

AIRLINE OPERATIONAL BENEFITS OF SURFACE SURVEILLANCE

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Abstract

Airlines can optimize surface operations using real-time surface surveillance data. The Federal Aviation Administration's Air Traffic Organization (ATO) Technology Development Office is examining the operational impacts of surface surveillance data sharing in current and future FAA tools. This study examines taxi time and departure rate benefits of surveillance data for airlines using two examples. The first example investigates the operational impact of data provided to Federal Express (FedEx) at Memphis International Airport (MEM) through a joint FAA/ National Aeronautics and Space Administration (NASA) project. We first use an unexpected loss of surface surveillance data as an opportunity to gauge impacts. The analysis measures changes in taxi-out times, queue lengths, and departure rates before, during, and after the surveillance outage. We repeat the analysis using a baseline period and a post-implementation period. Both data sets display a reduction in taxi-out times and indicate an increase in effective departure rates (approximately 3 aircraft per hour greater) during times when surveillance was available. The second example examines the impact of data provided to the Delta Air Lines ramp tower at Dallas-Fort Worth International Airport (DFW). We find a decrease in Delta taxi-out times relative to airport surface queues after implementation and compared with airlines not using surface surveillance.

Introduction

Better National Airspace System (NAS) planning and decision-making increasingly depend on greater information sharing. The FAA Technology Development Office has assisted airlines with obtaining shared surface surveillance data using currently available multilateration infrastructure at several sites. Surface surveillance tools are expected to provide specific aircraft operational information for ramp management, track flight plan information updates, and serve as a source for actual delay information.

We define surface surveillance as the real-time display of surface location and identity (i.e. call sign) of transponder-equipped aircraft. Past FAA tools, such as the Surface Movement Advisor (SMA), have provided airlines with some landing information useful for airline surface operations, but have not incorporated direct surface tracks.

A variety of current and future FAA tools can provide surface surveillance data to NAS users. At Detroit/Wayne County Metropolitan Airport (DTW), Northwest Airlines receives surveillance data from a system that was originally a prototype multilateration system funded by the FAA and NASA. The benefits of the surveillance data [1,2] convinced Northwest Airlines to procure this system and similar systems for other hub airports from a commercial vendor after termination of government funding. American Airlines and Delta Air Lines have had access to surveillance data feeds from the FAA's Airport Surface Detection Equipment – Model X (ASDE-X) system being installed at Dallas/Fort Worth International Airport (DFW). NASA and the FAA have been installing a prototype Surface Management System (SMS) at Memphis International Airport (MEM) and more recently at Louisville International Airport (SDF). Many SMS capabilities will be incorporated into a future production FAA tool called the Surface Traffic Management System (STMS). ATO Technology Development has also been installing ground-based transceivers and corresponding surveillance displays at airports to detect Automatic Dependent Surveillance-Broadcast (ADS-B) messages from properly equipped aircraft. The ADS-B feed can also be used for surface surveillance.

In this paper, we will examine the operational benefits of surface surveillance data to FedEx at MEM and Delta at DFW. Specifically, we briefly describe airline operations at each airport, summarize the system setup and history, review the mechanisms for benefit, and gauge the impact on taxi-out times, queue lengths, and runway departure rates.

FedEx at MEM

Airport Description and FedEx Operations

MEM is the major worldwide hub for FedEx. The diagram in Figure 1 displays the airport surface with buildings and runways in black and taxiways and parking areas in gray. The FedEx sorting facility dominates the north side of the airport. While local Air Traffic Control (ATC) controls all traffic on taxiways and runways, FedEx controls ground traffic in the large ramp and parking areas around their facilities. FedEx transfers control responsibility to the FAA at specified “spots” between the ramp area and the taxiways.

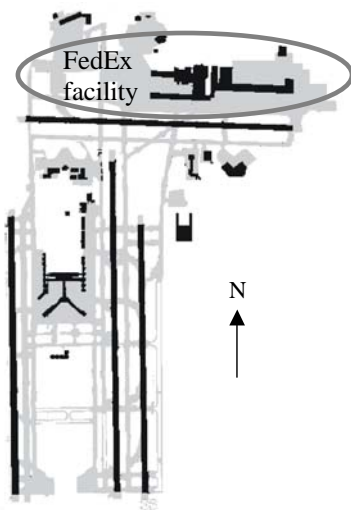


Figure 1. Diagram of MEM surface

On weekdays during daylight hours, operations are divided about equally between commercial air carrier traffic and FedEx traffic. At night (after 11:00 pm and before 6:00 am local time), nearly all traffic into and out of MEM is FedEx overnight air service aircraft. MEM experiences the highest arrival and departure peaks during the night. Figure 2 shows the departures in fifteen minutes during a typical day. The black line in the graph represents the total number of departures; the two colors separate the total into FedEx flights and non-FedEx flights. The data source is the Aviation System Performance Metrics (ASPM) database.¹

¹ The ASPM database is provided by the FAA Office of Aviation Policy and Plans, at <http://www.apo.data.faa.gov/>.

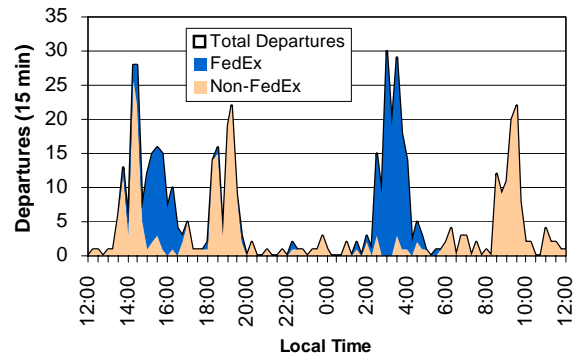


Figure 2. Departures at MEM (15 min)

Figure 2 demonstrates that most FedEx departures occur at times when there is little other departure traffic. This is important because we later consider FedEx taxi times separately from the other air traffic. Also, we see that the FedEx departure periods are highly peaked. FedEx must operate as peaked a schedule as possible to increase efficiency. On a typical operating night, well over 130 aircraft depart between 2:00 am and 5:00 am local time. Inefficiencies in ground operations can lead to costly delays for time-sensitive deliveries.

SMS System Description and History

The Surface Management System (SMS) is a decision support tool that helps air carriers and FAA ground, terminal, en route, and central flow controllers collaboratively manage the movements of aircraft on the surface. NASA intended SMS to use surface surveillance information and airline information to provide accurate arrival/departure demand, predicted pushback times, and runway utilization to all of these users.

The system incorporates location inputs from FAA Safe Flight 21 surface surveillance sensors² and call sign information from FAA terminal automation tools. Both FedEx and Northwest Airlines have tested a variety of commercially available surface management tools to display and process the current data. For more details on the architecture see Functionalities, Displays, and the Concept of Use for the Surface Management System [3].

After initial controller-in-the-loop simulations at NASA, the first operational tests occurred in the FedEx ramp tower and Northwest Airlines MEM Operations Center in August and October of 2002.

² The Safe Flight 21 multilateration sensors are part of a prototype ASDE-X system. Responsibility for this system was transferred to ATO Terminal Services in 2004.

Subsequently, FedEx obtained a display for each ramp control position, the administrator, and positions within their Airline Operations Center (AOC). They successfully networked the surveillance data to existing FedEx computers and displays, allowing displays for each ramp controller and some dispatchers within the FedEx operations center. They have been using this data on a daily basis to affect operations since April 2003.

An operational trial of SMS Traffic Management capabilities at MEM for FAA terminal and en route management occurred in September 2003. In January 2004, FAA ground controllers conducted a shadow test of some of the SMS ground controller tools. An operational trial of these tools would require SMS to be integrated on existing FAA ground controller displays.

A wide variety of human factors and performance analyses were performed during the tests and trials [4]. The human factors results provided valuable feedback on uses of the SMS tools. Most of the analysis focused on errors in the prediction of queue lengths, taxi times, and demand.

As of this writing, only FedEx makes daily operational use of the SMS to affect surface traffic.

Benefit Mechanisms

Because SMS is intended for many different FAA and NAS users, there are many proposed capabilities that may provide benefits. Multiple capabilities may contribute to a single benefit. An SMS cost/benefit analysis [5] described four major benefits mechanisms: reduced schedule delay, reduced taxi time, improved NAS-wide predictability, and improved adherence to schedule priorities. The assessment used surface models of different proposed applications to estimate an average delay savings of 1.12 min per aircraft at MEM.

While there are several proposed applications of SMS at MEM, the only user currently employing the surface surveillance information for operations is FedEx. Since we are primarily interested in measuring current benefits, we will focus on the airline user applications.

Functionalities, Displays, and the Concept of Use for the Surface Management System [3] details many airline applications, including: Ground Resource Planning, Departure Planning, Arrival/Departure Coordination, Handling Departure Time Restrictions, Sequencing Departures, and Changing Flight Plans. These applications should

allow reductions in taxi delay and increased surface efficiency.

The SMS Field Trials [4,6] reported that airline ramp controllers found SMS most useful during the arrival rush, and ramp control administrators found SMS most useful during the departure push. Ramp controllers used the real-time landing sequence and estimated gate arrival times more than the other available information.

Ramp control administrators used SMS to monitor the number of aircraft taxiing to a runway, the number of aircraft currently queued at a runway, and the number of aircraft approved for pushback to each runway. They used these current and predicted queues to manage the runway loading by helping them to decide when to hold aircraft at the gate.

Such effective ramp management can minimize taxi times and increase surface and runway efficiency. By controlling when and in what order aircraft are pushed back and taxied to the spot where FAA controllers assume responsibility, an airline can have a substantial impact on the efficiency of the airport runways. Without preconditioning, the FAA may not have enough control to optimize the departure throughput.

In subsequent discussions, FedEx agreed that surveillance-assisted ramp management increased efficiency in runway loading, which could lead to increased departure rates. They believe they affect departure capacity by providing a more consistent number of aircraft to the FAA Tower controllers, and by sequencing the aircraft for maximum departure throughput. For example, with the surface surveillance system, FedEx tries to order aircraft so that successive departures have diverging departure routes. This effectively increases runway throughput because it removes potential departure route spacing constraints.

Surveillance Outage Analysis

ATO Technology Development approached FedEx in November 2003 with the idea of measuring user benefits of shared surface surveillance. Even though Technology Development is transferring responsibility of the surface effort at MEM to ATO Terminal Services, they thought benefit results at this location would be beneficial to their other surface efforts. Also, Terminal Services expressed interest in using the results in their business case for ASDE-X multilateration data sharing.

As the FAA began to examine benefits at MEM, an opportunity arose to perform a quick study of taxi

times. FedEx lost data tags for their surface surveillance system due to a hardware conflict during the FAA installation of the Standard Terminal Automation Replacement System (STARS) on October 27, 2003. The issue was resolved and data tags reappeared on December 18, 2003. We use this unexpected loss of surveillance to gauge the operational impact of surface data to FedEx by examining taxi times for FedEx aircraft at MEM before, during, and after the loss of data.

While we hope to find a change due to surface surveillance, we are certain that the taxi times are heavily influenced by demand, runway configuration, and the weather. Our first step is to isolate taxi data with like traffic, runway, and weather conditions for periods with and without surveillance. However, if we focus too tightly, we will not have enough data to come to any definitive conclusions.

We use Aircraft Communication Addressing and Reporting System (ACARS) OOOI (Out Off On In) data, runway configuration data, and weather data all recorded on the ASPM database. Approximately 60 percent of FedEx flights record ACARS data. Note we do not use all the ASPM taxi times recorded in the database, only those that have verified ACARS data. The non-ACARS taxi times in ASPM are estimates based on historical data, and can be incorrect by several minutes. We compared a sample of ASPM non-ACARS taxi times to a sample of FedEx data for the same flights and found that the ASPM non-ACARS taxi times were two minutes longer on average and the difference distribution had a standard deviation of seven minutes. After presenting initial results to FedEx, they provided taxi times for their non-ACARS Boeing 727 fleet over the same time period. Together, this data represents over 90 percent of the fleet.

We chose to examine dates between September 9, 2003 and February 11, 2004 because we wanted to inspect seven-week periods before, during, and after the unexpected outage. Figure 3 displays the FedEx traffic load (all flights, not just ACARS) at MEM over the time period. During the holiday season, the daily traffic load can increase by as much as 25 percent. Because the increase in traffic affects the taxi times in a way that was difficult to model, we decided to remove data during this time (November 24, 2003 – January 5, 2004) from the taxi time analysis.

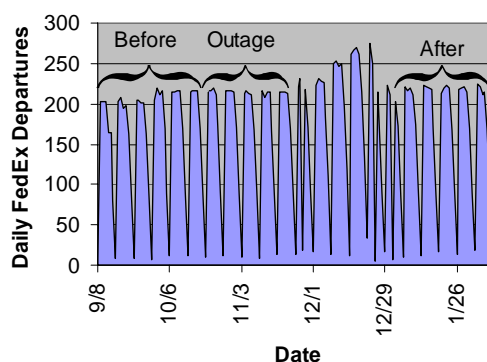


Figure 3. Daily FedEx departures at MEM

ASPM also records runways in use for each 15-minute period in a day. MEM uses different surface configurations for different conditions, but primarily operates in one of two runway configuration modes: North Flow or South Flow. During a particular flow, most of the flights arrive and depart in the direction of the flow. Since FedEx is located on the north side of the airport (see Figure 1), departures during a North Flow must taxi all the way to the south end of the airport to takeoff. Consequently, we expect that taxi-out times during a North Flow will be longer than during a South Flow. Sixty-one percent of yearly FedEx traffic operates in North Flow and 39 percent operates in South Flow. In the following analyses we separate flights for North or South Flow operations.

The last factor we consider is the weather. ASPM records airport surface visibility and ceiling. Using these variables, an algorithm divides the weather into Instrument Approach conditions (IA) or Visual Approach conditions (VA) based on facility input. To qualify for VA conditions at MEM, the visibility must be greater than five miles and the ceiling must be greater than 5000 feet. While this is a gross simplification of weather effects, this division should help isolate periods of relatively good and bad weather. We expect that average taxi times will increase during bad weather. Of the 54,000 FedEx flights recorded in ASPM, 75 percent operated in VA conditions and 25 percent operated in IA conditions.

In a previous paper, we examined each data set (before, during, and after the surveillance outage) in detail [7]. Figure 4 summarizes the results.

Figure 4 displays the difference in mean taxi-out time, comparing the combined periods with surveillance (before and after the outage) to the time without surveillance (outage period). A negative mean value indicates a reduction in taxi time. The graph shows separate measures for airport weather conditions and runway configurations. The error bars

represent the 95 percent confidence intervals around the differences in the means. If the confidence interval does not include zero, the difference in the means is significant at the 95 percent level. When MEM is in a North Flow operation, the average taxi-out time for FedEx aircraft is 1.3 minutes less with surveillance during VA conditions and 4.3 minutes less with surveillance during IA conditions using the surveillance outage data. We found no significant change in the taxi-out during South Flow.

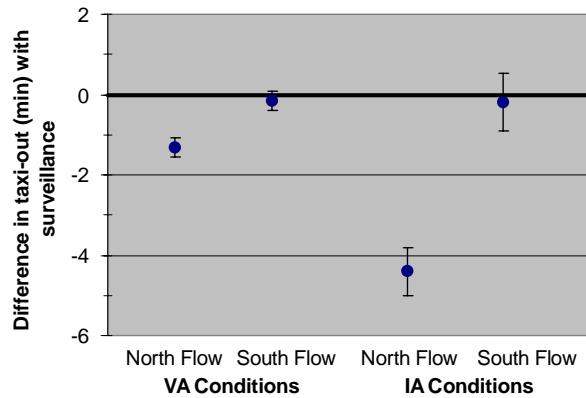


Figure 4. Difference in taxi-out between surveillance and outage periods

FedEx indicated that the surveillance information is more useful during North Flow. During South Flow, the runway queues are easily visible from the FedEx ramp tower permitting straightforward runway demand management. Surface surveillance allows the ramp controllers to stretch this visibility to the other side of the airport for North Flow operations.

Another way to examine surface efficiency is in relation to surface queue length. A recent study [8] found the main factor determining taxi-out time was queue length. We do not have enough information to determine specific runway queue lengths over the time spans involved. However, if we approximate the queue length for an aircraft as the number of takeoffs between an aircraft’s pushback and takeoff, we can have a general measure of airport surface demand that should relate to runway queues.

Exploring the queue length should allow us to examine surface performance in more detail. The queue length accounts for demand better than the mean taxi-out data and also incorporates weather. We no longer need to remove the large demand holiday period from the data set, as we did in the previous analysis. However, we still divide the data into different sets by airport configuration to account for the difference in terminal location.

Also, dividing the queue length by the taxi time for a given flight gives an approximate departure rate. This allows us to examine the average departure rates for the different data sets. Figure 5 displays the mean hourly departure rate versus queue length during North Flow, for the surveillance period (the 8-week periods before and after the outage, September 8, 2003 to October 25, 2003 and December 18, 2003 to February 11, 2004) and the outage period (October 26, 2003 to December 17, 2003). For each value of surface demand (queue length), the average departure rate in the surveillance period is higher. At high demands, both the surveillance and outage curves flatten to approximately 80 aircraft/hour. The departure rate plateau for the surveillance period is greater than that for the outage data by a few aircraft per hour. The departure rate over all the FedEx aircraft is, on average, 2.8 aircraft/hour greater in the surveillance period. The difference in departure rates is statistically significant at the 95 percent level.

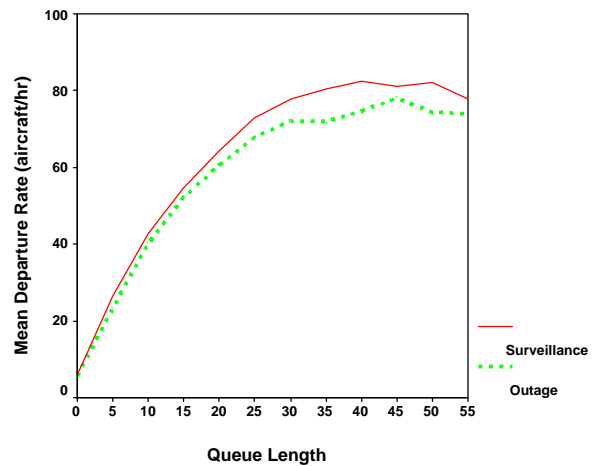


Figure 5. Departure rate vs. queue length, MEM North Flow Outage data

As mentioned in the Benefit Mechanisms section, FedEx suggests that increased departure rates during surveillance may be caused by their increased efficiency in runway loading. This analysis implies that FedEx flights performed better during times with surveillance, and supports the results found from the taxi-out means analysis.

Pre/Post Implementation Analysis

As a further confirmation of the surface surveillance benefit at MEM, we decided to compare data after implementation to that before implementation (as opposed to during the outage). Since FedEx reports that they began to use surface surveillance operationally in late March 2003, we

chose a baseline period of April 1, 2002 to March 31, 2003, and the post-implementation period as April 1, 2003 through March 31, 2004. We removed November and December flights from both data sets to account for the outage in the post-implementation period.

We repeat the analysis documented in the Surveillance Outage Analysis section above with this new baseline data. However, we did not have access to actual taxi-out times for non-ACARS flights in the new baseline period, so we only use taxi times from ACARS flights in the analysis. Approximately 60 percent of FedEx flights record ACARS data. ACARS data, runway configuration data, and weather data were gathered from the ASPM database. Figure 6 displays the difference in mean taxi-out time after implementation of surface surveillance (as compared to baseline period). A negative mean value indicates a reduction in taxi time. The graph shows separate measures for airport weather conditions and runway configurations. The error bars represent the 95 percent confidence intervals around the differences in the means. If the confidence interval does not include zero, the difference in the means is significant at the 95 percent level.

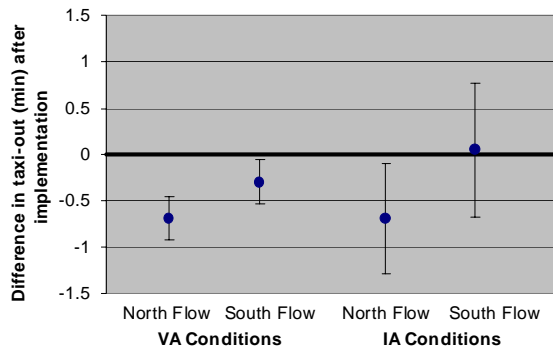


Figure 6. Difference in taxi-out time after implementation, MEM

Most of the results show decreases in the average taxi time after implementation of surface surveillance in the FedEx ramp tower. For North Flow, the mean taxi time decreased by about 0.7 minutes in both VA and IA conditions. For South Flow, the taxi-out time decreased by approximately 0.3 minutes in VA conditions, and there was an insignificant change in IA conditions.

While the magnitude of the taxi time decreases are less than that found using the outage data, the results generally confirm the supposition that surface efficiency improved after surface surveillance implementation. We believe the magnitude of the

outage results to be more accurate because they contain a larger percentage of the traffic (90 percent to 60 percent), and provide less time over which other changes may have affected the surface flow.

We also repeated the queuing and departure rate analysis performed in Surveillance Outage Analysis using this new baseline data. Figure 10 displays the mean hourly departure rate versus queue length during North Flow, for the baseline period and the post-implementation period. For each value of surface demand (queue length) above 15, the average departure rate in the surveillance period is higher. Much like Figure 8, both the surveillance and outage curves flatten to approximately 80 aircraft/hour, for high demands. The departure rate plateau for the post-implementation period is greater than that for the baseline period by a few aircraft an hour. The departure rate over all the FedEx aircraft is, on average, 3.0 aircraft/hour greater in the post-implementation period. The difference in departure rates is statistically significant at the 95 percent level.

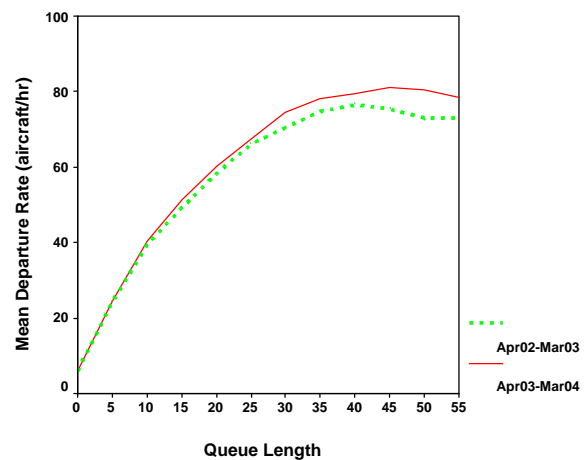


Figure 7. Departure rate vs. queue length, MEM North Flow Pre/post implementation data

While the mean taxi-out time results using the pre/post implementation data are different from those using the surveillance outage data, the departure rate results are similar. We believe the departure rate results represent an effective departure capacity increase caused by demand management using shared surface surveillance. The magnitude of the departure capacity increase is approximately 3 aircraft/hour.

One might argue that the nighttime air cargo operation of FedEx at MEM represents a somewhat specialized case as compared to general airline operations. In the next section we will examine the impact of surface surveillance at a major hub with competing airlines.

Delta Air Lines at DFW

Airport Description and Delta Operations

DFW is the world's third busiest airport in terms of operations. Figure 8 is an overhead view of the airport surface with runways and terminals in black and taxi and ramp areas in gray.

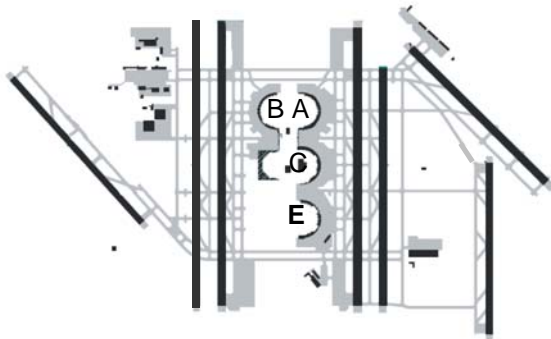


Figure 8. Diagram of DFW surface

During the past few years, the traffic at DFW has increased considerably. Figure 9 displays the monthly departures at DFW from November 2002 through September 2004. The trend line shows the steady increase in demand at DFW over the past two years. Comparing the number of departures in the first nine months of 2003 and 2004 we find a seven percent increase. We will comment on the consequences of this increase later.

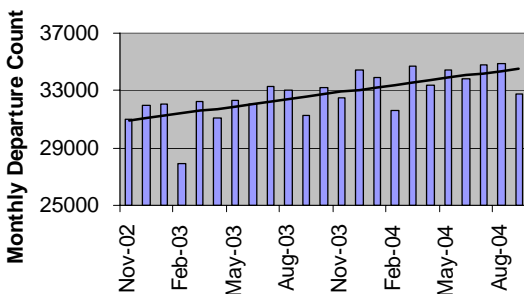


Figure 9. Monthly departures at DFW

SMS System Description and History

As part of the Runway Incursion Reduction Program (RIRP), the FAA installed an Airport Surface Detection Equipment - Model X (ASDE-X) multilateration (MLAT) system on the east side of Dallas-Fort Worth International Airport (DFW). NASA later installed ASDE-X on the west side as part of a data collection program. The Airport has been making these systems permanent in order to satisfy a commitment made to the FAA for mitigation

of visibility restrictions to the Center Airport Traffic Control Tower caused by airport development. The ASDE-X provides both surveillance and identification of all transponder-equipped aircraft and vehicles on the airport surface. The DFW ASDE-X MLAT installation will demonstrate the performance and effectiveness of current multilateration surveillance technology. The installation will also serve as a long-term test bed for runway safety technologies, such as Runway Status Lights (RWSL), which will begin an operational evaluation in February 2005.

In March 2002, the FAA gained the support of American Airlines, Delta Air Lines, and the DFW Airport Board to determine potential benefits in efficiency and safety associated with surface surveillance data sharing. The FAA agreed to provide a real-time MLAT data feed to the participants along with the necessary equipment, communications links, and training. The prototype MLAT data sharing began in May 2002 and became available for consistent use in November 2003.

Surface surveillance displays are currently located in the American Airlines SOC, ramp tower, the Headquarters; the Delta Air Lines ramp tower; the DFW Airport Board operation center; and at NASA Ames Research Center. As of this writing, only Delta Air Lines used the new information during daily operations. Displays for FAA users in the DFW ATC control towers and in the TRACON will be available when the ASDE-X system is commissioned.

In addition to the surface surveillance data, American and Delta also have some access to shared terminal area flight data through a Center TRACON Automation System (CTAS) feed provided by NASA through a separate program. The CTAS displays aircraft tracks close to the airport and estimated landing (On) times. This data can be used to accurately estimate arrival (In) times. We mention CTAS because ramp controllers may use this shared terminal information and shared surface surveillance information to perform similar duties. NASA performed a study of the use of CTAS in the American Airlines Systems Operations Center (SOC) in 1999[10] and a study of the CTAS display in the Delta ramp tower in 2002[11].

While the FAA will continue to share data from ASDE-X with the airlines and the airport board at DFW indefinitely, FAA funding for airline and airport board equipment, communication links, and training ended in December 2004. Currently, the airlines and the airport board are estimating the value of this data to their operations and negotiating with

individual contractors as necessary to continue operations.

The Delta Air Lines ramp tower (which controls Terminal E traffic, see Figure 8) started receiving a MLAT surface surveillance feed in April 2003. The system was made stable for consistent use by November 2003. We examine taxi times before and after implementation to gauge the impact of this new information. For unrelated financial reasons, Delta Air Lines discontinued use of their DFW hub operation in January 2005. As part of this change, Delta no longer controls the Terminal E ramp traffic.

Pre/Post Implementation Analysis

The baseline period data set contains dates between December 1, 2002 and September 30, 2003. The post-implementation data set includes data from December 1, 2003 through September 30, 2004. In November 2002, American Airlines (the dominant carrier at DFW) changed their number of arrival and departure peaks. This dramatically decreased average taxi times for all carriers at DFW. Since we thought that the effect of this depeaking operation would have dominated any change seen in the taxi data, we chose to only examine times after this event.

As in the MEM section, we use ACARS OOOI data, runway configuration data, and weather data from the ASPM database. While we are interested in all the flights controlled by the Delta ramp tower (all Terminal E flights except Northwest Airlines), we only have consistent ACARS data from Delta flights. Note we do not use all the ASPM taxi times recorded in the database, only those that have verified ACARS data.

Like MEM, DFW has many runway configurations, but primarily operates in one of two runway configuration modes: North Flow or South Flow. During a particular flow, most of the flights arrive and depart facing the direction of the flow. In the analysis we separate flights into North or South flow operations. For the time periods examined, DFW operated in South flow 68.6 percent of the time and in a North flow 31.4 percent of the time.

We consider weather in the same fashion as in the MEM data. To qualify for VA conditions at DFW, the visibility must be greater than five miles, and the ceiling must be greater than 3500 feet. For the time periods examined, DFW operated in VA conditions 81.5 percent of the time and in IA conditions 17.5 percent of the time.

Figure 10 displays the difference in mean taxi-out time after implementation of surface surveillance

(as compared to baseline period). A negative mean value indicates a reduction in taxi time. The graph shows separate measures for Delta and non-Delta flights at DFW, and separates data by airport weather conditions and runway configurations. The error bars represent the 95 percent confidence intervals around the differences in the means as determined by an independent samples T-test. If the confidence interval does not include zero, the difference in the means is significant at the 95 percent level.

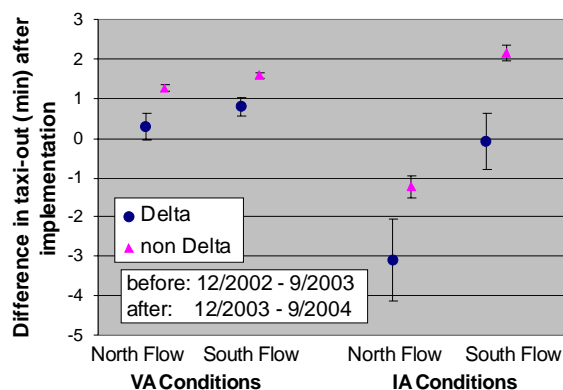


Figure 10. Difference in taxi-out time after implementation

Most of the results for both Delta and non-Delta flights show increases in the average taxi time after implementation of surface surveillance in the Delta ramp tower. We believe these increases are due in large part to the increase in traffic as seen in Figure 9. The difference between Delta and non-Delta traffic is in magnitude of the taxi time changes. For example, during VA conditions in North Flow configuration, the mean taxi-out time for Delta flights increased by a third of a minute, but the mean taxi-out time for non-Delta traffic increased by a minute and a third. This trend continues for each of the condition-configuration combinations. Where taxi times for non-Delta flights increased, Delta flights did not increase as much. In the one case where taxi times decreased in the post-implementation period, the Delta mean taxi-out time decreased by 3 minutes, while the non-Delta mean taxi-out time decreased by only a little over one minute.

The reason for the large variation during IA conditions may lie in the fact that all IA condition weather is not equal. For example, there may have been more severe ice storms in one winter compared to the other. Our analysis would not capture differences in weather severity.

As in the MEM analysis, we also examine queue lengths. The queue length accounts for demand

better than the mean taxi-out data and also incorporates weather. Unlike MEM, we do not consider departure rates. Because Delta is not the dominant carrier at DFW, we do not expect departure rates for the entire airport to increase appreciably. Instead we focus on taxi-out time vs. queue length.

Figure 11 shows the mean taxi-out time during South Flow for Delta flights versus queue length before and after implementation of the ASDE-X display. The curves are quite similar until the queue length reaches forty-five. After forty-five, all the points on the post-implementation curve lie beneath the baseline curve. This implies that Delta flights performed better at busy times after ASDE-X implementation.

Figure 12 displays the mean taxi-out time during South Flow for Delta and non-Delta flights after ASDE-X implementation. For zero queue length, the Delta taxi-out time starts higher. During a South Flow configuration, all flights must taxi to the north end of the airport to takeoff facing south. Since Delta operates out of Terminal E (see Figure 8), Delta flights must taxi a further distance, on average, than aircraft from the other terminals. As the queue length grows, the difference between the average taxi-out time between Delta and non-Delta traffic decreases. The taxi time vs. queue length curves cross at approximately forty aircraft. After forty, all the points on the Delta curve lie beneath the non-Delta curve. This implies that Delta flights performed better at busy times than non-Delta flights after ASDE-X feed implementation. These queue results support the supposition that the ASDE-X feed in the Delta ramp tower has positively impacted Delta operations. The results for the North Flow cases showed similar trends.

After considering some of the preliminary results, the Operations Engineering department of American Airlines began a new effort to find uses for its ASDE-X feed in late summer 2004. They have recently been testing the use of shared surface information for better surface route communication and priority queuing.

Conclusions

We have shown operational changes at two airports after the sharing of surface surveillance data with airline ramp towers. At MEM, FedEx uses the surface surveillance to manage runway demand. Using two different baseline periods, we find decreases in mean taxi times and an increase of approximately 3 aircraft per hour in the departure rate during times with surveillance. This change in departure capacity should be useful for future benefits

estimation. At DFW, Delta Air Lines used surface surveillance to prevent conflicts between inbound and outbound flights in their ramp area. Taxi-out time relative to queue length decreased for Delta Air Lines after implementation, and the taxi-out time relative to queue length was less for Delta than for airlines not using surface surveillance.

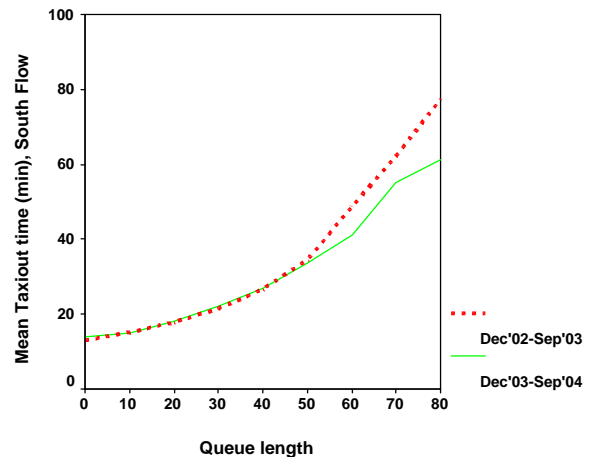


Figure 11. Taxi-out vs. queue length for Delta before and after implementation

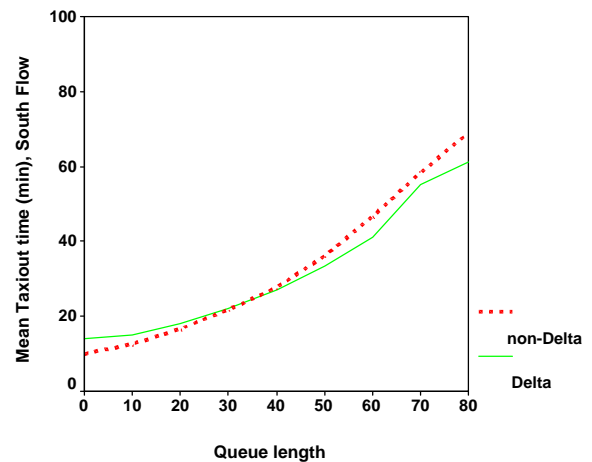


Figure 12. Figure 5-7. Taxi-out vs. queue length for different airlines after implementation

These results reveal the significant benefits of providing surface surveillance for the airlines. The surface surveillance tools allow FedEx to precondition the surface flows so as to assist FAA ground controllers in optimizing runway throughput. The tools also allowed Delta Air Lines to improve surface operations in a more competitive environment. We expect that as similar tools for FAA facilities become available, the benefits may

increase because of increased collaboration and control.

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Key Words

ASDE-X, data sharing, multilateration, departure capacity, Surface Management System, surface queues, surface surveillance, taxi times

Biography

Dan Howell is a senior research analyst at MCR, LLC. He has performed several benefit analyses in support of air traffic tools for the FAA's Free Flight and Safe Flight 21 programs. He currently coordinates metrics development for the FAA Air Traffic Organization (ATO) Technology Development Office. Before supporting the FAA, Dr. Howell was a postdoctoral researcher at Argonne National Laboratory studying nonlinear phenomena. He received a B.S. in Physics from Southwest Missouri State University and a M.A and Ph.D. in Physics from Duke University.

Steve Ritchey is the Development Coordination Lead for the FAA ATO Technology Development Office. He manages the metrics and risk assessment efforts and leads a group that assesses new technology applications within the ATO. He has worked in program management and implementation of systems in both surveillance and automation for the FAA. Prior to that, he worked as both a civilian and a Naval Aviator for the Navy. He received a BA from the University of Nebraska and an MBA from Loyola College of Baltimore.