OPERATIONS CONCEPT
FOR THE
SURFACE MANAGEMENT SYSTEM
PROTOTYPE

SMS-102

December 30, 1999

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
COMPUTATIONAL SCIENCES DIVISION
MOFFETT FIELD, CALIFORNIA

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1.0 INTRODUCTION

1.1 DOCUMENT OVERVIEW

This document describes the vision of a prototype Surface Management System (SMS) as part of the NASA/ARC Advanced Air Transportation Technologies (AATT) Program, Terminal/Surface Systems and Operations Area. This vision of a prototype SMS is intended to be consistent with the AATT Terminal/Surface Systems and Operations, Level III Plan (see reference 1 in Appendix I).

The background of the Surface Movement Advisor (SMA) at Atlanta and lessons learned are presented. The objectives of SMS are presented. The Operation Concept for the Surface Management System is presented. The justification and projected benefits of SMS are described.

The research and development activities that will be conducted in service of the Program Objectives are described in “SMS Research and Development Plan, “ SMS-101. (see reference 2 in Appendix I).

As airport surface research at NASA Ames progresses, and better approaches to surface management become available, this Operations Concept for the Surface Management System will be updated. This Operations Concept is considered a 'living document'.

Acronyms and abbreviations are listed in the Appendix II.

1.2 SITUATION OVERVIEW

Weather and terminal volume are cited as the primary causes of delay in the NAS (see reference 3 in Appendix I). The number of flights through major U.S. airports is expected to increase in the future. Although further work remains, the en-route and arrival solutions are more mature than existing solutions to problems on the surface of major U.S. airports. Gridlock within the NAS and in particular, on the surface of airports is predicted to occur by the year 2004.

Puget, et. al. has developed algorithms that may reduce taxi time. His work has largely been focused at Logan airport (see reference 4 in Appendix I).

Wood and Bush have worked on radar techniques that may be useful for surface surveillance, e.g., tagged aircraft and location on the airport surface (see reference 5 in Appendix I).

The Surface Movement Advisor (SMA) (see reference 3 & 6 in Appendix I) was developed at NASA Ames in conjunction with the FAA and U.S. airlines, to determine if software tools could assist the FAA and airlines in dealing with the increasing demand on the airport surface. The conclusion was, yes, such software tools, in conjunction with the necessary hardware, could assist the FAA and airlines in dealing with the increasing demand on the airport surface.

2.0 BACKGROUND, SMA AT ATLANTA

In order to test the feasibility and potential payoff of surface information exchange that could be implemented in the near-term, a proof-of-concept prototype system, located at the Atlanta Hartsfield International Airport (ATL) referred to as the Surface Movement Advisor (SMA), was developed through a joint NASA/FAA partnership. The goals of SMA were to understand the nature of airport surface operations, identify user requirements, evaluate potential data sources, and research various advisory capabilities as well as the associated human factors issues. The information and advisories provided by SMA have facilitated evaluation of data sources, helped reduce voice radio communication, optimized the use of gate resources (improved gate and crew rescheduling), and assisted with balancing the departure runway loads. The goal of facilitating analysis of airport operations was not fully met. Further work remains in understanding human factors issues involved in assisting controllers with making decisions. The only airport where the nature of airport surface operations was studied and understood was ATL.

The SMA system, first used operationally in June 1996, was developed and deployed at the Atlanta Hartsfield International Airport in 18 months. Since that time, SMA has demonstrated a greater than 98% up-time. NASA/FAA provide 7 (days) x 23 (hours) operations support for: a) FAA Tower controllers, b) AGI & Delta Air Lines ramp controllers c) AirTran & Delta Air Lines operations centers, d) the City of Atlanta Operations Center, and e) Department of Aviation (DOA), City of Atlanta Planning & Procedures Office.

FAA/ASD and MCA Research Corporation conducted a benefits analysis of SMA in October 1997 (see reference 7 in Appendix I). The results showed that SMA is generating benefits in the form of cost savings. These cost savings, projected to range from $16 - $21 million in 1997, are a result of taxi-out times being reduced by, on average, approximately one minute per aircraft. The analysis concluded that, by using SMA technology, airports with similar traffic loads and runway configurations to those at Atlanta would likely experience comparable savings.

Primary Lessons Learned

1. Significant benefits to airline, gate, and ramp operations have been derived from sharing real-time radar information about arrival aircraft status. Additional improvements to airline data accuracy need to occur in order for a positive return on investment for the FAA related operations.

2. The SMA users within the airport community have different requirements for data accuracy and time frame of interest. FAA Tower controllers demand 100% coverage and 100% accuracy, whereas airlines are able to benefit with +/- 2 to 3 minute accuracy on pushbacks (‘out’ time) and blockins (‘in’ time). FAA Tower, ramp, and airline dispatch all have different time frames for operations: ramp +/- 10 minutes, FAA tower 15 minutes to 2 hours, and airline dispatch 1-8 hours.

3. To load balance the runways, FAA Tower controllers require higher accuracy data than is available from the airlines. SMA's data coverage, before the Electronic Flight Strip (EFS) enhancement (added in the summer of 1999), was between 60 and 85 percent, depending on time of day. The accuracy of SMA with the EFS strip will be measured, and reported in FY2000. The data accuracy problems from the air carriers arise from: significant numbers of non-active, canned flight plans; missing or inaccurate gate assignment information; and missing, late, or inaccurate pushback and block-in messages.

4. The SMA system has been used by the FAA's Traffic Management Unit (TMU) to optimize individual aircraft runway assignments before and after large pushes. This is limited to a case-by-case basis rather than applying airport-wide configuration changes (which would have the largest impact on improving taxi-times).

5. Accuracy of the information from the air carriers goes down during large delays and heavy system loads. Unfortunately, this is when accurate information from the airlines is needed most.

6. Secondary benefits of SMA have been derived from the Oracle database storage of the operations data. By providing a COTS data management system that has a significant third party tool base it has enabled the development of simple web-based interfaces for the air carrier managers and airport managers to use for analysis of their own operations.

7. Intent information is critical for planning and coordinating airport operations. In addition, airline priorities are necessary for departure and arrival planning to be optimal with respect to airline business objectives.

8. The lack of data standards for surface operations has a significant impact on portability and accuracy of air carrier information. No standards exist for code shares, stub flights, schedule updates, pushback messages, block-in messages, and other surface related activities.

9. Building a prototype system at a specific airport will tend to be focused and unique. It will not tend to provide a solution common to the surface problems within the entire NAS.

3.0 JUSTIFICATION OF PROPOSED SMS

The previous model (SMA at Atlanta) was to install surface management tools at selected U.S. airports, sequentially. Simultaneously, the 'core' functionality and 'airport-specific' functionality would be identified. The core functionality would be the portable portion of the system and the installation at a given airport would need to be customized with the airport-specific functionality. Based on the lessons learned with SMA at Atlanta, implementation of this model at several U.S. airports will not be cost or time effective. The benefit of SMA at Atlanta is largely its information sharing capability; e.g., users have access to information that they did not previously have. The capability of the combined ETMS and ADL data feeds from Volpe/Metron will very soon accomplish on a national level the bulk of the information sharing that SMA accomplished at Atlanta. Thus, the need for locally installed surface management tools has decreased since SMA was installed at Atlanta.

The NAS is an interdependent system. A complete solution to the current and future surface problems in the NAS can not be developed by individual entities working for their individual benefit. The FAA and other organizations need to cooperate and collaborate. Neither can a complete solution be developed by sequential analysis of individual airports. Analysis of surface data and problems must be conducted at the system or national level, to improve overall system performance rather than local performance.

4.0 CONCEPT OF OPERATIONS FOR THE PROTOTYPE SMS

4.1 SMS PROTOTYPE OBJECTIVES

The primary objective of the SMS research prototype developed at NASA Ames will be to contribute to the understanding and solution of various problems existing within the surface domain of airports within the NAS. Examples of traffic problems on the surface of the airport terminals in the NAS are terminal volume (amount of traffic), surface congestion and throughput. However, a complete list of known problems facing every user (FAA, Airline, City) and every airport is not appropriate here. A thorough description of the NAS, including problem areas and planned enhancements, is described in reference 3 in Appendix I.

The primary objective of SMS is directly related to the goals of other programs, either internal or external to NASA. For example, CDM/FSM desires to know, as early as possible, the expected departure (a.k.a., wheels-up or 'off') time of every aircraft.

The secondary objectives of the SMS are to (1) demonstrate commonality and portability (between airports), and (2) integrate with CTAS tools as appropriate.

The explanation of how these objectives will be met is contained in reference 2 in Appendix I.

4.2 DESCRIPTION OF PROPOSED SMS PROTOTYPE

Figure 4.2 shows the proposed SMS Prototype Concept of operations.

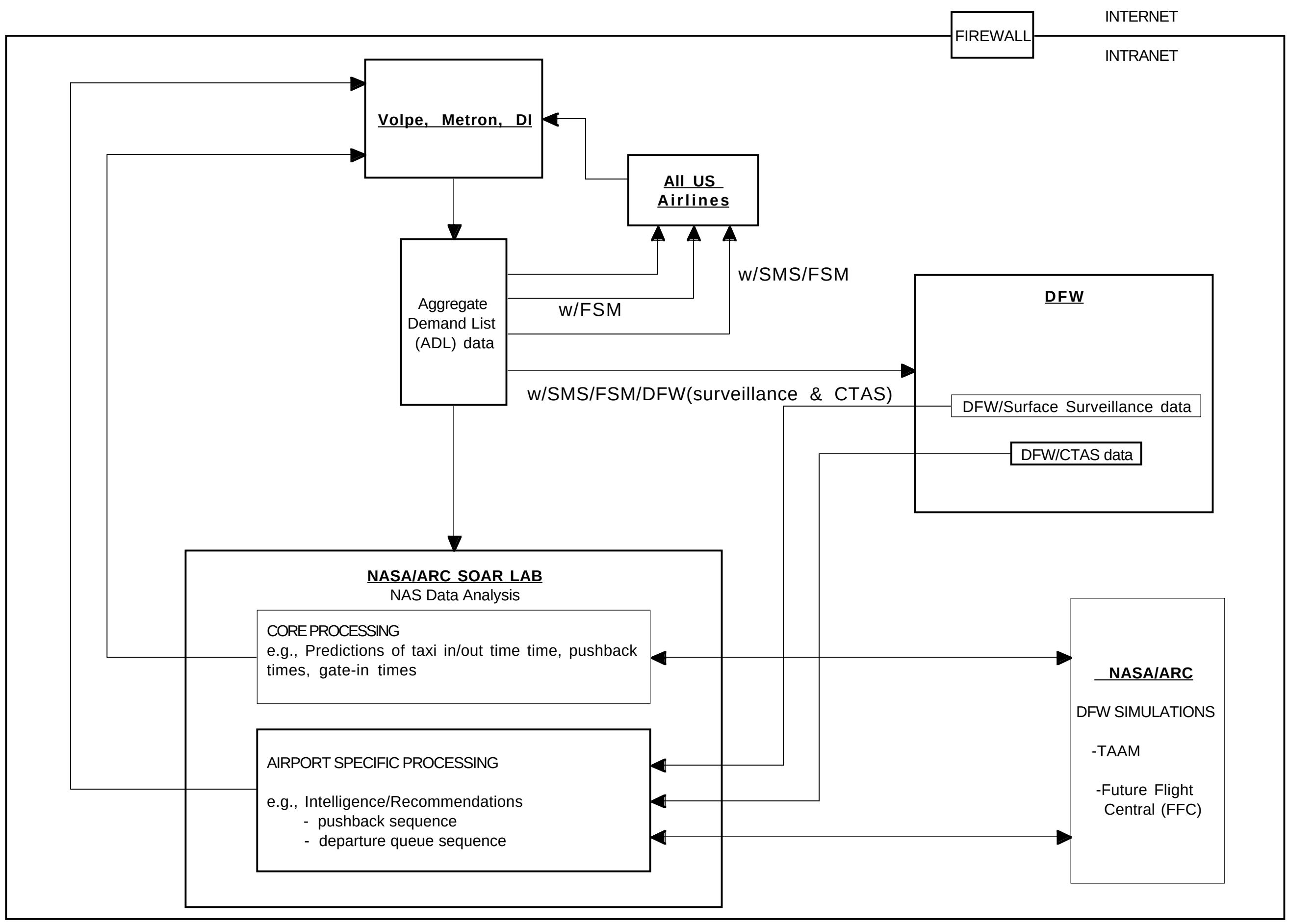

FIGURE 4.2
PROPOSED SMS PROTOTYPE CONCEPT OF OPERATIONS

The ETMS and ADL national data feeds will be available for use by SMS at NASA Ames. The data received at Ames will be contained within a secure intranet. None of the supplied data will be placed on computer systems that have access to the internet. Encryption of data will be used when requested, or deemed necessary. Security of the ETMS/ADL data is of the highest priority.

The SMS prototype (running at NASA Ames) will add two types of information to the ADL, (1) predictions, and (2) recommendations (to controllers). This information will be passed back to Volpe/Metron and then onto the recipients of the ADL.

Examples of predictions added to the ADL include:
- taxi out time
- take off time

These can be used for better en-route planning.

Examples of recommendations to ramp controllers and FAA ground controllers include:
- pushback sequence
- departure queue sequence

These will help minimize congestion, maximize throughput and minimize de-icing delays. Also, airborne holding can be accommodated if the information that a desired gate will be occupied (when an arrival flight needs it) is available prior to descent and landing.

The addition of useful recommendations to the ADL will be difficult without surface surveillance data, which is not currently available. The surface surveillance system that is partially installed at DFW will be enhanced and completed to investigate the ability of SMS to make these recommendations. SMS will access surface surveillance data from other airports when it becomes available.

The SMS program (in conjunction with others, e.g., Metron) may develop prototype displays and tools that allow users (FAA controllers, airlines, ramp controllers) to have a common situational awareness.

The approach for implementing the proposed SMS is described in Reference 2 in Appendix I.

4.3 USERS OF THE PROPOSED SMS

Target users of SMS are recipients of the ADL, FAA controllers and ramp tower controllers as appropriate.

5.0 PROJECTED BENEFITS OF SMS

The national SMS proposed in this Operations Concept will provide predictions of surface events (taxi time, congestion, etc.) and recommendations to tower and ramp controllers.

The recommendations to FAA and ramp controllers regarding pushback sequence, departure queue sequence and airborne holding will be the fruit of the SMS research into algorithms designed to minimize surface delays, congestion, de-icing delays and maximize throughput.

The collaborative departure scheduling tools in SMS will help load balance runways, through both strategic and tactical traffic management, by supporting the FAA Tower, ramp towers, and air carriers in making decision about how to sequence the departures. In particular, runway load balancing is intended to increase runway throughput by mitigating constraints due to timing miscues at departure fixes, wake vortex separation requirements, noise abatement routes, and runway crossings.

SMS will reduce the environmental impact caused by aircraft on the airport surface (noise and pollution emissions) by minimizing the length of time that aircraft run their engines on the ground. This goal will be achieved by minimizing the taxi time to the runway and, when an aircraft's takeoff will be delayed, delaying the time at which the aircraft starts its engines, when permitted by other constraints. Avoiding long takeoff queues at the runway also yields operating cost benefits for the air carriers.

All airlines at all airports can benefit from the national SMS. A sequential implementation, airport by airport, using SMA at ATL as a model, would tend to benefit the bigger airlines at the bigger airports.

APPENDIX I REFERENCES

1. NASA, AATT, Sub-element 4, "Terminal/Surface Systems and Operations, Level III Plan", Version 2.0, March 1999.

2. D.Signor, C. Leidich, SMS-101, "SMS Research & Development Plan", December 1999

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6. B.J.Glass, "Automated Data Exchange and Fusion for Airport Surface Traffic Management". AIAA#97-3679

7. Willma Rada, "Surface Movement Advisor (SMA) Benefit Analysis", prepared by FAA/ASD and MCA Research Corp, October 1997.

APPENDIX II ACRONYMS & ABBREVIATIONS

AATT	NASA Advanced Air Transportation Technologies (AATT) Program
AGI	Airport Group International (the company that provides ramp controllers for concourse C and E in Atlanta).
AOC	Airline Operations Center
ARC	Ames Research Center
ASD	ASD is an organization within the FAA.
ATM	Automated Traffic Management
CAP	Collaborative Arrival Planning
CDM	Collaborative Decision Making
CNS	Communications, Navigation and Surveillance
COTS	commercial off-the-shelf
DOA	Department of Aviation
DST	Decision Support Tool
DTA	Departure Transition Area
EDP	Enhanced Departure Planner
EFS	Electronic Flight Strip
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FAST	Final Approach Spacing Tool
FSM	Flight Schedule Monitor
MCA	MCA Research Corporation

NAS	National Airspace System
NASA	National Aeronautics and Space Administration
SMA	Surface Management Advisor (at ATL)
SMS	Surface Management System
TRL	Technology Readiness Level
TMA	Traffic Management Advisor
TMU	Traffic Management Unit
VDQ	Virtual Departure Queue