NASA/TM–2009-215383

Surface Management System Departure Event Data Analysis

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September 2009

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ACRONYMS

AOC	Airline Operations Center
AOFF	Actual OFF
AOUT	Actual OUT
ARTCC	Air Route Traffic Control Center
ASDE-X	Airport Surface Detection Equipment Model X
ASDI	Aircraft Situation Display to Industry
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
DFW	Dallas-Ft. Worth International Airport
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
SMS	Surface Management System
TFM	Traffic Flow Management
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control

SURFACE MANAGEMENT SYSTEM DEPARTURE EVENT DATA ANALYSIS

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ABSTRACT

This paper presents a data analysis of the Surface Management System (SMS) performance of departure events, including push-back and runway departure events. The paper focuses on the detection performance, or the ability to detect departure events, as well as the prediction performance of SMS. The results detail a modest overall detection performance of push-back events and a significantly high overall detection performance of runway departure events. The overall detection performance of SMS for push-back events is approximately 55%. The overall detection performance of SMS for runway departure events nears 100%. This paper also presents the overall SMS prediction performance for runway departure events as well as the timeliness of the Aircraft Situation Display for Industry data source for SMS predictions.

INTRODUCTION

Enhanced management of air traffic and airports will achieve future goals of greater safety and efficiency in the National Airspace System (NAS) as capacity and operations increase. As the NAS grows, decision support tools will continue to play an integral role in the future of air traffic management. These tools and their data sources should sustain a high level of information integrity, as they are used to make decisions regarding air traffic operations.

NASA Ames Research Center and the Federal Aviation Administration (FAA) jointly developed a decision support tool known as the Surface Management System (SMS). SMS improves capacity, efficiency, and flexibility of aircraft movement on the surface of busy airports. In order to do so, SMS enables shared surface awareness that can be utilized by the air traffic control tower (ATCT), Terminal Radar Approach Control (TRACON), Air Route Traffic Control Center (Center), and airline personnel through the use of map displays, timelines, and load graphs. SMS provides forecasting and advisory tools to assist in the management of surface activities (ref. 1).

Given multiple data sources, as shown in figure 1 of the system architecture, SMS detects and predicts both arrival and departure event times. These detections and predictions offer valuable traffic information on arrival or departure aircraft status, aircraft arrival or departure time for various reference points (e.g., spot, runway), and future arrival or departure demand. This information also assists air traffic controllers in performing tactical tasks such as runway assignments, as well as traffic management coordinators in performing strategic tasks such as runway balancing and configuration changes. Airline ramp controllers might also use this information in gate assignment tasks. Having more accurate aircraft state information and reliable predictions allows for more informed decision-making regarding surface operations.

As the air traffic system evolves, so will operational procedures and the tools used to perform them. To meet that evolution process, SMS will need to provide its users with reliable data and timely, reliable data sources. This must be true of the system as a stand-alone tool, as well as through integration with other air traffic management tools.

A previous analysis of SMS arrival events showed a significant improvement in prediction accuracy through integration with the Traffic Management Advisor (TMA) arrival scheduler (ref. 2). The results indicated that the integrated system produced more accurate runway arrival times than the stand-alone SMS system throughout the prediction horizon (ref. 3). No such analysis of SMS has been done specifically for departure events.

The goal of this analysis was to determine the overall detection and accuracy performance of the SMS system as well as the timeliness and accuracy of its data sources, specifically for departure events. The results of the departure event data analysis presented here will help to identify areas of improvement in departure event detection and prediction. This analysis will also help illustrate SMS timing behavior with its actual event data that will be integral for its planned future integrations with other air traffic management tools.

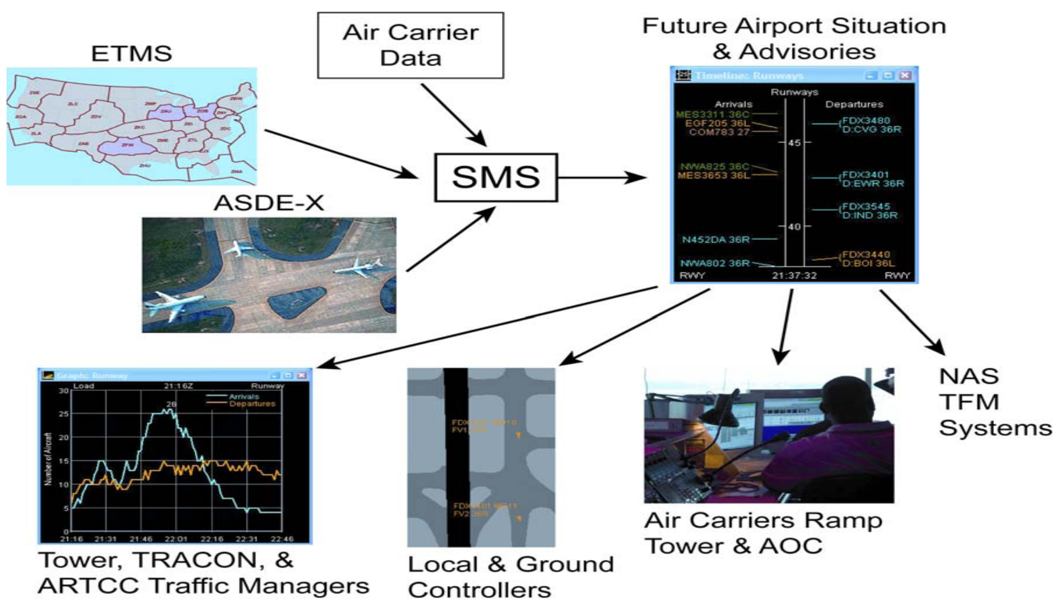

Figure 1. SMS system architecture.

This paper focuses specifically on the detection and prediction accuracy of SMS, given its data sources for departure events, the Aircraft Situation Display for Industry (ASDI) and the Airport Surface Detection Equipment Model X (ASDE-X). ASDI allows near real-time air traffic data to be distributed to the aviation industry while ASDE-X provides position and identification information of aircraft on the airport surface, as well as within 5 miles of the airport. This analysis used recorded traffic data from the Dallas/Ft. Worth International Airport (DFW). A general description of the push-back, or OUT, event detection capabilities and OUT event scheduling assistance capabilities will be provided. A description of the data sources for runway departure, or OFF event detection and OFF event time prediction will also be included. A comparison of the ASDI data source's OFF time prediction performance and the actual SMS OFF time was completed and the results will be presented.

SMS BACKGROUND

SMS is a decision support tool that manages aircraft on the surface of busy airports and within the terminal airspace. SMS enables shared situation awareness between both airline and FAA facilities. SMS also provides surface predictions and advisories to assist in the management of surface operations and to enable air carriers and air traffic control (ATC) coordination (ref. 4).

SMS consists of three primary toolsets to assist users. The first of these are the Controller Tools that use map displays, timelines, and load graphs to provide air traffic control tower and airline ramp controllers with flight-specific information, as well as tactical advisories for efficient traffic operations (see figure 2). The second set of user tools are the Traffic Manager Tools that provide ATC Tower, TRACON, and Center managers with predictions of future demand in order to strategically plan future airport surface operations. The final set of tools are the NAS Information Tools that provide surface demand predictions to NAS users for improved decision making.

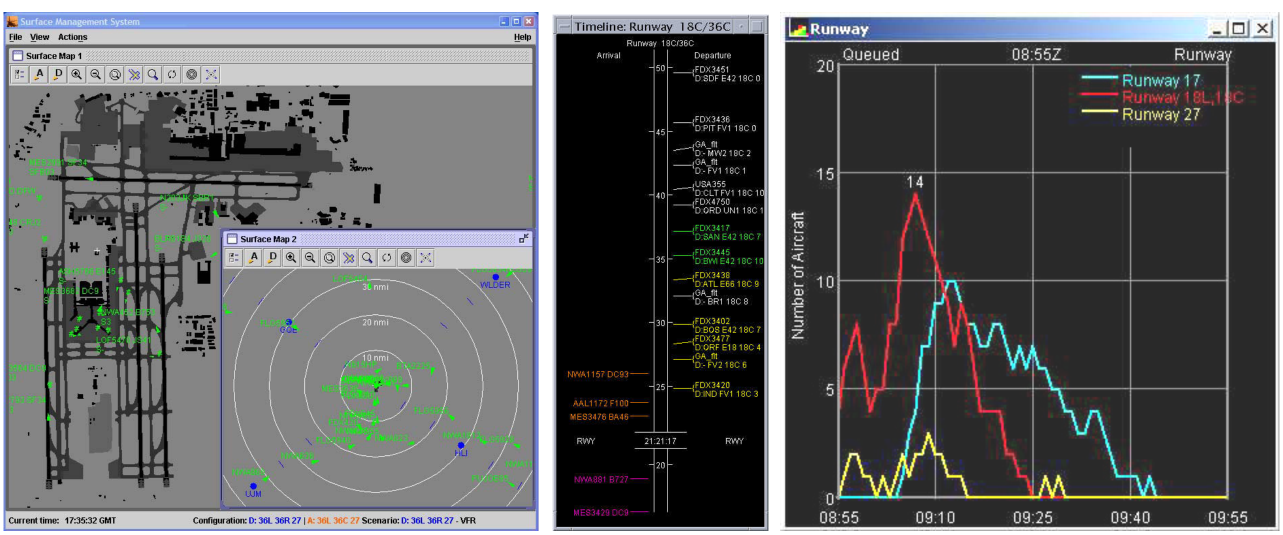

Figure 2. SMS map display, timeline, and load graph.

Research activity and testing of Build I SMS, a grouping of SMS capabilities, has been conducted in both simulation and operational environments. In 2001 and 2002, simulations were conducted to assess the system information requirements (ref. 5). In 2003, an operational evaluation to assess traffic management coordination usage of SMS was conducted at Memphis International Airport. Shadow testing of the traffic management functions of SMS at the Memphis Airport in 2004 assessed local and ground controller use of SMS. The results indicated controller acceptance of the display tools, as well as the accuracy of the displayed data on SMS (ref. 6). The results also showed the need for improved prediction accuracy (ref. 1).

Currently, SMS is fielded in various locations throughout the nation. It is operational at the both the Federal Express and Northwest Airlines Ramp Towers at the Memphis International Airport as well as at the United Parcel Service facilities at Louisville International Airport. It is also installed at the center tower of the DFW airport to support NASA research. SMS is will also be used in future NASA research as an engineering testbed for surface simulations.

SMS PREDICTION CAPABILITY

Using multiple data sources, SMS possesses predictive capabilities to assist in the scheduling and routing of aircraft and in the allocation of airport resources. The predictions assist in the generation of advisories, which are used for managing the airport surface flow (ref. 4). SMS is able to assist airline operators in scheduling push-back events to improve flight prioritization, as well as predict OFF events.

A. Push-Back (OUT) Scheduling

The OUT time delineates when an aircraft pushes back from its gate. Currently, flights are authorized to push back from the gate when they notify the ramp controller that they are ready for push-back. SMS predicts the amount of taxi delay that each aircraft may incur once it has pushed back and can advise ramp controllers to modify their push-back procedures to minimize the total taxi delay of the aircraft.

Accurate push-back time prediction is beneficial to airport surface operations. Estimates of actual push-back times could allow for faster and more accurate runway departure time predictions (ref. 7). When SMS predicts a taxi delay, and a possibility of waiting in a departure queue when an aircraft indicates readiness for an early push-back, SMS may advise ramp controllers to temporarily hold the push-back of the aircraft. By holding the push-back time of these flights, other late operating push-back aircraft may be given priority and placed ahead of these early flights, thus improving overall efficiency. Aircraft wait time in taxi queues may also be minimized, which may reduce the cost to the airlines through reduced fuel use.

Flight plan data containing scheduled push-back times are provided to SMS by ASDI (ref. 1). Unlike runway departure predictions, which receive updated aircraft track data throughout the taxi status of the aircraft, the push-back prediction is largely uncertain since the only input to this prediction is the flight plan push-back time. With the inclusion of airline data, which provides aircraft gate information, estimated push-back time, and flight status, SMS can better predict push-back times, gate arrival times, and takeoff times. Also airport terminal area activities (i.e., passenger delay, catering, and maintenance) introduce uncertainty in push-back times, which would greatly affect any predictions. Although SMS does not provide precise OUT time predictions in the absence of airline data, it is capable of assisting ramp operators with scheduling OUT events with the knowledge of predicted taxi delay.

B. Runway Departure (OFF) Event Prediction

The OFF time delineates the time at which an aircraft starts its take-off roll from its designated runway. The prediction time of an OFF event is calculated based on when an aircraft pushes back from its gate, the amount of taxi time and delay incurred, and the time spent in the departure queue. Depending upon the status of an aircraft, along with the availability of other data sources, SMS can predict OFF times for flights using three methods: Enhanced Traffic Management System (ETMS)/ ASDI data only (i.e., planned push-back times from the Collaborative Decision Making data stream, which is part of ETMS), planned push-back data as well as real-time push-back event data, or planned push-back data with complete real-time surface surveillance data (ref. 1).

The large uncertainty in aircraft OFF time predictions impacts all other predictions downstream. By modeling the movement of the traffic that is actually on the surface of the airport and, thereby, supplying accurate taxi time estimates, SMS can further improve the time predictions of OFF events. These SMS-predicted OFF times can then be used to improve all other predictions and products that are based on predicted OFF times such as regional traffic flow management, including arrival metering scheduling.

DATA ANALYSIS

The data used in these analyses were taken from the Dallas-Fort Worth International Airport for departure events only. Data were collected over a period of five days, from January 22-26, 2007, during the three major departure pushes: 8:00 a.m., 11:00 a.m., and 1:30 p.m. Central Standard Time, when there is a higher capacity of departure operations than at other times of the day. The data collected from those days were recorded for one-hour time durations and were averaged over the five days for the reported results. The data were collected under normal traffic and weather conditions with a North departure flow configuration. No anomalies were removed from the data sets, and each reported value reflects the actual data collected. ASDI and ASDE-X data were used as sources for event detection and prediction time. Though airline data may also be used as a source for event detection and prediction time, it was not available when these analyses were conducted. Here, an accurate prediction of detection and prediction time is defined as a time error within a –1 to 1 minute range.

A. OUT Event

Detection

The accurate detection of push-back events can help to improve departure event predictions. SMS uses surface surveillance data to detect push-back events by examining both the position and speed of an aircraft while it is in the ramp area. SMS uses model output AOUT (actual OUT) data, a collection of data variables, to identify an actual OUT event of an aircraft. SMS also considers an aircraft to have pushed back when the aircraft is first detected on the movement area of the airport; SMS then "guesses" and assigns its gate push-back time to be the same as the time it was actually detected. SMS denotes these occurrences as guessed detections. This OUT event detection analysis determines the number of push-back events that actually occur during 15-minute intervals over 1-hour durations. Because cooperative surveillance data, such as multi-lateration, is used in the detection of push-back events, this analysis gives insight into the number of aircraft that have their transponders on before leaving the ramp area.

B. OFF Event

Detection

Just as surface surveillance data are used to detect push-back events, they are also used to detect runway departure events of aircraft on the surface of the airport. SMS uses model output AOFF (actual OFF) data, a collection of data variables, to identify an actual off event occurrence of an aircraft. SMS also considers an aircraft to have departed the runway when it is first detected, either on the surface or within the terminal airspace, and calculates or "guesses" the runway departure time of the aircraft. SMS denotes these events as guessed detections. This OFF event detection analysis determines the number of runway departure events that actually occur during 15-minute intervals over 1-hour durations.

Prediction accuracy

As SMS predicts the OFF time of an aircraft, it uses a timestamp from the GUIFLIGHT data, a collection of controlled and undelayed timestamps for reference points on the surface and in the terminal airspace, to provide predictions to the system. The timestamps from these data are matched with the model output AOFF data to identify the total number of matching timestamps between the GUIFLIGHT and AOFF data sets. This OFF event prediction accuracy analysis determines the overall prediction accuracy, within 1 minute of the actual event, of runway departure events.

ASDI data source comparison

SMS receives data input from various sources, which in turn affect the timeliness as well as accuracy of the system. SMS receives the DZ message, a transmitted departure message for all eligible activated flight plans, from its ASDI data source to supply the system with runway departure times for aircraft (ref. 8). The timestamps from the DZ messages are compared with the SMS model AOFF timestamps to determine the difference in minutes for the arrival of the OFF event data. This OFF event ASDI data source comparison analysis compares the timeliness of the ASDI data with the actual time of the OFF event.

RESULTS

A. OUT Event

Overall detection

The data analysis was performed on the overall OUT event detection performance of SMS. When SMS detects that an aircraft has pushed back from the gate, via surface surveillance data, an actual push-back detection is identified. If an aircraft is detected on the surface after it has actually pushed back from its gate, SMS will "guess" its OUT time. For example, if an aircraft is scheduled to push-back from its gate at 9:15 a.m., but it is not detected on the surface until 9:20 a.m. and it is already taxiing, SMS will identify the aircraft as having pushed back and will "guess" the OUT time of the aircraft to be 9:20 a.m., even though its current location is on a taxiway. SMS assigns the current time for an OUT event, because there is no way to accurately back calculate an OUT time of an aircraft after it has left its gate. This is due to the uncertainty of the actions of the aircraft before it is actually detected. For instance, an aircraft may have been sitting in the ramp area for an extended amount of time or may have had to return to its gate after departing. Because the system is unaware of any of these potential events, a truthful OUT time calculation cannot be provided.

Figure 3 shows the number of flights that were detected or guessed by the SMS system over three hours of departure pushes at the DFW airport. The data are shown in 15-minute intervals from the start of the departure push hour. Figure 3 also shows the percentage of actual detections made by SMS, not including the guessed detections.

As the figure shows, a little more than half of the departure flights were identified as actual surface surveillance detections. There were no significant differences at the various rush periods. These data reveal room for improvement in the detection of OUT events within the SMS system, especially during heavy departure traffic times. These improvements, though, are greatly dependent upon the aircraft capabilities and the undelayed activation of transponders by pilots.

SMS uses aircraft position and speed to detect push-back events, but there are times when SMS does not have this information. One major reason is pilot delay in turning on the transponder, which projects the aircraft position data for the surface surveillance to identify it. If the transponder is not turned on before the aircraft pushes back from its gate, it is possible that an aircraft does not get detected until it is taxiing or even until it is departing its assigned runway. By increasing transponder usage at the gate, OUT event detection within SMS will improve. As a result, OFF time predictions would be improved and lead to more efficient surface and en-route operations.

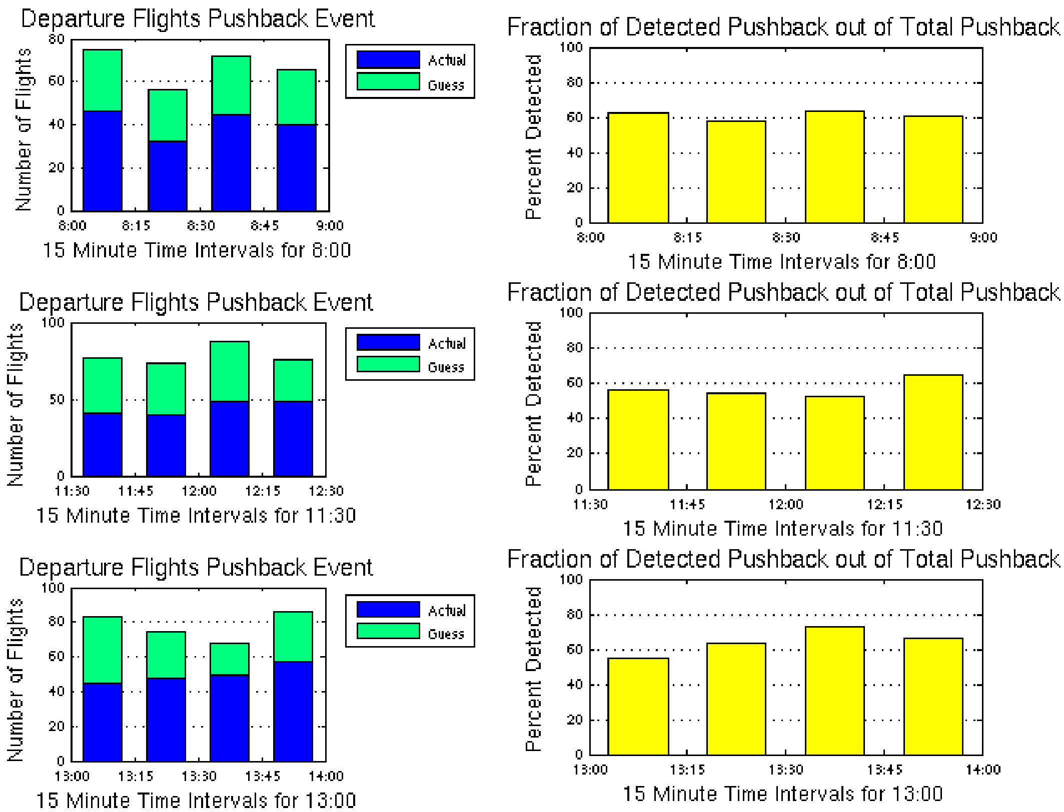

Figure 3. OUT event detection performance.

B. OFF Event

Overall detection

This data analysis was performed on the overall OFF event detection performance of SMS. When SMS detects that an aircraft has departed its assigned runway, via surface surveillance data, an actual runway departure is identified. If an aircraft is detected after it has actually started its roll for a runway departure, SMS will calculate, or "guess," the OFF time of the aircraft, dependent upon its current location. SMS will identify this as a guessed departure. For example, if an aircraft is scheduled to depart its runway at 2:00 p.m., but it is not detected until it has already left the runway, SMS will identify the aircraft as having departed the runway and will use the speed of the aircraft to back calculate its runway departure time and "guess" the OFF time of the aircraft to be 2:03 p.m., since its current location is beyond the runway.

Figure 4 shows the number of flights that were detected or guessed by the SMS system over three hours of departure pushes at the DFW airport. The data are shown in 15-minute intervals from the start of the departure push hour. Figure 4 also shows the percentage of actual detections made by SMS, not including the guessed detections.

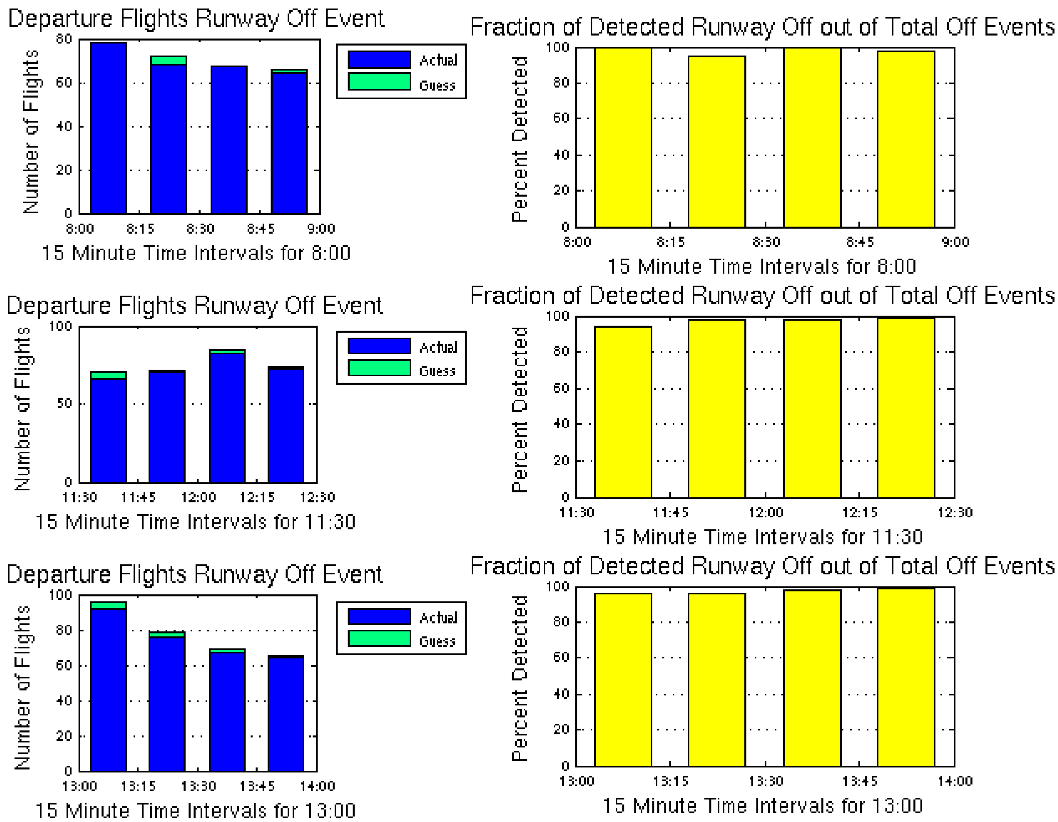

Figure 4. OFF event detection rerformance.

As shown in figure 4, the results of the analysis indicate that SMS is successful in detecting runway departure events. For each of the 15-minute intervals over the 3 hours of operations, figure 4 shows 100% detection, or nearly 100% detection, of the OFF events.

Because figure 3 indicates that many transponders are not activated while still at the gate, it appears that they are being turned on before they reach their departing runway. The few guessed OFF events in figure 4 may be the result of aircraft that did not activate their transponders prior to their take-off roll. There were no significant differences between the various rush periods.

Overall prediction accuracy

The accuracy analysis was performed to determine the overall precision of the SMS event time predictions for runway departures. The prediction accuracy is determined by an error rate of no more than 1 minute from the actual runway departure time. Since departure events typically happen within a 1–1½ minute timeframe, a 1- minute error rate provides high integrity to the precision of the prediction. Within the system, SMS is provided with messages from its data sources containing runway departure times. SMS uses these supplied departure times in its advisories and predictions that are displayed to the user.

Figure 5 shows the percentage of correctly predicted runway departure times by SMS, given the ASDI data prior to push-back and ASDE-X data after push-back. The data represent OFF time prediction accuracy for three separate departure pushes containing varying numbers of included aircraft. The time horizon spans from an hour prior to the actual OFF event taking place.

Figure 5 illustrates that the farther out from the actual OFF event, SMS does not perform well in predicted OFF times. Until approximately 10 minutes before an OFF event, the system is constant at just below 10% accuracy. It is not until 10 minutes out, that prediction accuracy begins to increase, yet it does not reach 100% accuracy until aircraft are within approximately 1 minute of departure.

The 10-minute timeframe before takeoff often is representative of the time taken for an aircraft to taxi from its gate to its departure runway at DFW. Because this is when track data are being collected for a moving aircraft, the OFF time predictions are continually updated, becoming more accurate the closer it is to the time of departure. Though inaccuracy for OFF time predictions is high prior to this 10-minute timeframe, this might be due to the lack of surveillance data before an aircraft has departed its runway.

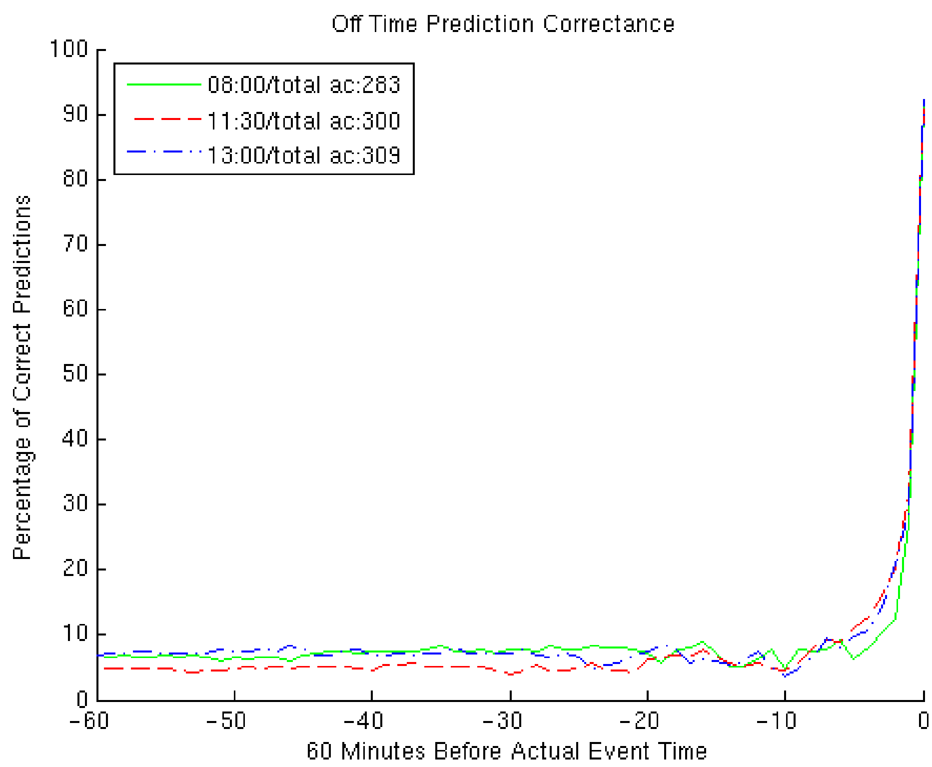

Figure 5. OFF event prediction accuracy performance.

Data source comparison

The data analysis was performed on the ASDI OFF time prediction function to determine the timeliness of the ASDI data source. ASDI provides a DZ message to SMS, which supplies it with runway departure times. Upon receiving this message, SMS continually updates in order to output more recent runway departure times. To discern how quickly the ASDI data source is supplying this information to SMS, the ASDI information arrival time is compared to the actual OFF time given by the system.

Figure 6 shows the difference in minutes between the ASDI DZ message and the actual departure time. These data are shown for the total number of OFF events that occurred during the 3 departure pushes at the DFW airport.

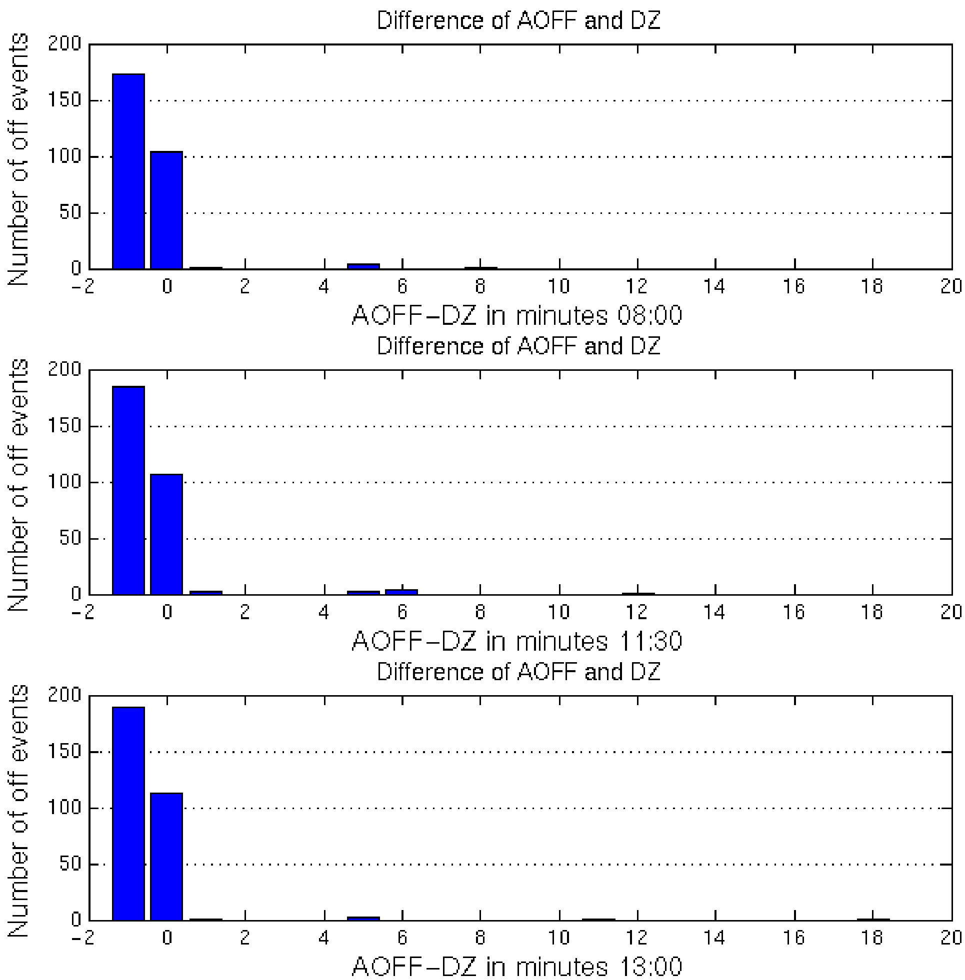

Figure 6. ASDI OFF event time prediction comparison.

The data suggest that ASDI is providing timely runway departure times to SMS. Most of the ASDI DZ messages arrive to SMS within 1 minute of the system OFF time. There are outliers that mostly fall within the 5–6 minute range, which might be caused by data messages being missed or dropped out of the system during the transition from the ASDI data source to SMS. Further investigation would be required to evaluate this hypothesis.

CONCLUSIONS

It is imperative that SMS provide reliable data and timely, reliable data sources. Its detection and prediction accuracy, as both a stand-alone tool and an integrated tool, should be high-quality for all surface operations, both arrival and departure events. The goal of this analysis was to determine the overall detection and accuracy performance of the SMS system as well as the timeliness and accuracy of its data sources, specifically for departure events.

The results of the analysis have shown that lack of aircraft surveillance data contributes to the low detection performance of SMS for OUT events, while surveillance data allows nearly perfect SMS detection performance for OFF events.

Improvements in the accuracy of SMS push-back time predictions are anticipated to assist push-back scheduling that may aid the airline operators in reducing operating costs and improving flight prioritization.

Although SMS OFF time prediction accuracy is better the closer an aircraft is to its departure, SMS can improve OFF time prediction accuracy farther out in time through improved OUT time prediction. These improvements will likely result in NAS-wide improvement in air traffic management scheduling predictions.

The analysis also shows that the ASDI data source is usually getting runway departure data to SMS in a timely manner.

RECOMMENDATIONS

As SMS can offer valuable decision support to its users through its detection and prediction capabilities, there are a few areas of interest that might assist in the improvement of SMS functionality. These recommended areas are identified below.

A. Inclusion of Airline Data

Airline data play an integral part in the functionality of SMS. Airline data contain parking gate assignments, updated predicted push-back time, flight priority, gate availability, and even maximum de-icing holdover time. SMS can use these data to more efficiently construct taxi routes on the surface and provide more accurate predictions of push-back and departure times as well as gate IN and runway arrival times.

B. Mandatory Early Transponder Activation

When the transponder of an aircraft is activated, it can be identified on both radar and collision avoidance systems. Without transponder activation, air traffic controllers may not see the aircraft on a radar screen. If all aircraft transponders are activated before they leave the gate area, SMS will not only show all aircraft on the airport surface on its map display, but will also improve on its detection of aircraft departure events, thus improving prediction accuracy of these events. Many pilots do not activate their transponders before leaving the gate area; it is not a required, standard procedure, possibly because the aircraft at this state are usually under airline ramp rather than ATC supervision. Pilots may also prefer not to activate their transponders due to desires to preserve battery life. Mandatory, early transponder activation will prove to be beneficial to SMS prediction accuracy and subsequent surface scheduling.

C. Surface Optimization

The optimization of surface operations can be helpful for SMS OFF time prediction accuracy. Through optimized operations such as departure aircraft scheduling and taxi route planning, more accurate data regarding aircraft maneuvers and processes will be available to SMS. This accessibility to more accurate data will allow SMS to provide improved advisories and predictions to its users.

REFERENCES

1. Raytheon: CTO-05 Surface Management System (SMS). CTOD 5-24-1 Final Report, 2004.
2. Swenson, H. N.; Hoang, T.; Engelland, S.; Vincent, D.; Sanders, T.; Sanford, B.; and Heere, K.: Design and Operational Evaluation of the Traffic Management Advisor at the Fort Worth Air Route Traffic Control Center. 1st USA/Europe Air Traffic Management R&D Seminar, Saclay, France, 1997.
3. Jung, Y.; and Monroe, G.: Development of Surface Management System Integrated with CTAS Arrival Tool. AIAA 5th Aviation, Technology, Integration, and Operations Conference, Arlington, Va., 2005.
4. Atkins, S.; Brinton, C.; and Walton, D.: Functionalities, Displays, and Concept of Use for the Surface Management System. 21st AIAA/IEEE Digital Avionics Systems Conference, Irvine, Calif., 2002.
5. Walton, D.; Quinn, C.; and Atkins, S.: Human Factors Lessons Learned from a Surface Management System Simulation. AIAA 2nd Aviation, Technology, Integration, and Operations Conference, Los Angeles, Calif., 2002.
6. Atkins, S.; Jung, Y.; Brinton, C.; Stell, L.; and Rogowski, S.: Surface Management System Field Trials Results. AIAA 4th Aviation, Technology, Integration, and Operations Conference, Chicago, Ill., 2004.
7. Clow, M.; Howard, K.; Midwood, B.; and Oiesen, R.: Analysis of the Benefits of Surface Data for ETMS. 2004.
8. Volpe Center Traffic Flow Management Division: Aircraft Situation Display to Industry: Functional Description and Interface Control Document. Version 5.4, 2005.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
21/09/2009	Technical Memorandum	

4. TITLE AND SUBTITLE
Surface Management System Departure Event Data Analysis

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gilena A. Monroe

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
WBS 305295.02.07.01.10

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Ames Research Center, Moffett Field, CA 94035-1000

8. PERFORMING ORGANIZATION REPORT NUMBER
A-090016

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, D.C. 20546-0001

10. SPONSORING/MONITOR'S ACRONYM(S)
NASA

11. SPONSORING/MONITORING REPORT NUMBER
NASA/TM–2009-215383

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified — Unlimited   Distribution: Nonstandard
Subject Category: 03
Availability: NASA CASI (301) 621-0390

13. SUPPLEMENTARY NOTES
Point of Contact: Gilena A. Monroe, Ames Research Center, MS 210-6, Moffett Field, CA 94035-1000
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14. ABSTRACT
This paper presents a data analysis of the Surface Management System (SMS) performance of departure events, including push-back and runway departure events.The paper focuses on the detection performance, or the ability to detect departure events, as well as the prediction performance of SMS. The results detail a modest overall detection performance of push-back events and a significantly high overall detection performance of runway departure events. The overall detection performance of SMS for push-back events is approximately 55%.The overall detection performance of SMS for runway departure events nears 100%. This paper also presents the overall SMS prediction performance for runway departure events as well as the timeliness of the Aircraft Situation Display for Industry data source for SMS predictions.

15. SUBJECT TERMS
Air traffic management, Departure events, Airport ground operations, Surface Management Systems (SMS)

16. SECURITY CLASSIFICATION OF: a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Gilena A. Monroe
Unclassified	Unclassified	Unclassified	Unclassified	22	**19b. TELEPHONE** *(Include area code)* (650) 604-2545