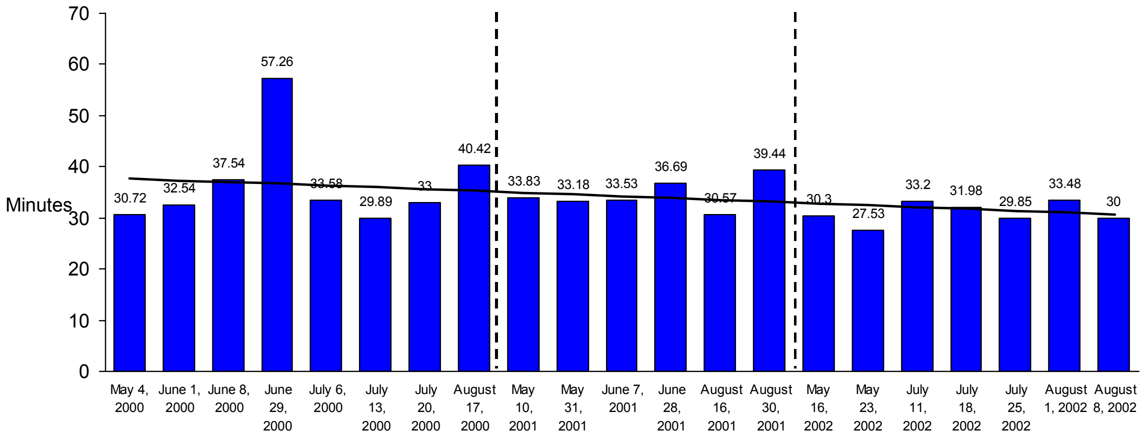


**Figure F.5 - Average Departure Delay per Aircraft for Choke Point 1**

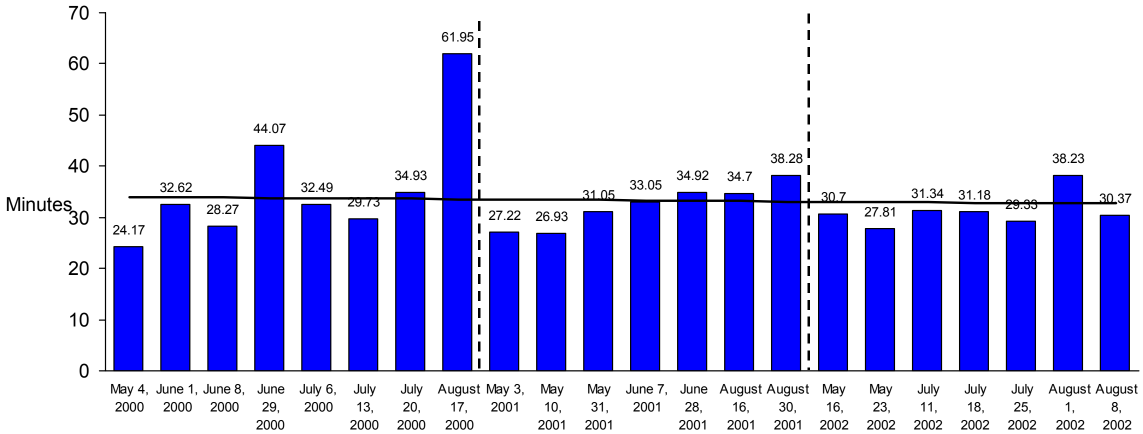


**Figure F.6 - Average Departure Delay per Aircraft for Choke Point 2**

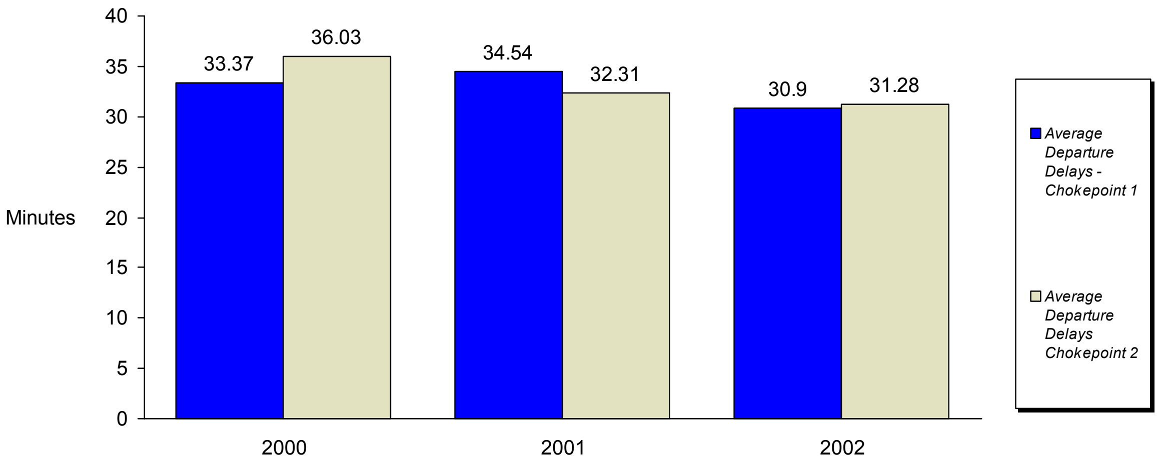


**Figure F.7 - Average Departure Delay per Aircraft for Choke Points 1 & 2**

This data shows that average departure delays have been declining from 2000 to 2001 and from 2001 to 2002.

The evaluation team also reviewed the departure delays by departure fix to identify any trends in departure delays based on fixes from 2000 to 2002. Figure F.8 shows the average departure delay per aircraft for flights using the Westgate fixes (ARD, BIGGY, ELIOT, LANNA, and PARKE) while Figure F.8 shows the average departure delay per aircraft for the Northgate fixes (COATE, GAYEL, HAAYS, NEION, and SAX).

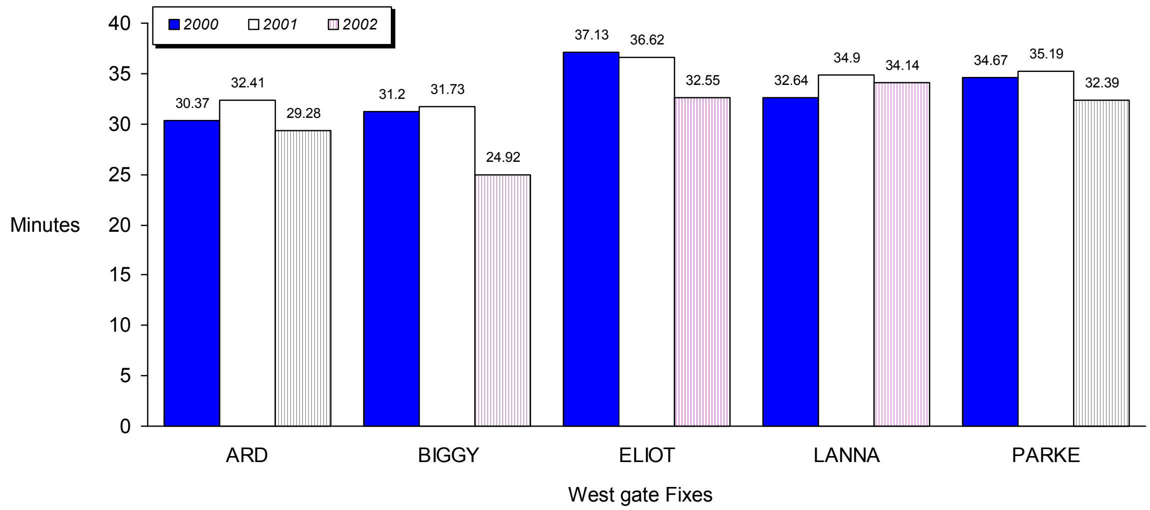


**Figure F.8 - Average Departure Delays Per Aircraft for Westgate Fixes for Choke Point 1**

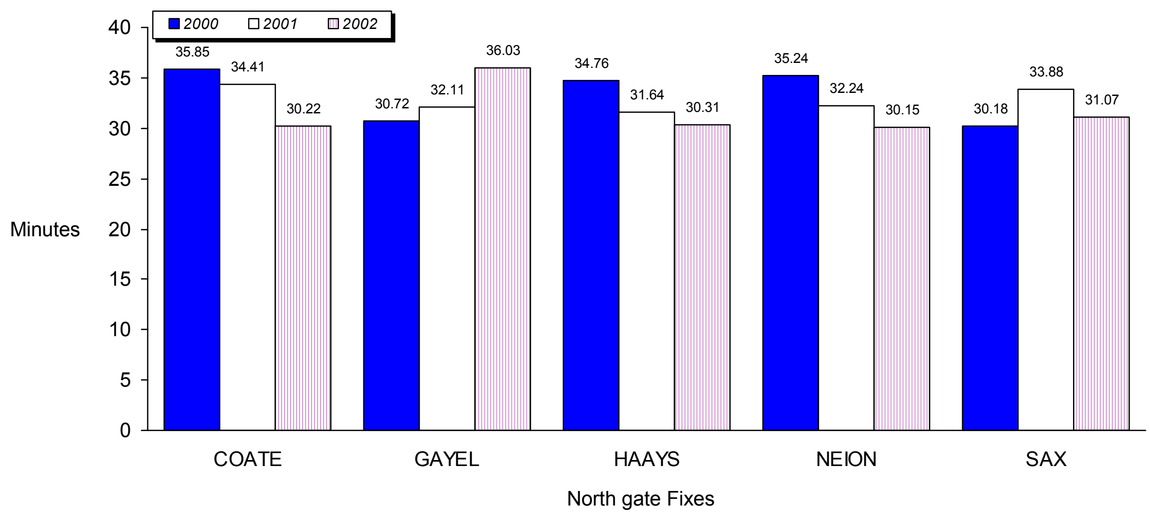


**Figure F.9 - Average Departure Delays Per Aircraft for Northgate Fixes for Choke Point 2**

### *Choke Points 1 and 2 Summary*

Seven out of the ten fixes (see Figures F.7 and F.8) show a decline in average departure delays from 2000 to 2002, with many of those fixes experiencing slightly higher average departure delays per aircraft during 2001. Just as the number of departures from the New York metropolitan area increased from 2000 to 2001, so also did the average departure delays for many of the fixes. Four of the ten fixes have shown a decline in average departure delays per aircraft from 2000 to 2001 and from 2001 to 2002. When evaluating the overall trend in average departure delays per aircraft, choke points 1 and 2 have each shown an overall decline in average departure delays when comparing 2000 to 2002.

## Choke Point 3: Washington Air Route Traffic Control Center Sectors

ZDC ARTCC Sectors 12, 16, 18, and 19 sequence traffic that is inbound to New York. These sectors are narrow and congested due to the amount of east coast traffic. The objective of choke point 3 was to reduce the congestion in these sectors and decrease departure and arrival delays for aircraft with routes through ZDC12, ZDC16, ZDC18, and ZDC19. Figure F.10 illustrates these four sectors.

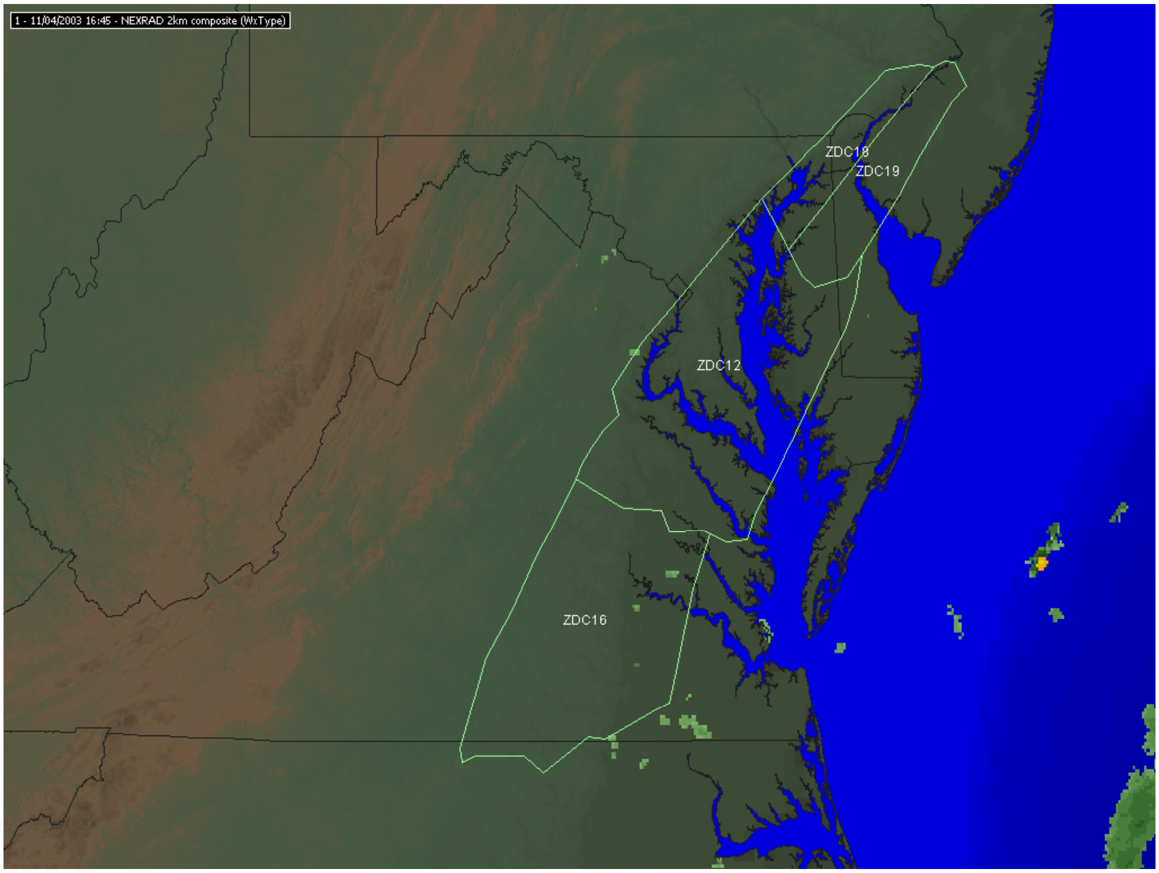


**Figure F.10 - ZDC Sectors 12, 16, 18, 19**

The evaluation team requested ETMS data for all flights passing through ZDC Sectors 12, 16, 18, and/or 19 and then passing through Fixes ARD or RBV, just outside of the New York metro area. The team requested the following data for each date listed in Table F.3 below:

- Flight number
- Departure and arrival airports
- Fix crossed
- Time across fix
- Filed flight plan
- Actual route flown
- Planned and actual departure time
- Planned and actual airtime
- Planned and actual air miles
- Planned and actual arrival time

| Year | Month | Date |
|---|---|---|
| 2002 | May | 9, 30 |
| | June | -- |
| | July | 4, 11 |
| | August | 8, 22 |
| 2001 | May | 10, 31 |
| | June | -- |
| | July | 12 |
| | August | 2 |
| 2000 | May | 11, 18, 25 |
| | June | 8, 22 |
| | July | 6 |
| | August | 10, 17 |

**Table F.3 Choke Point 3 Data Dates**

Choke point 3 calls for decreased congestion in the four ZDC sectors; therefore, the evaluation team analyzed average aircraft departure delays and arrival delays to determine if the level congestion has changed enough to result in an overall decrease in delays. To reach these goals, industry representatives used the following Choke Point Actions:

- ARD/RBV Flip-Flop and EWR Final Vector Position for Runway 4L/R
- NRP Traffic Impact on ZDC
- Test Changes to NRP
- Smoothing
- CRCT
- Reduce restrictions during ground delay program to (+ / - 3 minutes)

The team first reviewed the average number of flights, using the dates above, for each year (see Figure F.11). We found that the average number of flights per day through ZDC sectors that used RBV or ARD increased from 2000 to 2001 but decreased from 2001 to 2002 (as well as decreased from 2000 levels). This could be partly due to the effects of the Choke Point Actions that were taken to alleviate congestion in these sectors. ZDC has also experienced a decrease in the level of traffic from the Washington, D.C. area since September 11, 2001, as Washington's Regan International Airport (DCA) reduced its overall level of operations in 2002.

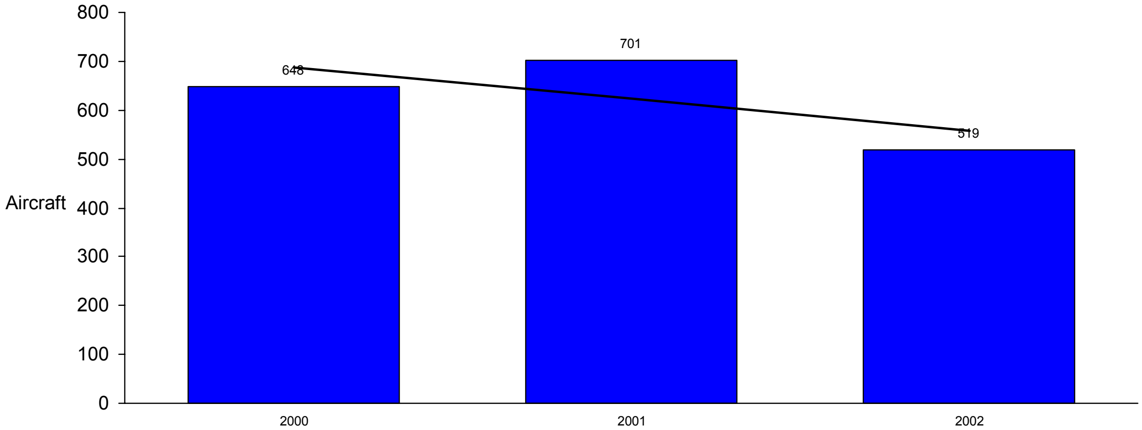


**Figure F.11 - Average Number of Flights through ZDC Sectors to RBV/ARD May through August 2000 - 2002**

As Figure F.12 shows, the average departure delays have decreased from 2000 to 2002.

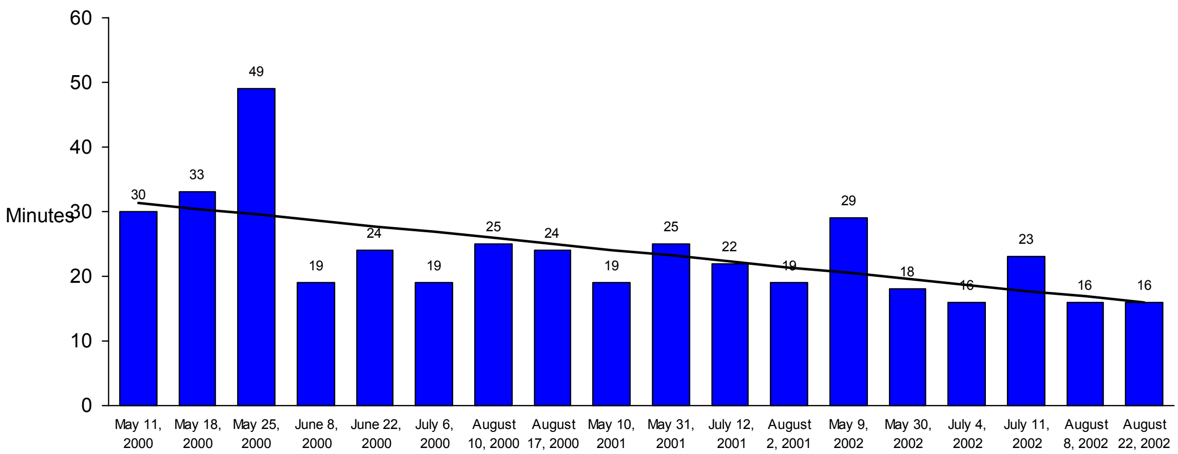


**Figure F.12 - Average Departure Delays per Aircraft for Choke Point 3**

Figure F.13 shows that average arrival delays have also decreased from their 2000 and 2001 levels.

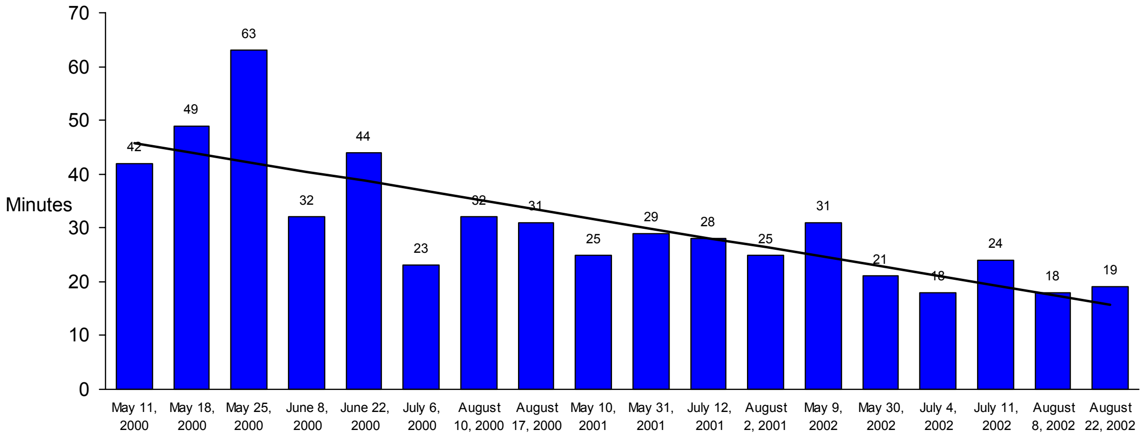


**Figure F.13 - Average Arrival Delays per Aircraft for Choke Point 3**

In evaluating the average arrival delays, the evaluation team calculated the difference between the average departure delay and the average arrival delay to determine if any additional delay occurred once the aircraft was airborne. For example, if the average departure delay per aircraft was 20.00 minutes and the average arrival delay was 21.00 minutes per aircraft for the same period, then the average additional minutes of delay accrued after takeoff was 1.00 minutes. This signifies that once the aircraft was airborne, it encountered limited airborne or holding delays. We found that the difference between the average departure delay per aircraft and the average arrival delay per aircraft has decreased from 2000 to 2001 and from 2001 to 2002. In 2000, the difference between average departure delay per aircraft and average arrival delay per aircraft was 11.62 minutes; in 2001, it was 5.5 minutes; and in 2002, it was 2.16 minutes. This showed that once flights were airborne, they experienced less airborne restrictions and arrival delays. These results are depicted in Figure F.14.

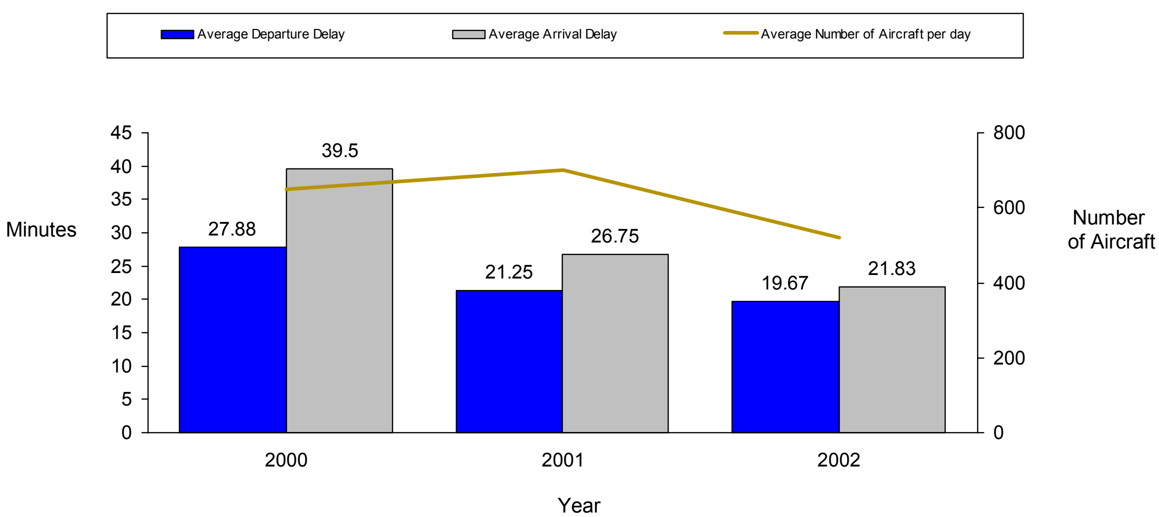


**Figure F.14 - Summary of Data Results for Choke Point 3**

### *Choke Point 3 Summary*

Choke point 3 shows that average departure delays and average arrival delays have decreased from 2000 to 2002 (See Figure F.14). Choke point 3 initiatives have played a role in the reduction of arrival and departure delays, although the lower level of operations has also helped to alleviate choke point 3 congestion.

## Choke Point 4: Jet Route 547

Jet Route 547 (J547) is a major westbound airway on which aircraft typically experience miles-in-trail restrictions. The lack of alternative routes to ORD, Chicago Midway International Airport (MDW), DTW, CLE, and CVG limit the flexibility of air traffic control (ATC) to reduce sector congestion. Such congestion often results in ground and airborne delays. Figure F.15 shows the location of J547, which serves as a major route between NY and other east coast traffic heading to the Great Lakes Region.

To reduce miles in trail restrictions on J547, industry representatives agreed to complete the following Choke Point Actions:

- Review of ZBW's 1994 Airspace Redesign Team's findings
- ATCAA Redesign Proposal
- Utilization of Canadian Routes
- Test changes to NRP
- Smoothing
- CRCT
- Reduce restrictions during ground delay program to (+ / - 3 minutes)

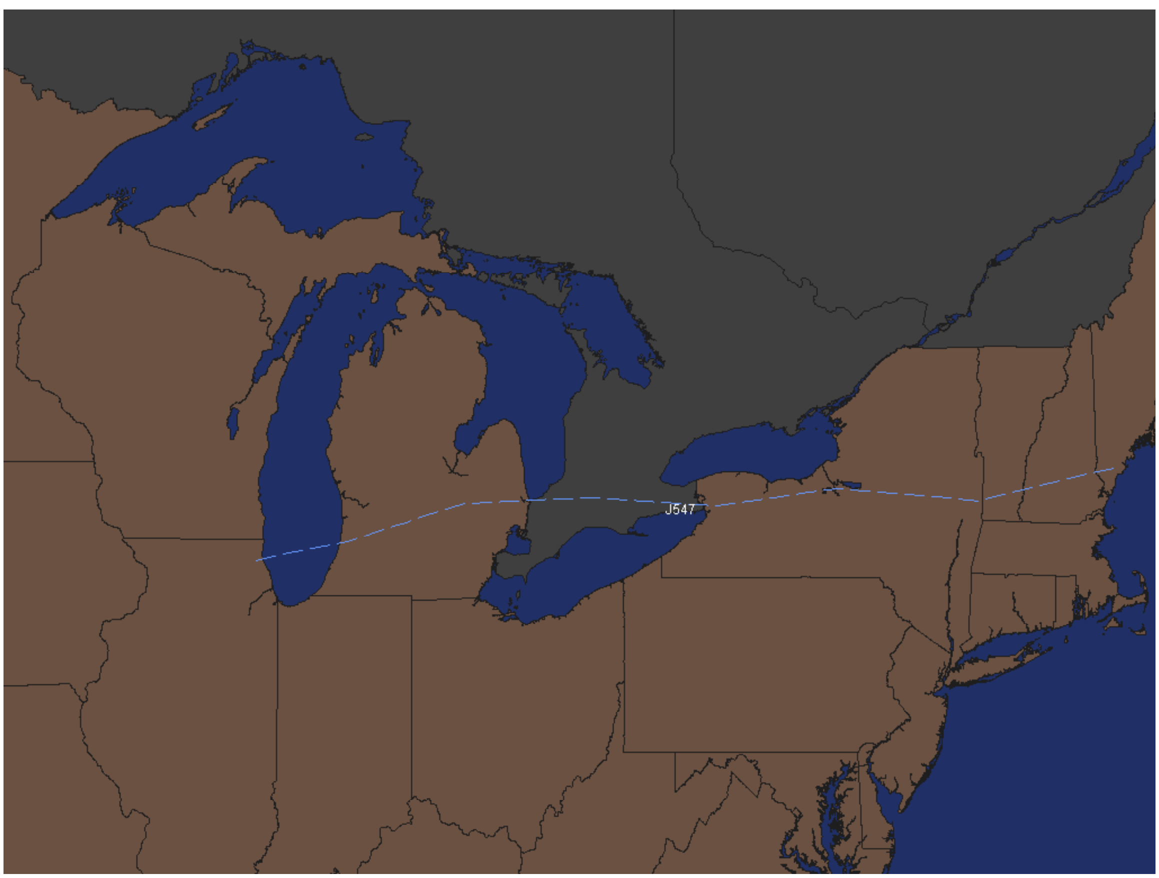


**Figure F.15 - Jet Route 547**

Although the objective for choke point 4 was to reduce the miles in trail (MIT) restrictions, ETMS was unable to provide MIT information. Therefore, the evaluation team could not determine the MIT restrictions for J547. The evaluation team obtained the following ETMS data for the dates listed in Table F.4:

- Flight number
- Departure and arrival airports
- Planned and actual departure times
- Planned and actual arrival times
- Planned and actual air times
- Planned and actual air miles

| Year | Month | Date |
|---|---|---|
| 2002 | May | 16, 23 |
| | June | 20 |
| | July | 4, 11, 18, 25 |
| | August | 1, 8, 15 |
| 2001 | May | 3, 10, 17, 31 |
| | June | 7, 21, 28 |
| | July | None |
| | August | 2, 9, 16, 23, 30 |
| 2000 | May | 4 |
| | June | 1, 8, 22, 29 |
| | July | 6, 13, 20 |
| | August | 10, 17 |

**Table F.4 - Choke Point 4 Data Dates**

The evaluation team was unable to analyze the data for all of the dates listed in Table F.4. To determine which dates the team would analyze, we looked at the total number of daily flights to determine which dates had the highest level of traffic. We also ensured that the chosen dates had a full set of data (no data elements missing).

The evaluation team first reviewed the ETMS data to determine the level of operations that occurred on each date for J547. This analysis was to ensure that the levels of operations had not increased or decreased significantly between years. As shown in Figure F.16, the total number of aircraft using J547, based on ETMS data, per date has remained relatively constant from 2000 to 2002.

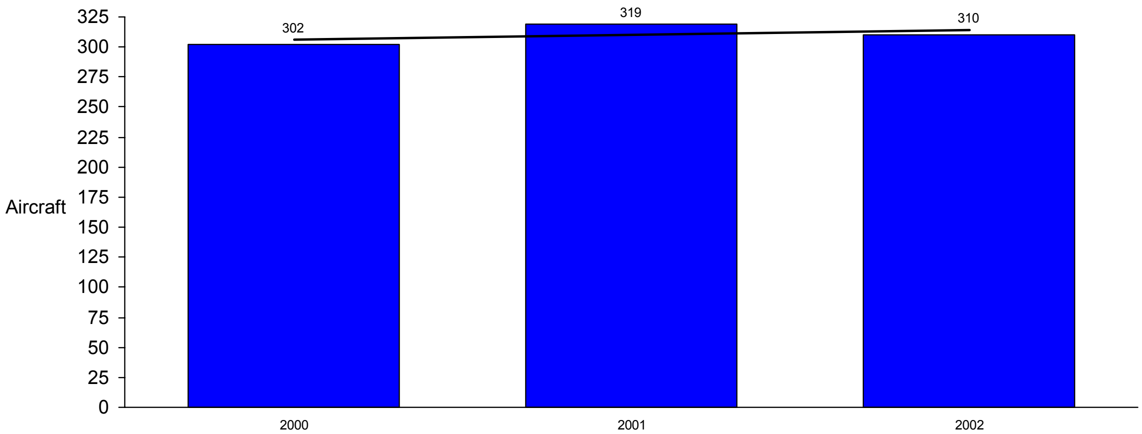


**Figure F.16 - Average Number of Aircraft on J547 per day**

Figure F.17 shows the number of aircraft reported in ETMS for each date listed in Table F.4.

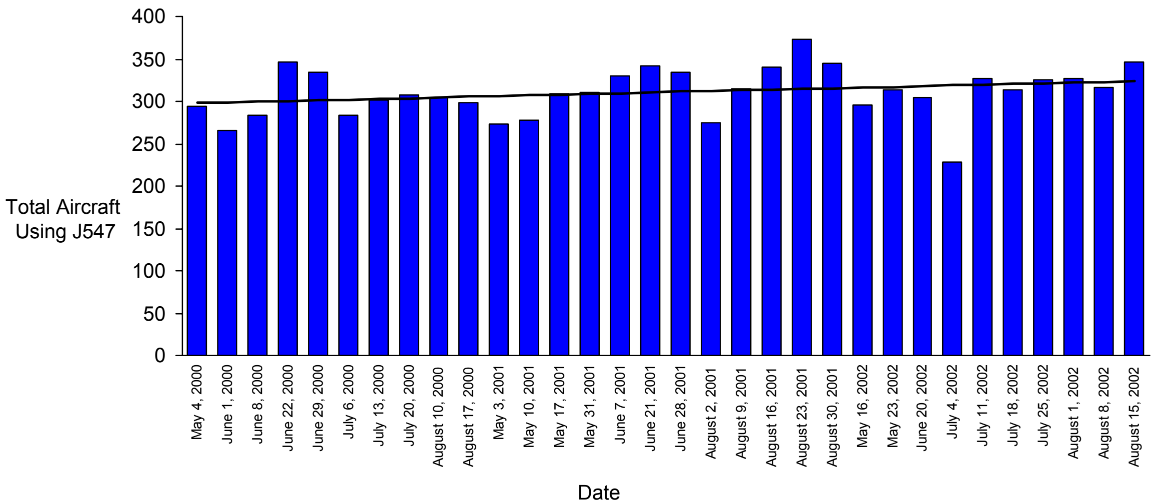


**Figure F.17 - Number of Aircraft Using Jet Route 547 on the Given Date**

The evaluation team found that average departure delay per aircraft has been decreasing for flights using J547 (summer months 2000 – 2002).

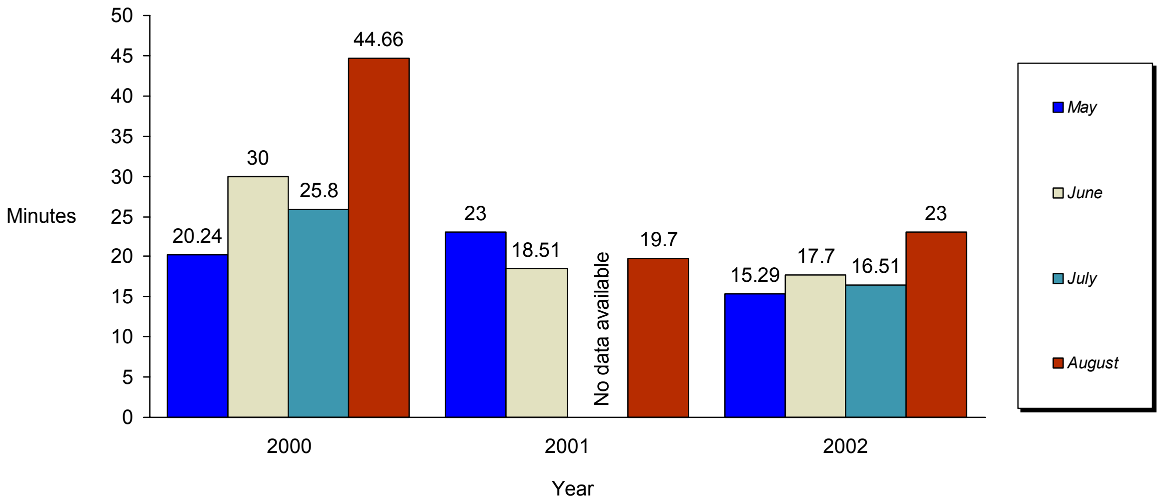


**Figure F.18 - Average Departure Delay per Aircraft for Choke Point 4**
**Summer Months 2000 – 2002**

The evaluation team also looked average arrival delays per aircraft for flights using J547. Figure F.18 shows the results of the data analysis. Aircraft using J547 arrived, on average, late in 2000; however, by 2002, aircraft on J547 were arriving early.

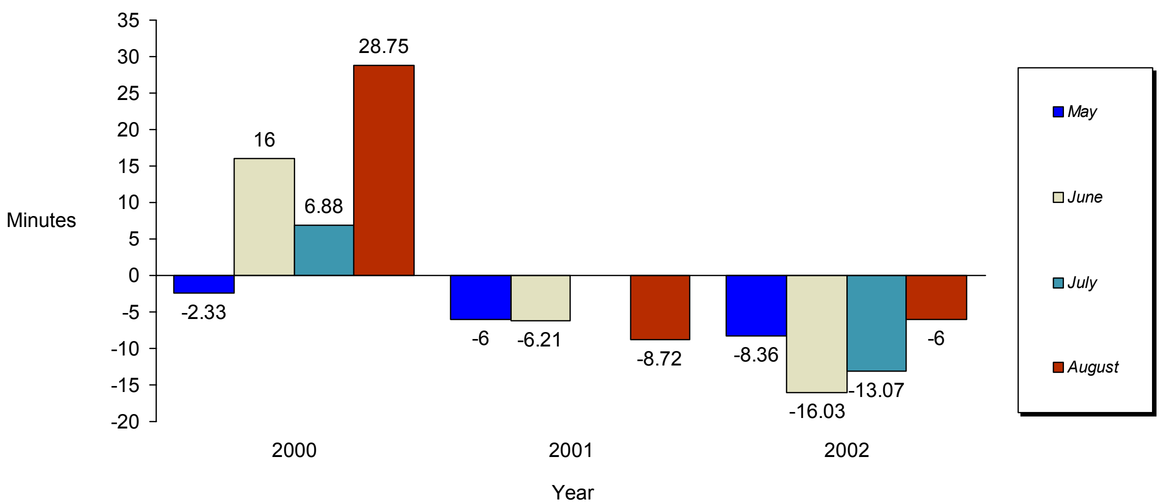


**Figure F.19 - Arrival Delays for J547**
**Summer Months 2000 through 2002**

Comparing the results of Figure F.18 to Figure F.19, we found that average arrival delays per aircraft were significantly less than average departure delays per aircraft. In 2000, aircraft were able to make up an average of 13.87 minutes during the flight after experiencing departure delays. In 2001 aircraft made up 27.38 minutes of departure delay during the flight - allowing aircraft to average early arrivals. In 2002, aircraft were able to make up for 28.99 minutes of departure delay, putting them at their destination early. This trend can be attributed to several factors including (1) airlines building additional time into their schedules for delays, (2) aircraft able to reduce the overall delay during airborne time, and/or (3) choke point 4 initiatives reducing the level of restrictions to improve traffic flows on J547.

***Choke Point 4 Summary***

Stakeholders are receiving benefits from the implementation of choke point 4. The number of aircraft using J547 has remained fairly constant from 2000 through 2002 (summer months) and delays have shown a downward trend from 2000 to 2002.

## Choke Points 5 and 6: Great Lakes Corridor and High Altitude Holding of East Coast Arrival Streams

The Great Lakes Corridor contains highly congested and complex airspace in its three ARTCCs – ZAU, ZOB, ZID. ATC must move arrival and departure flows into and out of ZNY, mixing with other east coast and Midwest traffic heading west – a task that increases the congestion and complexity of the sector. Sector capacity is reduced as a result of the requirements for high altitude holding due to the starts and stops of east coast airports. Such holding patterns result in delays for ORD, DTW, CLE, PIT, and CVG.

To reduce sector congestion and delays for flights originating at ORD, DTW, CLE, CVG, or PIT, industry representatives agreed to complete the following Choke Point Actions:

- Utilization of Canadian Routes (CP #5)
- Automation Interface with Canada (CP #5)
- Tactical Altitude Assignment (CP #5)
- Test changes to NRP (CP #5/6)
- Smoothing (CP #5/6)
- CRCT (CP #5/6)
- Reduce restrictions during ground delay program to (+ / - 3 minutes) (CP #5/6)

The evaluation team requested ETMS data for all flights using the following sectors at any segment of the flight (see Figure F.20). The flights had to originate at ORD, DTW, CLE, PIT, or CVG and access:

- ZAU Sectors: 60, 75, 90, 92, 52, 45, 46, 83, 34, 36, 82, 24, 25
- ZOB Sectors: 18, 19, 27, 28, 46, 48, 66, 67, 57, 77, 36
- ZID Sectors: 80, 81, 82, 83, 84, 85, 86, 87, 88, 89

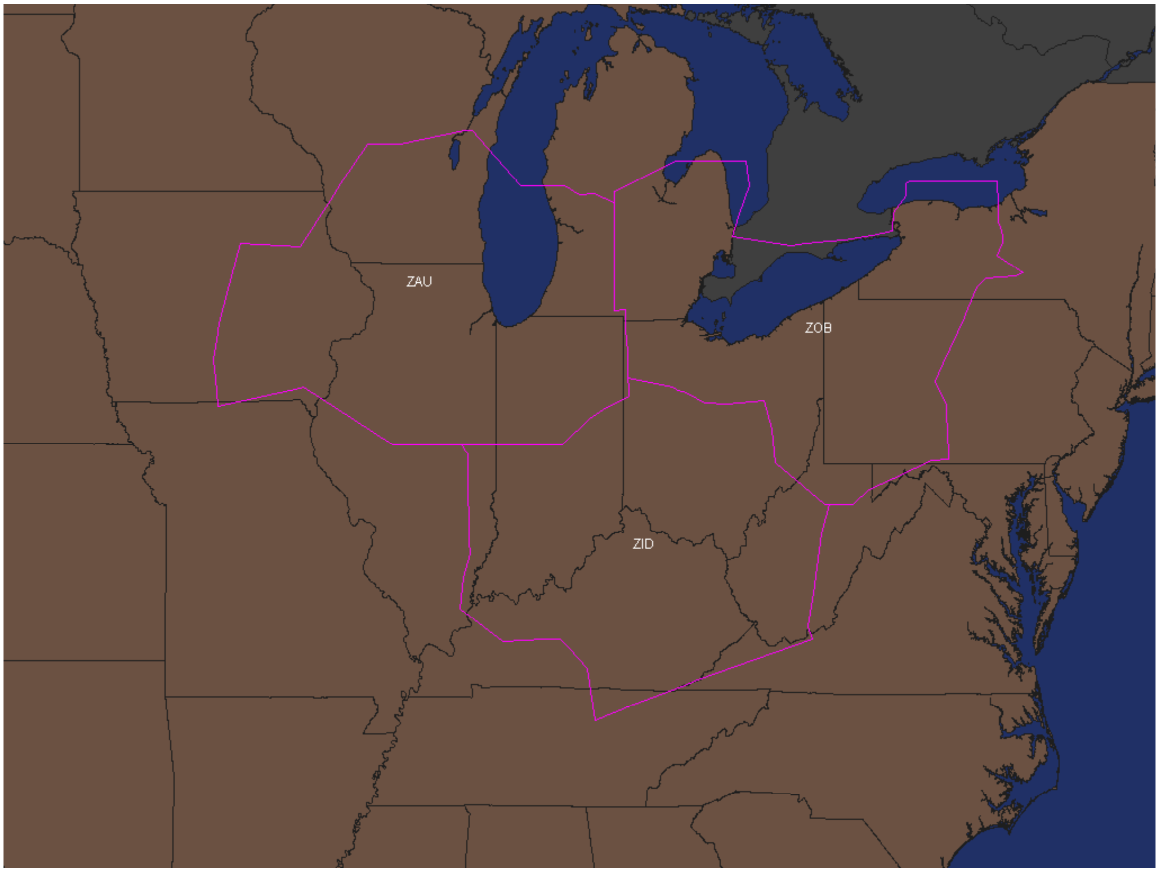


**Figure F.20 - ZID, ZAU, and ZOB**

The evaluation team specifically requested the following ETMS data for the dates listed in Table F.5 below.

- Flight Number
- Sector (From list above)
- Sector Entry and Exit Times
- Departure and Arrival Airports
- Filed Flight Plan
- Actual Route Flown
- Planned and Actual Departure Times
- Planned and Actual Airtimes
- Planned and Actual Air miles
- Planned and Actual Arrival Times

The evaluation team was unable to analyze the data for every date shown in Table F.5, so the team chose to analyze the data from one date each month. If one month did not have a clear weather Thursday, the evaluation team chose an additional date from another month. If no additional Thursdays were available, then the evaluation team chose a Friday date. The evaluation team attempted, when possible, to avoid using holidays (such as the July 4$^{th}$ holiday). The dates that the evaluation team used are in bold type in Table F.5.

| Year | Month | ORD Dates | DTW Dates | CLE Dates | PIT Dates | CVG Dates |
|---|---|---|---|---|---|---|
| **2000** | May | ***4***, 25 | ***4***, 25 | ***4***, 11 | ***4***, 11, 18, 25 | ***11***, 18, 25 |
| | June | ***15***, 22, 29 | ***8***, 22 | ***8***, 22, 30 | 1, ***8***, 22 | ***8***, ***29*** |
| | July | ***13***, 20, 27 | 6, ***13***, 20 | 6, ***13***, 20 | 6, ***13*** | -- |
| | August | ***3***, 31 | ***10*** | ***10***, 31 | ***10***, 17, 31 | ***3***, 10, 31 |
| **2001** | May | ***3*** | ***3***, 10, 31 | ***3***, 10, 31 | ***3***, 31 | ***10*** |
| | June | ***14***, ***21***, 28 | ***7***, 14, 21 | ***7***, 14 | ***28*** | ***8***[21] |
| | July | 5, ***12*** | 5, ***12***, 26 | 5, ***12*** | ***12*** | ***5***, 6, ***12***, 13 |
| | August | -- | ***30*** | ***16***, 30 | ***30*** | -- |
| **2002** | May | ***23***, 30 | ***23*** | ***9***, 23, 30 | ***2***, 9, 16, 23, 30 | ***16***, 23, 30 |
| | June | ***20***, 27 | ***20*** | ***20***, 27 | ***13***, 20 | ***20*** |
| | July | 4, ***11***, 18, 25 | 4, ***11***, 25 | 4, ***11***, 18, 25 | 4, ***11***, 18 | 4, ***11***, 25 |
| | August | ***8***, 29 | ***1***, 8, 29 | ***1***, 8, 29 | 1, ***8***, 15, 22, 29 | ***1***, 8, 22 |

**Table F.5 - Choke Points 5 and 6 Dates**

The evaluation team first reviewed the departure data from ORD, DTW, CLE, PIT, and CVG to determine if any significant increases or decreases in the average number of departures occurred between 2000 and 2002.

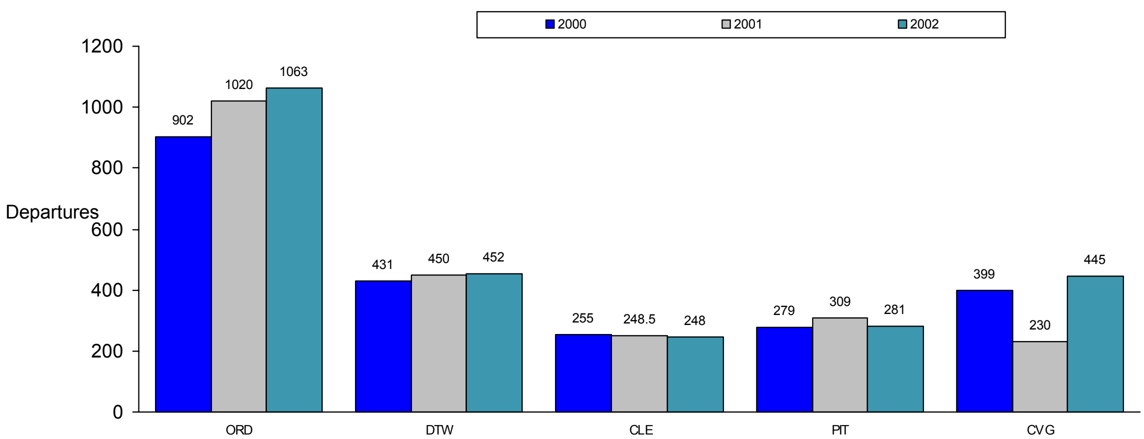


**Figure F.21 - Average Number of Departures per Day**
**May - August 2000 through 2002**

Figure F.21 shows that the average number of departures for choke points 5 and 6 has either remained constant or increased from 2000 to 2002.

- ORD 2000 vs. 2002 = 15.15% increase in number of departures using choke point 5 and 6 sectors
- DTW 2000 vs. 2002 = 4.65% increase in number of departures using choke point 5 and 6 sectors
- CLE 2000 vs. 2002 = 2.8% decrease in number of departures using choke point 5 and 6 sectors

[21] *June 8, 2000, July 6, 2001, and July 13, 2001 are Fridays (under CVG).*

- PIT 2000 vs. 2002 = 0.7% increase in number of departures using choke point 5 and 6 sectors
- CVG 2000 vs. 2002 = 10.3% increase in number of departures using choke point 5 and 6 sectors

The evaluation team reviewed the number of departures, average departure delays, and average arrival delays for each of the five airports listed in choke points 5 and 6 that passed through sectors ZAU, ZOB, and/or ZID.

Figure F.22 shows that **ORD** is experiencing a slight increase in the number of flights using ZAU, ZOB, and/or ZID sectors from 2000 to 2002. In addition, average arrival delays and average departure delays have both decreased. Figure F.22 shows that choke points 5 and 6 are helping to reduce sector congestion and departure delays at ORD.

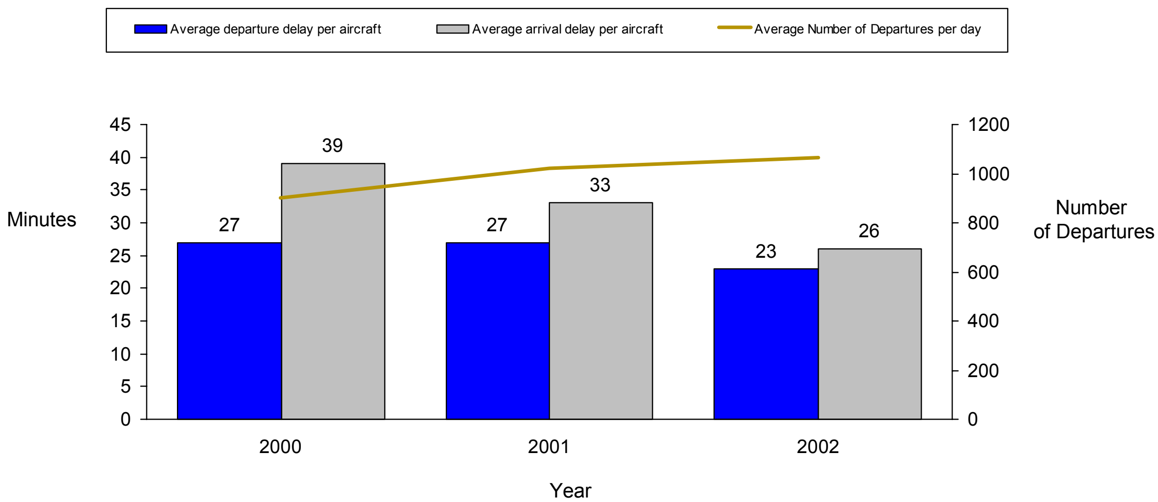


**Figure F.22 - Average Departure Delays, Arrival Delays and Number of Departures ORD Departures through ZAU, ZOB, ZID**

Figure F.23 shows that **CLE** is experiencing a very slight decrease in the number of flights using ZAU, ZOB, and/or ZID sectors from 2000 to 2002. Average arrival delays and average departure delays have shown mixed results – both types of delay are reduced when comparing 2000 to 2002. However, 2002 average arrival and departure delays increased when compared to 2001. Figure F.23 shows that choke points 5 and 6 have produced mixed results for CLE.

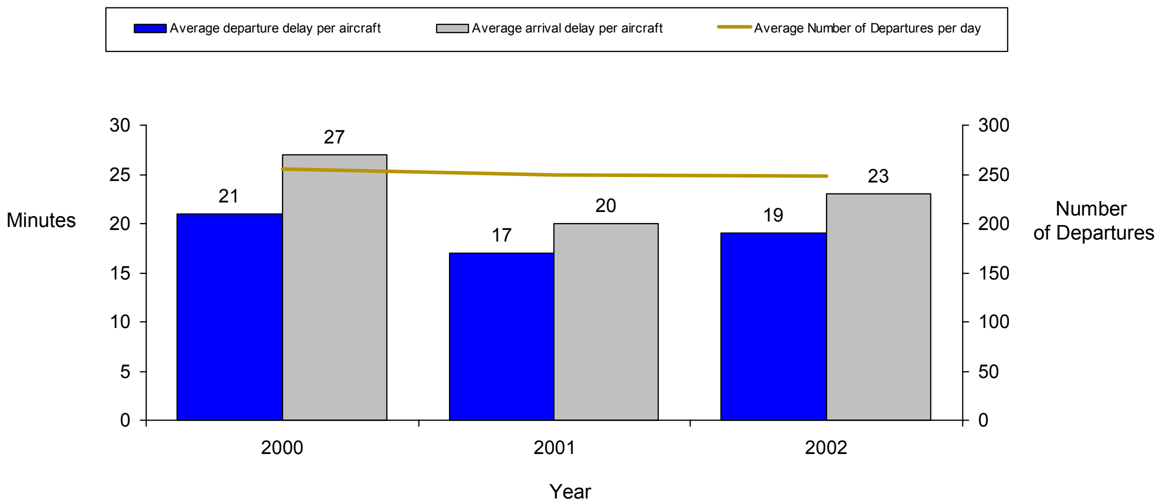


**Figure F.23 - Average Departure Delays, Arrival Delays and Number of Departures CLE Departures through ZAU, ZOB, ZID**

Figure F.24 shows that DTW is experiencing a very slight increase in the number of flights using ZAU, ZOB, and/or ZID sectors from 2000 to 2002. Average arrival delays and average departure delays have increased from 2000 through 2002. Figure F.24 shows that choke points 5 and 6 have not yet shown benefits for DTW.

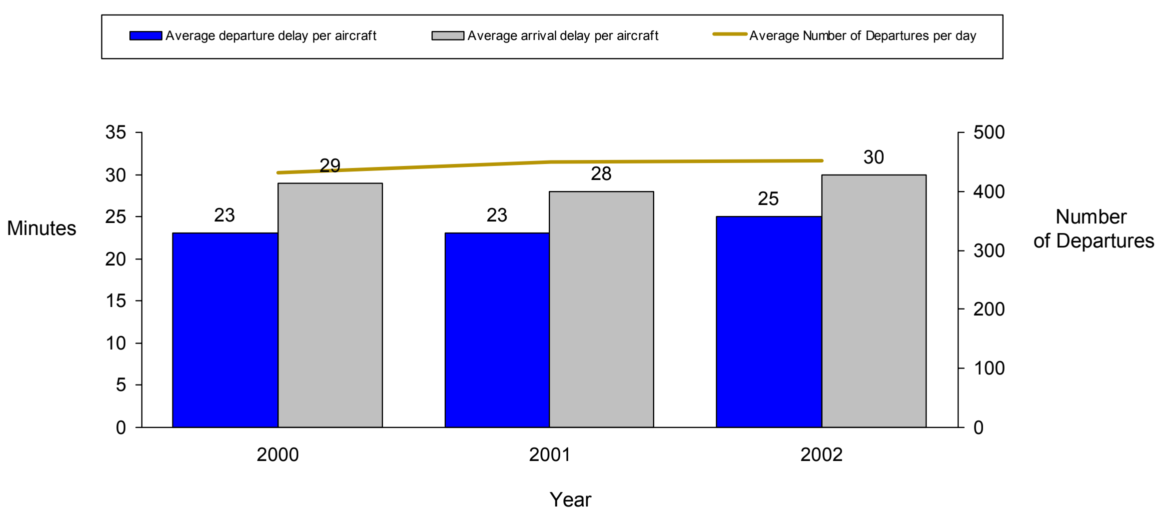


**Figure F.24 - Average Departure Delays, Arrival Delays and Number of Departures DTW Departures through ZAU, ZOB, ZID**

Figure F.25 shows that **CVG** is experiencing an increase in the number of departures using ZAU, ZOB, and/or ZID sectors from 2001 to 2002. This increase comes after a sharp decline in the number of departures using ZAU, ZOB, and/or ZID from 2000 to 2001. Average arrival delays and average departure delays have shown mixed results, each decreasing from 2000 to 2001 and increasing from 2001 to 2002. Choke points 5 and 6 have not shown benefits for CVG.

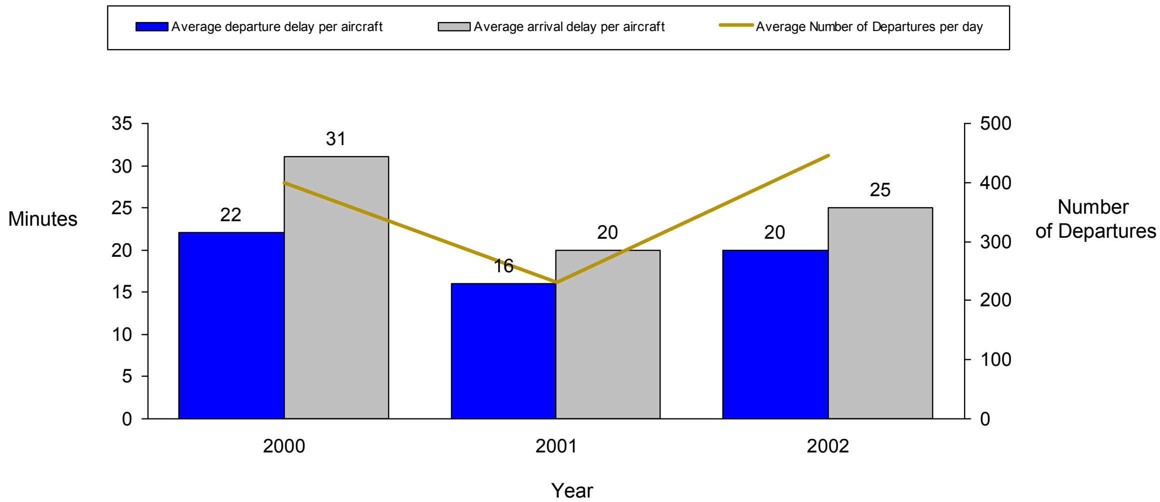


**Figure F.25 - Average Departure Delays, Arrival Delays and Number of Departures CVG Departures through ZAU, ZOB, ZID**

Figure F.26 shows that **PIT** is experiencing a very slight decrease in the number of flights using ZAU, ZOB, and/or ZID sectors from 2001 to 2002. Average arrival delays have shown a very slight increase from 2001 to 2002, while average departure delays have shown a very slight decrease from 2000 to 2001. Choke points 5 and 6 have produced benefits for PIT, as the change in arrival and departure delays is extremely small.

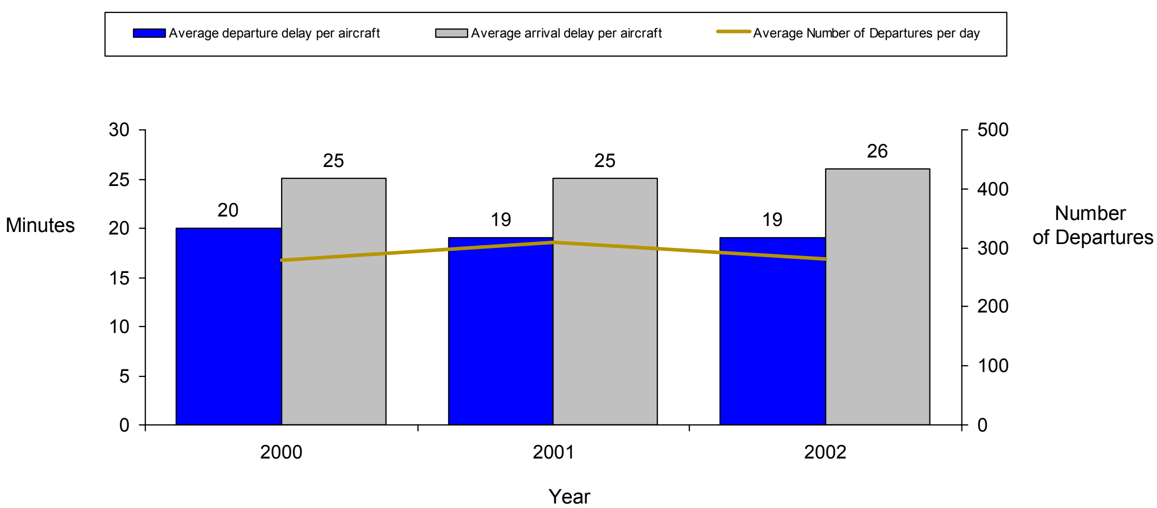


**Figure F.26 - Average Departure Delays, Arrival Delays and Number of Departures PIT Departures through ZAU, ZOB, ZID**

The purpose of implementing choke points 5 and 6 was to reduce the departure delays of ORD, CLE, CVG, PIT, and DTW that resulted from congested airspace in the Great Lakes Corridor using a variety of initiatives. The results of these two choke points are mixed – while most airports showed that departing flights accessing specific sectors are experiencing less departure delays, DTW experienced increased departure delays. At the same time, CVG experienced dramatic increases and decreases in departures accessing these specific sectors between 2000 and 2002.

| Airport | Change in Average Departure Delays 2000 v. 2002 | Change in Average Arrival Delays 2000 v. 2002 | Change in Number of Departures 2000 v. 2002 |
|---|---|---|---|
| ORD | -13% | -50% | 15.5% |
| DTW | +8% | +3.33% | 4.65% |
| CVG | -4.76% | -24% | 10.3% |
| CLE | -10.5% | -17.39% | -2.8% |
| PIT | -5.26% | +3.85% | 0.7% |

**Table F.6 - Choke Points 5 and 6 Data Summary**

***Choke Points 5 and 6 Summary***

Choke points 5 and 6 appear to have played a part in reducing average departure and arrival delays on flights using ZID, ZOB, and ZAU from ORD, DTW, CVG, CLE, and PIT. For ORD and CLE, average departure delays, average arrival delays have decreased while the number of operations has increased. PIT and CVG both show decreases in departure delays and very little change in the number of departures from 2000 to 2002.

## Choke Point 7: Departure Access to Overhead Streams

Aircraft eastbound from Chicago, east and southbound from DTW, and north and eastbound from CVG had difficulty accessing overhead streams due to saturated routes between specific city pairs. In order to evaluate if aircraft had difficulty accessing these overhead streams (via departure delays), the evaluation team obtained data from all flights between the following city pairs.

- ORD to: DCA, BOS, LGA, EWR, and PHL
- DTW to: CLE, LGA, EWR, PHL, CVG, MEM, ATL, and BNA
- CVG to: ORD, CLE, PIT, EWR, and PHL

To improve access to overhead streams, the industry representatives agreed to complete the following Choke Point Actions:

- Test changes to NRP
- Smoothing
- Design and implement new sectors
- Tactical Altitude Assignment
- CRCT
- Develop RNAV Departure Procedures
- Reduce restrictions during ground delay program to (+ / - 3 minutes)

The evaluation team obtained the following data for each flight that matched the city pairs listed above for each date listed in Table F.7.

- Flight Number
- Departure and Arrival Airports
- Filed Flight Plan
- Actual Route Flown
- Planned and Actual Departure Times
- Planned and Actual Airtimes
- Planned and Actual Air miles
- Planned and Actual Arrival Times

| Year | Month | ORD Dates | DTW Dates | CVG Dates |
|---|---|---|---|---|
| 2002 | May | 23, 30 | 23 | 16, 23, 30 |
| | June | 20, 27 | 20 | 20 |
| | July | 4, 11, 18, 25 | 4, 11, 25 | 4, 11, 25 |
| | August | 8, 29 | 1, 8, 29 | 1, 8, 22, 29 |
| 2001 | May | 3 | 3, 10, 31 | 10 |
| | June | 14, 21, 28 | 7, 14, 21 | 8[22] |
| | July | 5, 12 | 5, 12, 26 | 5, 6, 12, 13[23] |
| | August | 31 | 30 | -- |
| 2000 | May | 4, 25 | 4, 25 | 11, 18, 25 |
| | June | 8, 15, 22, 29 | 8, 22 | 8, 29 |
| | July | 13, 20, 27 | 6, 13, 20 | -- |
| | August | 3, 31 | 10 | 3, 10, 31 |

**Table F.7 - Choke Point 7 Data Dates**

The evaluation team first reviewed the average number of aircraft that departed from the origin airport (ORD, CVG, and DTW) and arrived at one of the airports listed above. Figure F.27 shows the average number of aircraft that matched choke point 7 criteria for origin and destination airports.

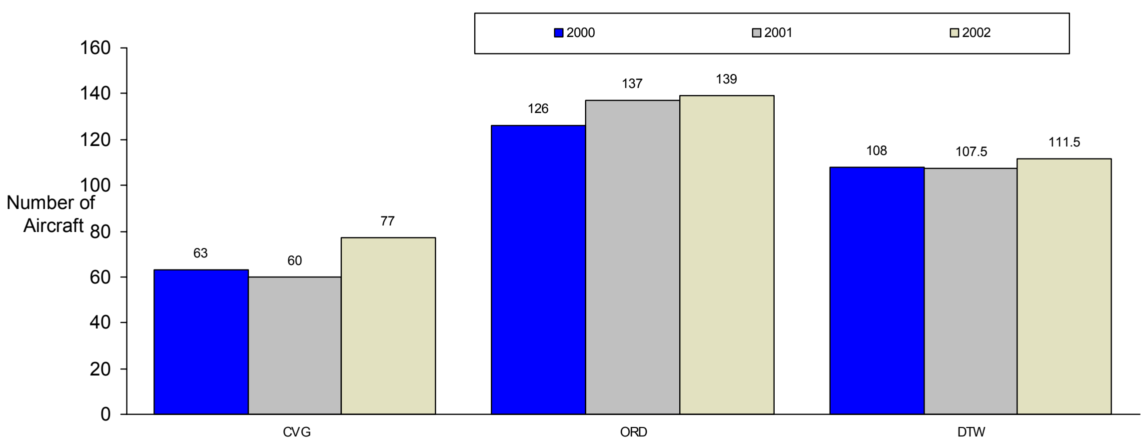


**Figure F.27 - Average Number of Aircraft Departing Origin Airport/ Arriving City Pair Airports**

22 *Friday*

23 *6th and 13th are Fridays*

The average number of aircraft departing CVG, ORD, or DTW for one of the airports listed in the city pairs above has been increasing from 2000 to 2002.

The inability to access overhead streams from these three airports causes departure delays for flights headed to a specified city pair. Therefore, the evaluation team analyzed departure and arrival delays for the specified city pairs to determine if delays had been decreasing, increasing, or remaining constant from 2000 to 2002 (See Figures F.28 – 30).

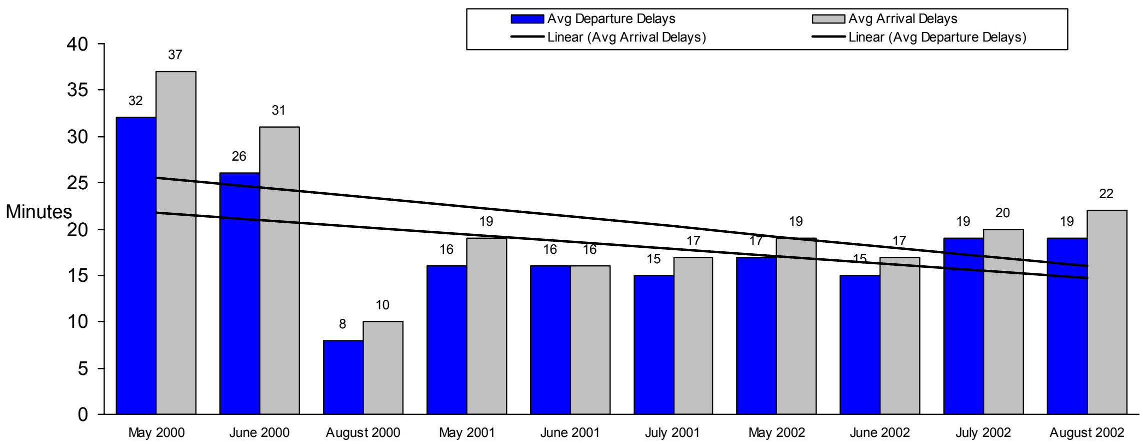


**Figure F.28 - Average Departure and Arrival Delays**
**CVG to ORD, CLE, PIT, EWR, or PHL**

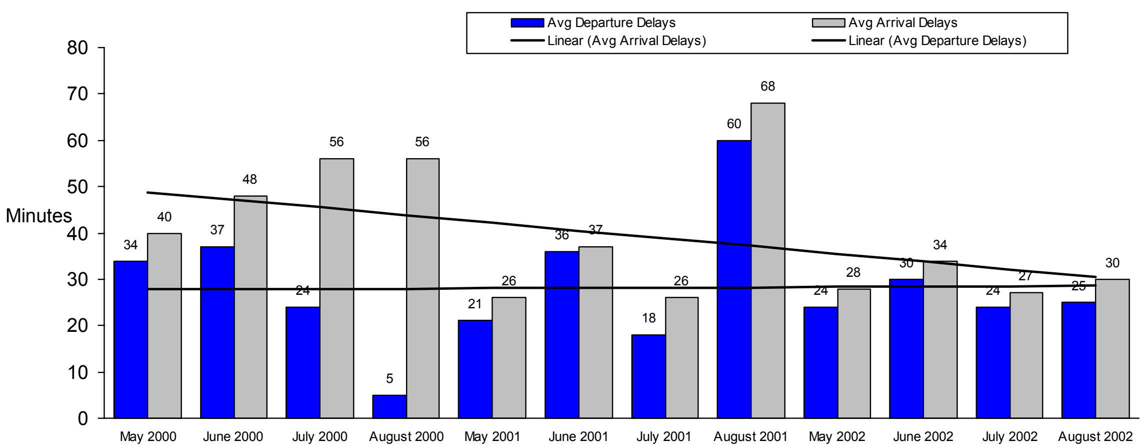


**Figure F.29 - Average Arrival and Departure Delays**
**ORD to DCA, BOS, LGA, EWR, and PHL**

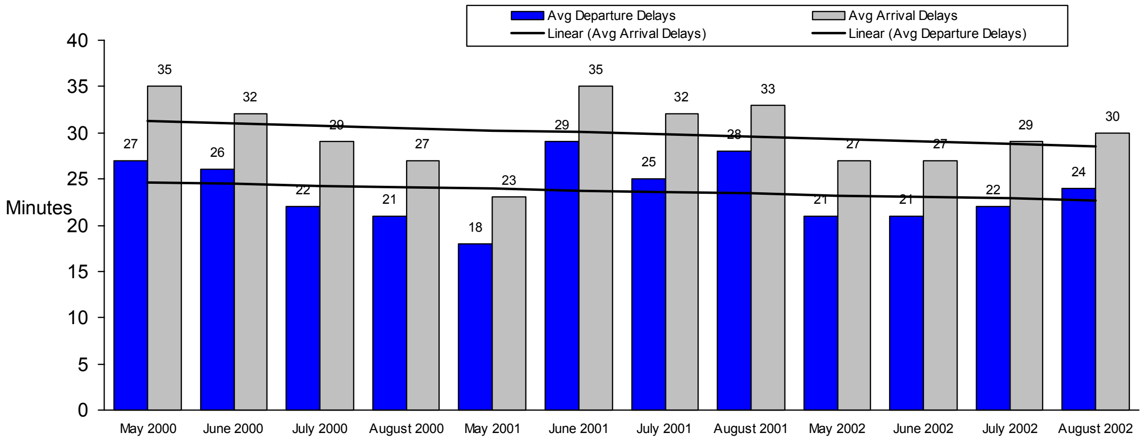


**Figure F.30 - Average Arrival and Departure Delays**
**DTW to CLE, LGA, EWR, PHL, CVG, MEM, ATL, and BNA**

### *Choke Point 7 Summary*

With the average number of flights between these city pairs increasing and the average arrival and departure delays either holding constant or decreasing, choke point 7 is providing stakeholders with benefits. Choke point 7 is helping to reduce departure delays that result from a lack of access to overhead streams due to a saturated airspace. ORD, CVG and DTW each showed that the average departure delays are decreasing from 2000 to 2002. Average arrival delays for ORD and DTW are holding fairly constant and even decreasing in CVG. For a graphical summary of choke point 7, see Figure F.31

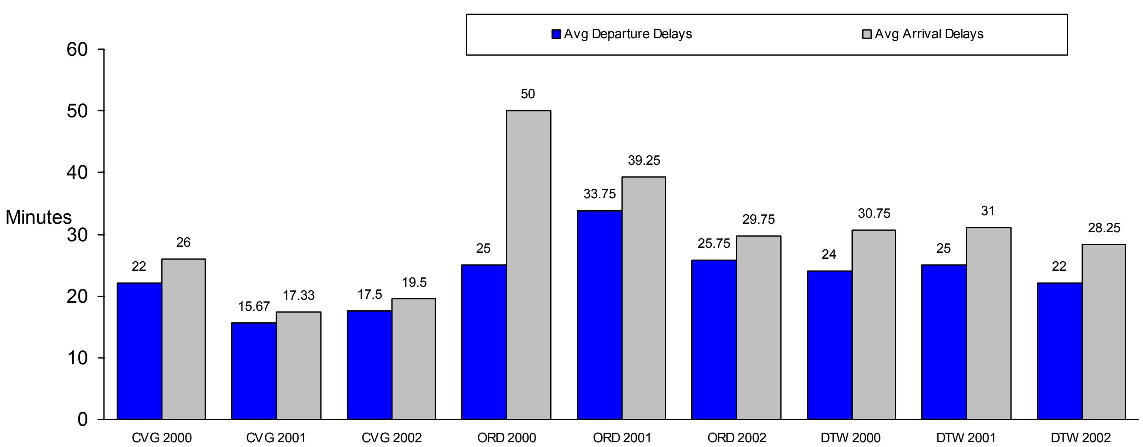


**Figure F.31 - Average Arrival and Departure Delays per Aircraft**
**CVG, ORD, and DTW**
**May – August 2000 through 2002**

# Appendix G: Acronyms

| | |
|---|---|
| 9/11 | September 11, 2001 (events of) |
| AAR | Airport Arrival Rate |
| ACB-330 | Simulation and Analysis Group |
| ACM | NAS Configuration Management and Evaluation Staff |
| ACM-10 | Program Evaluation Branch |
| AFS | Flight Standards Service |
| ARA | Research and Acquisitions |
| ARA-1 | Associate Administrator for Research and Acquisitions |
| ARTCC | Air Route Traffic Control Center |
| ASD-400 | Investment Analysis and Operations Research Division |
| ASPM | Aviation System Performance Metrics |
| ASR | Airport Surveillance Radar |
| ASR-9 | Airport Surveillance Radar (Model 9) |
| ATA | Air Traffic Airspace Management Program |
| ATA-1 | Air Traffic Airspace Management Program Director |
| ATB | Terminal Business Service |
| ATB-450 | Terminal Business Services – En Route Surveillance Services |
| ATC | Air Traffic Control |
| ATCAA | Air Traffic Control Assigned Airspace |
| ATL | Hartsfield-Jackson Atlanta International Airport |
| ATP | Air Traffic Planning and Procedures Program |
| ATS | Air Traffic Services |
| ATS-1 | Associate Administrator for Air Traffic Services |
| AWP | Western Pacific Region |
| BNA | Nashville International Airport |
| BOS | Logan International Airport (Boston) |
| BWI | Baltimore-Washington International Airport |
| CLE | Cleveland Hopkins International Airport |
| CLT | Charlotte Douglas International Airport |
| CRCT | Collaborative Routing and Coordination Tools |
| CRDA | Converging Runway Display Aid |
| CVG | Cincinnati/Northern Kentucky International Airport |
| DCA | Ronald Regan Washington National Airport |
| DCIA | Dependent Converging Instrument Approach |
| DTW | Detroit Metropolitan Wayne County International Airport |
| ETMS | Enhanced Traffic Management System |
| EWR | Newark Liberty International Airport |
| FAA | Federal Aviation Administration |
| FLL | Fort Lauderdale/Hollywood International Airport |
| FRG | Farmington Republic Airport |
| GSO | Piedmont Triad International Airport (Greensboro, NC) |
| HAATS | Houston Area Air Traffic System |
| HPN | Westchester County Airport |
| HQ | Headquarters |
| IAH | George Bush Intercontinental/Houston Airport |

| | |
|---|---|
| ICIA | Independent Converging Instrument Approach |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| J547 | Jet Route 547 |
| JFK | John F. Kennedy International Airport |
| KC | Kansas City |
| LAS | Las Vegas McCarran International Airport |
| LAX | Los Angeles International Airport |
| LDA | Localizer Type Directional Aid |
| LGA | LaGuardia Airport |
| MAP | Missed Approach Point |
| MCO | Orlando International Airport |
| MDW | Chicago Midway International Airport |
| MEM | Memphis International Airport |
| MIA | Miami International Airport |
| MIT | Miles In Trail |
| MITRE-CAASD | MITRE Corporation's Center for Advanced Aviation System Development |
| MSP | Minneapolis-Saint Paul/Wold-Chamberlain International Airport |
| NAR | National Airspace Redesign |
| NAS | National Airspace System |
| NATCA | National Air Traffic Control Association |
| NCT | Northern California TRACON |
| NJ | New Jersey |
| NMI | Nautical Miles |
| NRP | National Route Program |
| NTZ | No Transgression Zone |
| NY | New York |
| NYICC | New York Integrated Control Complex |
| OEP | Operational Evolution Plan |
| ORD | Chicago O'Hare International Airport |
| PDX | Portland International Airport |
| PHL | Philadelphia International Airport |
| PHX | Phoenix Sky Harbor International Airport |
| PIT | Pittsburgh International Airport |
| POET | Post Operational Evaluation Tool |
| PRM | Precision Runway Monitor |
| RDSIM | Runway Delay Simulation |
| RDU | Raleigh Durham International Airport |
| RNAV | Area Navigation |
| SEA | Seattle-Tacoma International Airport |
| SFO | San Francisco International Airport |
| SOIA | Simultaneous Offset Instrument Approach |
| STL | Lambert - Saint Louis International Airport |
| SUA | Special Use Airspace |
| SWAP | Severe Weather Avoidance Program |
| TM | Traffic Management |
| TPA | Tampa International Airport |

| | |
|---|---|
| TRACON | Terminal Radar Approach Control |
| US | United States |
| VFR | Visual Flight Rules |
| WJHTC | William J. Hughes Technical Center |
| ZAN | Anchorage Air Route Traffic Control Center |
| ZAU | Chicago Air Route Traffic Control Center |
| ZBW | Boston Air Route Traffic Control Center |
| ZDC | Washington D.C. Center |
| ZDV | Denver Air Route Traffic Control Center |
| ZHU | Houston Air Route Traffic Control Center |
| ZID | Indianapolis Air Route Traffic Control Center |
| ZLC | Salt Lake City Air Route Traffic Control Center |
| ZMA | Miami Air Route Traffic Control Center |
| ZNY | New York Air Route Traffic Control Center |
| ZOA | Oakland Air Route Traffic Control Center |
| ZOB | Cleveland Air Route Traffic Control Center |
| ZSE | Seattle Air Route Traffic Control Center |
| ZTL | Atlanta Air Route Traffic Control Center |