Support of Airline Operations Centers using the Surface Management System

Philip J. Smith, Chris Pear, Charles Billings and Amy Spencer

February 15, 2002

Acknowledgement

This report was produced under a subcontract to Metron Aviation Systems from the Raytheon Corporation in support of Concept Element 5: Surface Management Systems of the NASA Advanced Air Transportation Technologies program.

Table of Contents

Introduction

Safe, efficient surface movement operations of transport aircraft requires communication and collaboration among Airline Operations Centers (AOCs) or Dispatchers, Airline Coordination Centers (ACCs) or Ramp Control facilities (Spencer, Smith, Billings, 2001), the Air Traffic Control Tower (ATCT) and other terminal area and enroute FAA facilities. A Surface Management System (SMS) could provide information and displays to support the activities of each of these groups individually, and could facilitate shared situation awareness and coordination among decision makers in all of these organizations. The needs and opportunities in terms of AOC involvement are discussed below.

Information Required to Support Decision Making in Air Transport Operations

In terms of AOC involvement, the information to support individual and collaborative decision making should include:

- Aircraft capabilities (minimum equipment lists, fuel on board, minimum runway lengths as a function of load and runway conditions, etc.)
- Predicted and actual out, off, on and in times for individual aircraft (and revision of the predicted times when contingencies arise)
- Planned and actual departure and arrival gates for aircraft
- Alternative out/off/on/in times, departure taxi routes, departure runways, routes, altitude profiles, arrival taxi routes and arrival gates for individual aircraft
- Acceptable tradeoffs among the alternatives (such as a preference for departure route 1 over route 2 if it reduces the off time by at least 23 minutes by avoiding surface or airspace constraints)
- Predicted and actual out/off/on/in times for aircraft for alternatives identified above
- Current position on the airport surface for each aircraft relative to other aircraft on the airport surface (discriminating among airlines as well as arrivals and departures)
- Current position of various aircraft enroute and in arrival terminal area airspace (discriminating among airlines as well as arrivals and departures)
- Information indicating the nature, cause and likely duration of delays, including:
    - surface queues
    - dynamic surface constraints other than surface traffic (closed runways, etc.)
    - current and predicted constraints during departure, enroute and in terminal area airspace (demand vs. capacity)
    - ATC advisories and restrictions (miles-in-trail restrictions, assigned reroutes, ground stops, ground delay programs, etc.)
    - ATC recommended runways, departure routes, altitude profiles and arrival routes
    - ATC-entered flight plan amendments (preflight and enroute)

Some of this information would be provided by ATC, dispatchers or the AOC for use by SMS and other users of SMS, while other information would be provided to dispatchers by SMS or by other tools that would need to be integrated with SMS. In this role, SMS could serve as a tool to integrate information, as well as to provide certain data and predictive capabilities that represent unique contributions of SMS. SMS could also provide displays to support visualization to enhance problem detection and problem solving, along with improved situation awareness, communication and coordination for collaborative decision making.

AOC Uses of SMS

A well-designed SMS would be of value to AOCs in a number of areas. Some involve the use of SMS-provided information to accomplish tasks performed by dispatchers. Others involve the use of SMS as a mechanism for communication of information produced by dispatchers to other groups, such as airline Ramp Control staff, or staff at FAA facilities (Towers, Terminal Radar Control facilities (TRACONs), Enroute Traffic Control facilities (ARTCCs) or the ATC System Command Center (SCC). SMS could be especially useful during irregular operations when weather, traffic congestion or some other factor is impacting departures or arrivals.

An Information Reservoir

There has been an explosion of relevant, available information in the aviation system in recent years. The problem has become how to ensure that all system participants who may need particular information for decision making can share this information when it is needed. Under both normal and irregular conditions, SMS, with its prediction capability, integrated with other information management tools, can be extraordinarily useful as an information reservoir: a compendium of up-to-date information and data concerning the status and progress of aviation operations in a given area. This need is highlighted by the comments of subject-matter experts:

"I think if I were going to field the system (SMS), I'd field it first within the airline industry, because the airlines ... are becoming more and more in control of our destiny ... I think with a system like this, you can put in place a system that will allow the airline to do the staging ... because they've got them all sitting at the gate, and you can control when they're going to push off the gates and go. ... Let the FAA tell the airline, you can launch them to Chicago and let the airline decide who "they" are, and stage them accordingly to their spots. Then you're not stepping on [the FAA's] toes, nor are you being restrained from doing what you think you can do best. I think this system has the opportunity to do that ... to be able to develop that kind of scenario."

"And you need this information—more accurate information (most) when you get into an irregular operation. When you're really going to need this thing is when you're in the middle of an irregular operation, and now you need the information that can [be supplied] to the airlines."

"Somehow, this sharing of information has to be automated ... and the technology is out there. It's a matter of some[one] putting their arms around all this stuff and bringing it together so it all makes sense ...

"I'm convinced that you'll find, for the most part, a very receptive audience in the airline industry for this type of technology ... because it's going to improve the efficiency of the operations ... The airline industry operates on such a small margin, that a minute or 30 seconds on every flight amounts to millions of dollars over the period of a year, so they're going to really look at this (SMS) as being a positive stroke."

A Communication Medium with ATC Concerning Airline/AOC Priorities

In the course of normal operations AOCs and/or Ramp Control, for a variety of reasons, may need to indicate to ATC the relative priorities of different flights for departure or arrival. Several experts, however, have pointed out the difficulty inherent in synchronous communication between AOCs and ATC facilities during busy periods. SMS can be used to indicate airline operational priorities to ATC without the necessity for verbal interactions. Examples of the need for this is the following, provided by a dispatcher.

"Flight 895 goes out of O'Hare to Hong Kong, and it always needs the long[est] runway for takeoff, which is a problem ... We have set up procedures where the crew was supposed to call the Tower 10 minutes before their push[back] to let the Tower know they're going to be there, and they never called, or they called and an airplane was delayed and they couldn't make it, and he gets out to the end of the runway and sits there for 45 minutes while they make a hole in the regular traffic for him to get off the runway. Somehow we could convey that information [automatically], not depending on the crew to call the Tower ..."

Even smaller, short-range aircraft may on occasion be carrying numbers of international connecting passengers or high-priority cargo and may therefore become priority traffic for an airline if it is known that there is a potential for arrival delays at an international hub.

"All the airlines have specific flights that are considered to be priority—they have international passengers on board to connect with the Hong Kong or Beijing flight. Each airline does it now manually—we call Tower and say, 'Hey, we have to [get this flight in on time] today' ... Sharing information needs to be done some way other than by phone, because for the most part, Towers are too busy to be talking about this stuff ... and yet it's critical to the operation of the airline."

These will usually be sporadic occurrences not likely to be known to ATC unless they are flagged in some manner by the airline AOC or Ramp Control. Information concerning these priorities would help ATC, with the assistance of SMS, to make better, more responsive decisions regarding sequencing of flights for departure or arrival to accommodate user needs.

Information Sharing to Keep Track of System Constraints

The National Airspace System is highly dynamic, although experience gained during daily operations allows controllers and traffic managers to predict its performance under normal or usual conditions. The ATC System Command Center (ATCSCC) has made major efforts to share information concerning especially predicted weather constraints by holding Strategic Planning teleconferences every 2 hours and by disseminating Advisories periodically throughout the day, providing information concerning likely changes in system status and routes to be used. This information, however, is always subject to change as weather systems develop and move, and airlines need as much additional information as they can obtain to permit them to plan for near-term future operations, including reroutes.

Reroute advisories currently pose serious problems for AOCs, as illustrated by the following comment:

The advisories may be updated in a timely manner. It's reacting to the advisories that's the problem, because in the current situation, when that advisory comes out, it requires the airline to build a new route in its computer database—and that could take a lot of time. It could take anywhere from 20 minutes to an hour to get the new route built in, and then all that information must be given to the crew, whereas if machine-readable code comes through with a list of flights attached, the airline computer will build the route, and when the dispatcher pulls up the format, the route's already in there. All he has to do is push a button to send it."

The opportunity to coordinate reroutes motivated by SCC Reroute Advisories will become appreciably easier in the near future because of work being performed under the Collaborative Decision Making (CDM) program in collaboration with the ATCSCC and Volpe Transportation Research Center, which are creating machine-readable reroute advisories using the Reroute

Advisory Tool (RAT) (Beatty and Smith, 2000). These advisories will indicate specific flights that are covered by an advisory, as well as assigned reroutes or alternative permissible reroutes. If SMS received such reroute information, it could help to ensure that airline AOCs and Ramp Control staff, as well as relevant ATC facilities, were aware of assigned reroutes, and that the affected flights were in compliance with the changes. Furthermore, SMS could use such information to help plan departure sequences that take into consideration the constraints communicated within these advisories.

Providing AOCs with current information about surface movement delays for inbound flights could help both AOCs and Ramp Control staff make better decisions about how to adjust flights while enroute to improve congestion management in flight and surface congestion and delays after landing, as well as to reduce customer dissatisfaction. To quote a dispatcher, “Nothing is more frustrating to a passenger than sitting on an airplane looking at where he wants to be and being told he has to stay in his seat, with a seat belt fastened. He would have been much happier to take another circle around the pattern.”

Another example where information access needs to be considered in the design of SMS has to do with accessing the most current data available. As an illustration: “The ground delay program is one case where more realistic data is available if they chose to tap that instead of the normal P-times.”

With regard to departure delays, SMS can provide appreciable assistance both to ATC and to AOCs. As a traffic manager said, “In terms of where SMS is contributing ... you’re not just looking out the window, but you’ve got the color coded stuff ... you can tell this guy is an east bounder ... I was looking at the … the maps to see when they were coming off the spots, and then we’re looking at the timelines ... because I can see [which departure gates or fixes the airplane needs].”

When significant delays are predicted for either arrivals or departures, AOCs must make decisions about reassigning aircraft or flight crews, or even decisions about cancellations in order to avoid more serious problems downstream. SMS offers the potential to provide this information to the AOC, allowing better resource allocation decisions to be made in real time.

Improvement of AOC Situation Awareness

One subject matter expert said, “The overall industry and the National Airspace System is definitely lacking when it comes to situational awareness of airports around the country.” Another said, “I see this as a possible meeting between the controlling agency and the airline to be able to start that kind of awareness that needs to take place—silent communication, if you will, to take place, to allow the operation to run efficiently.”

A controller observed, after watching a scenario, “The one graphical display that I thought was interesting was the demand of the arrival delays and departure delays, [which] would give the dispatchers ... an idea of how much delay the airplanes are going to take coming in, therefore giving the dispatchers a kind of heads up alert, so that when the crew starts screaming, they’ll know what the problem is ... The planners really need to know just what the arrival and departure rates are, so they can plan accordingly ... these kinds of things happen with AOCs routinely, and ... they need some technology that helps them along these lines, so the AOC will have a great deal of play in this role. It’s a matter of the coordination that happens between ramp tower, gate management and the AOC in planning the overall flight ... Those three entities within the airline need to be able to have good situational awareness of ‘how are things going on our given schedule.’”

Examples of SMS Utility for AOCs

Some comments about the potential utility of SMS for AOCs have been given above. In the course of this research, a number of examples have also been given by subject matter experts and persons involved in research in this domain. Some examples will be presented here.

Flexible Use of Coded Departure Routes (CDRs), Capping and other "Escape" Routes

Under the FAA's Collaborative Decision Making (CDM) program, a variety of approaches have been explored to increase flexibility to opportunistically take advantage of developing weather or traffic conditions. Two examples are the collaborative use of CDRs (Smith, Billings et al., 2000; Smith, McCoy and Billings, 2000) and the use of low altitude departure and arrival routes (capping and tunneling).

The collaborative use of CDRs involves approval by Dispatch of 2-3 alternative "escape" routes for the departure of a flight from an airport. Given a forecast indicating that weather or traffic may delay departure along a user-preferred route (but that there is uncertainty about whether this constraint will or will not occur), using this procedure the dispatcher, relevant ARTCC, airport Tower and ATCSCC coordinate to determine alternative routes that would be acceptable if they could reduce the departure delay. The dispatcher or AOC determines whether all of these alternative routes are acceptable, fuels the aircraft appropriately, and includes this information on the flight release. A traffic manager at the ARTCC, in coordination with Tower personnel, then makes a decision about what route to use as the aircraft begins taxi out for departure. A similar process has been explored using lower altitude departures (capping), avoiding departure delays because the normal high altitude departure sector has become saturated.

SMS could contribute to this existing process by providing flight-specific displays containing information about what alternative routes and departure runways have been pre-approved for each flight, making coordination more efficient. More significantly, however, given knowledge of the approved alternative routes or altitudes, in some cases SMS could support the development and implementation of plans by ATC (departure routes, etc.) to ensure departure queues that minimize the likelihood that a lead aircraft will delay other departures because of a constraint at its departure fix or along its filed route.

In other cases, these alternative routes may permit the use of alternative departure runways (assuming no aircraft constraints due to gross weight in relation to runway length). In these latter cases, SMS could provide information about departure queue lengths at different runways and help develop plans for accessing and utilizing different runways that have been pre-approved by the AOC for certain departures. As a Dispatcher noted: "A system like SMS could look and say: 'What are the queues like? And if they're not too bad, let's take him out the south side because that's preferable if he gets off on time.'" SMS could also provide dispatchers with up-to-date information regarding which route or departure altitude has actually been selected, and with information on the impacts of such revised plans on predicted off times.

In addition, there are many situations in which alternative departure routes have not been pre-planned, and where ATC needs to quickly move some flights to other departure fixes. This could be coordinated in real time if the Tower TMC or supervisor, Ramp Control and Dispatch were alerted that a given flight was experiencing, or was predicted to soon experience, a significant departure delay due to a constraint at a departure fix, and that ATC wanted to move that aircraft to another departure fix. If, in addition to such an alert from SMS, the Tower

TMC/supervisor, Ramp Control and Dispatch could all see the nature of the constraint, they would all be kept in the loop and would be able to coordinate with each other, thus enabling more effective real-time decisions regarding the alternative departure route or altitude.

Planning of Arrival Sequences and Timing

Providing the dispatcher with information about inbound taxi delays and gate availability in an integrated fashion could help improve decisions about how to adjust or re-sequence flights while they are enroute (such as slowing an aircraft to conserve fuel and delay its arrival until a gate will be available). This could benefit enroute congestion management as well as surface congestion, and perhaps reduce customer dissatisfaction, as noted above.

Planning and Conduct of Irregular Operations

A special, but very important case of departure and arrival constraints involves irregular operations. To provide information relevant to procedures such as snow removal and deicing, SMS could be integrated with tools like those under development at New York Metro airports to provide shared access to airport status information for the New York Port Authority, Local Tower and airline Airport Coordination Centers. This integration could improve situational awareness among the AOCs, Ramp Controllers and ATC, and provide SMS with up-to-date information on dynamic surface constraints for use in developing plans for surface movements. Included in this list would be runway and taxiway availability—which airport movement areas have been plowed and are clear of snow removal equipment and vehicles. Aircraft readiness could also be included: which aircraft have been deiced and, very importantly, when they were deiced, as an airplane has only a certain number of minutes post-deicing in which to become airborne before it must go through another deicing procedure.

As a specific example of this issue concerning post-deicing time, consider the following illustration. During winter operations an important problem encountered by ATC ground controllers is getting treated flights to the end of the runway before their holdover times run out. If a flight reaches its holdover limit and has not departed, it must return to be deiced again, causing further delay and airport surface congestion problems. The holdover time varies depending on the type of deicing fluid used. Using SMS to give this information to the Tower would help in making decisions about how to give certain flights priority for takeoff. SMS could provide a display of this information for ground controllers. In figure 1, the information is shown on a surface map as holdover time remaining for each flight. The time in the data block would be supplied by SMS from airline input; it would count down and could indicate when the holdover limit was approaching, as shown for flight UAL200, which has only 8 minutes of holdover protection left before it must be deiced again. The figure indicates that DAL200 has 16 minutes of holdover time remaining. SMS could further indicate which taxi route could be used to avoid exceeding the holdover time limit, allowing UAL200 to be moved ahead of DAL200 to expedite its departure.

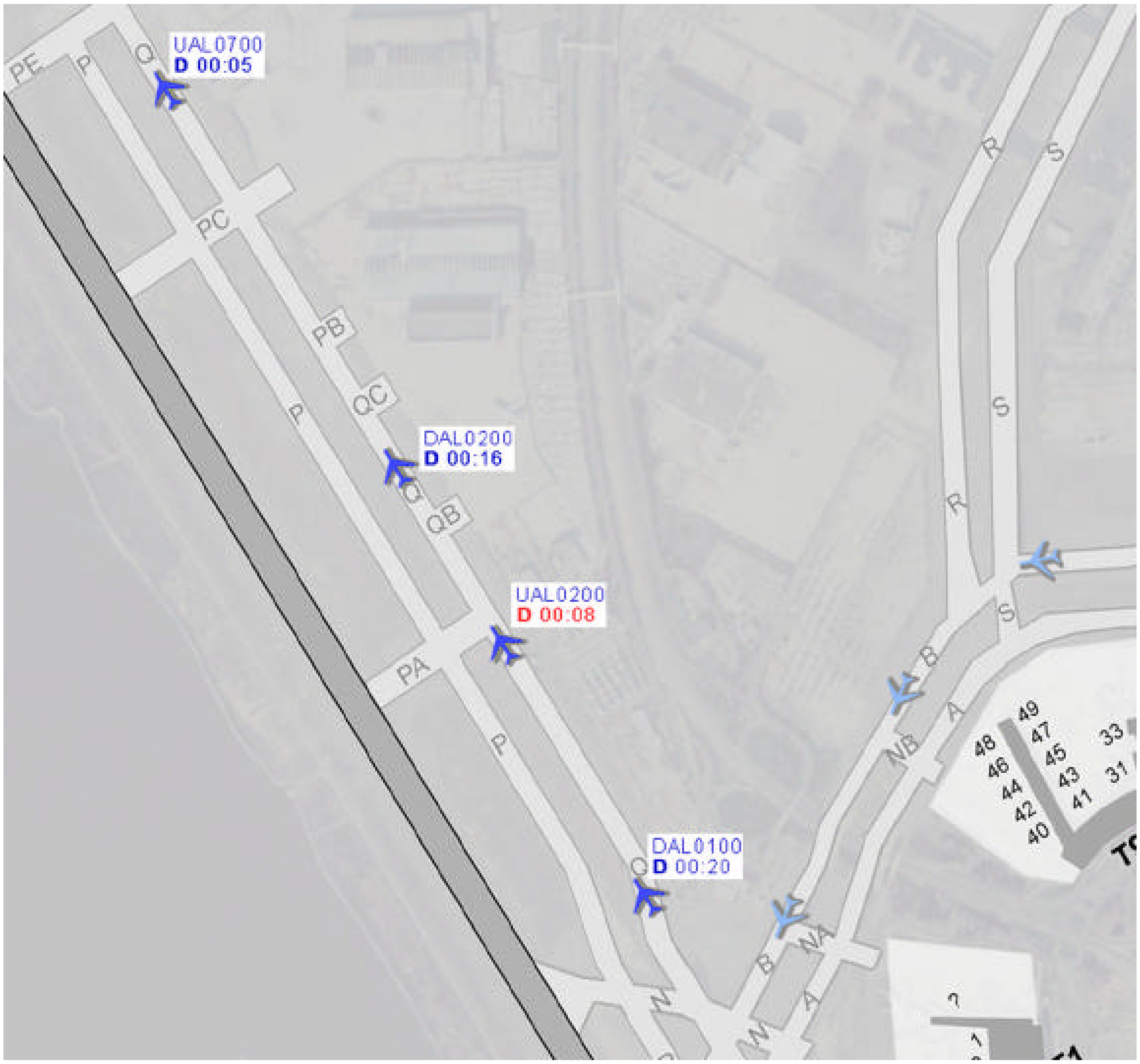

Figure 1. Display of critical holdover times.

Regulatory Compliance

There are other reasons why an airplane may have to return to its gate—including new FAA regulations. In the past, if an airplane was operating on an active airport surface (such as a departure queue) when the flight crew's flight or duty time limit was reached, the crew would remain on duty until the airplane received takeoff clearance, departed and reached its next destination.

New flight and duty time regulations require that a flight must return to the terminal when a crew's statutory limit is reached, even if this time was reached because of significant surface delays. Thus, these types of aircraft and flight crew availability issues need to be communicated and considered in planning surface movement operations. SMS, integrated with other airline data management systems, could be useful in determining which aircraft are constrained and in quickly determining efficient ways to get those aircraft optimally positioned.

Pathfinder Selection

A straightforward use of surface position data by AOCs would be to support identification and location of a "pathfinder" for use in determining whether severe weather has dissipated along a specific route, so the route can be reopened. To accomplish this, a dispatcher must work with traffic flow managers to find a suitable flight, obtain pilot and ATC concurrence and plan a route for that aircraft, including an alternate in case the weather has not adequately cleared.

Using SMS, integrated with additional information such as the departure runway and assigned route, dispatchers could look at departure queues on an annotated ground map and determine the positions of candidate aircraft in the queues. This would improve decision making; at present, without the integrated information, the dispatcher and TFM may select a potential pathfinder that is well back in its departure queue, resulting in significant delays.

As an example, consider the scenario illustrated in figure 2. Thunderstorms west of JFK have closed off several departure fixes for over an hour. ATC wants to determine whether the BDR fix can be reopened and contacts airlines to determine whether there is a flight that could serve as a pathfinder. The map display shows flights identified by flight ID; SMS timeline data shows their departure fixes. The data in figure 1 indicate that UAL200 is in a position to be moved to the runway threshold by allowing it to pass UAL700 and DAL200. Using this information, the dispatcher can work with UAL200 to be sure that its flight crew is agreeable to serving as a pathfinder.

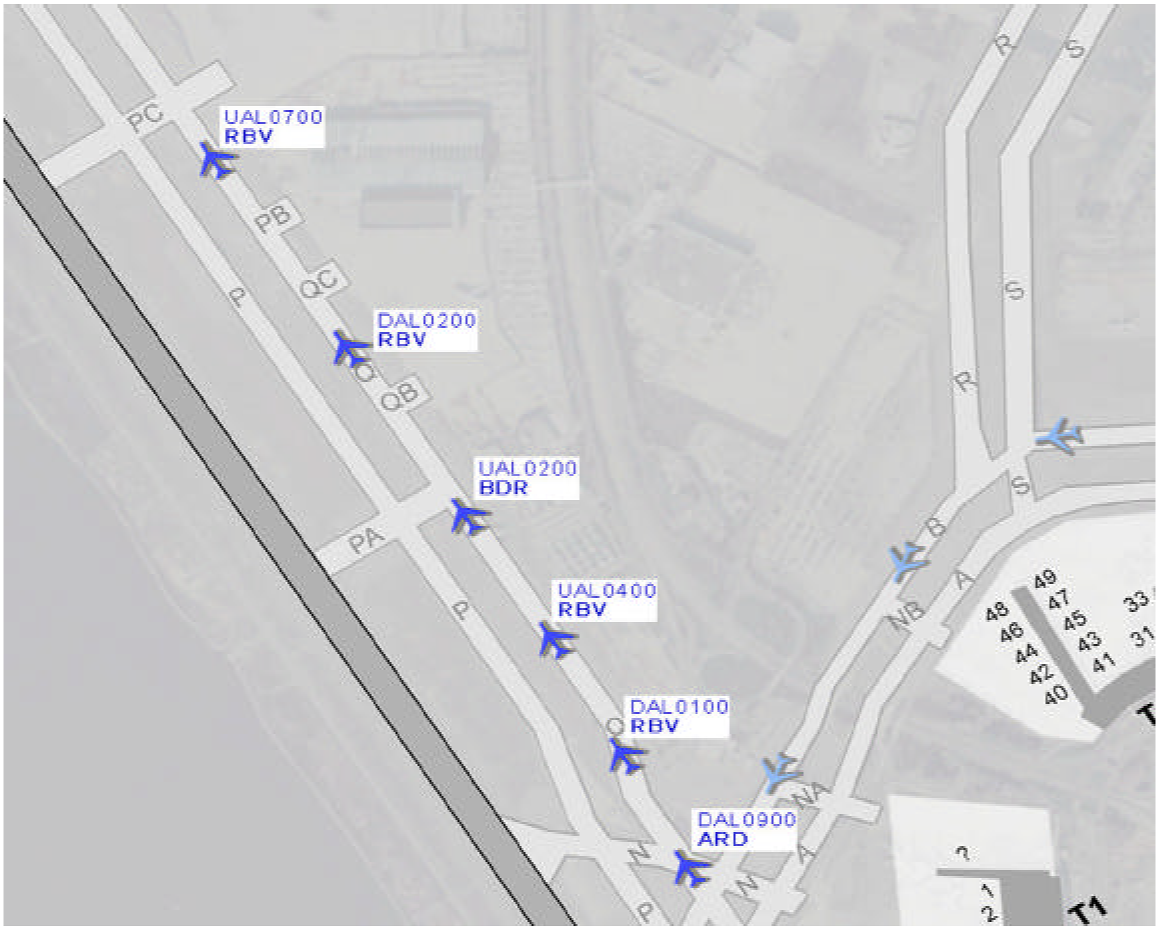

Figure 2. Locating a potential pathfinder.

Recommendations Based on Consideration of AOC Uses of SMS

As discussed above, the interviews with airline staff during Simulation 2 resulted in a number of recommendations:

1. Provide SMS with access to additional information sources (some from FAA sources and some from airline sources) –
    a. EDCTs
    b. ATCSCC advisories
    c. Holdover times
    d. Other airline priorities and constraints
    e. AOC-approved alternate departure runways, escape routes and departure altitudes (capping)
2. Use SMS as medium to provide an integrated access to airport information, to improve shared situation awareness and to reduce communication workloads by providing up-to-date information on:
    a. current departure queues and delays
    b. current arrival queues and delays
    c. changes in the utilization of departure fixes by ATC to deal with weather, traffic congestion, etc.
    d. the location of specific aircraft on the airport surface
3. Use SMS to predict future conditions –
    a. future departure queues and delays
    b. future arrival queues and delays
4. Use of SMS to guide the development of flight plans using alternative departure runways and routes.

References

Beatty, R., Smith, P.J. (2000): *Design Recommendations for an Integrated Approach to the Development, Dissemination and Use of Reroute Advisories.* Institute for Ergonomics Technical Report #2000-13. Columbus, Ohio: The Ohio State University.

Spencer, A., Smith, P.J., Billings, C.E. (2001): *Sample Scenarios Provided by an Airport Coordination Center at JFK.* Institute for Ergonomics Technical Report #2001-18. Columbus, Ohio: The Ohio State University.

Smith, P.J., Billings, C.E., Chapman, R., Obradovich, J., McCoy, E. and Orasanu, J. (2000): *Alternative "Rules of the Game" for the National Airspace System.* Stockholm, Sweden: Proceedings of the Fourth Conference on Naturalistic Decision Making.

Smith, P.J., McCoy, E., Billings, C. (2000) *Issues in the Use of Coded Departure Routes.* Institute for Ergonomics Technical Report #2000-12. Columbus, Ohio: The Ohio State University.