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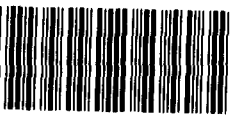

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AIRPORT SAFETY

New Radar That Will Help Prevent Accidents Is 4 Years Behind Schedule

Statement by
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Development Division

Before the
Subcommittee on Government Activities and
Transportation,
Committee on Government Operations
House of Representatives

Madam Chair and Members of the Subcommittee:

We welcome the opportunity to appear before you today to discuss ground safety at our nation's airports. Our testimony presents the results of our review of a new Federal Aviation Administration (FAA) ground radar called Airport Surface Detection Equipment, or ASDE-3. FAA plans to replace earlier models of ASDE currently operating at 13 airports with ASDE-3 to provide controllers at those and at 16 additional airports with a radar system that has longer range, higher reliability, and clearer displays of the airport surface.

Specifically, you asked us to address the delays associated with the installation of the ASDE-3 radar, the significance of problems uncovered during recent testing at Pittsburgh airport, and the status of FAA's plan for enhancing ground safety at our nation's airports.

In summary, we found that the schedule to deploy this new technology has slipped almost 4 years and could slip even further, a performance question about the radar's screen display has been raised, some airports with questionable ground safety records may not be considered for ASDE-3, and planning for FAA's umbrella effort to enhance airport ground safety is a good first step but funding levels and project priorities need to be established.

Our work is based on discussions with the ASDE-3 contractor, FAA officials in the ASDE-3 project office, and 83 air traffic controllers with ASDE radar experience and who work in the towers at Seattle, Los Angeles, San Francisco, Atlanta, and Dulles airports. We also reviewed the agency's overall plan for enhancing ground safety and observed testing of the ASDE-3 radar by the contractor at the Pittsburgh test site.

We will make four basic points:

-- First, recent concern over ground safety is well-founded, and air traffic controllers' ability to prevent runway accidents during periods of low visibility needs to be improved. This concern is not new, however. One of aviation's worst accidents occurred on a runway in March 1977 when two Boeing 747s collided at Tenerife Airport in the Canary Islands killing 583 passengers and crew. Further, if controllers had clear images of objects on the airport surface, accidents in Atlanta, Detroit, and Los Angeles may have been prevented, particularly at Detroit where a pilot became lost in the fog and ultimately collided with another aircraft.

-- Second, despite the need, ASDE-3 field implementation that was to begin in March 1988 has been delayed to December 1991--almost 4 years behind schedule--primarily because (1) developing software for the radar was much more complex and took longer than FAA and the contractor expected, (2) FAA required that changes be made to the radar's design before production, and (3) several performance problems have been discovered during testing. Moreover, where ASDE-3s will be installed is not certain because preparation of some sites may be delayed.

-- Third, because FAA is revising its criteria for determining which airports qualify for ASDE-3, the final number and location of ASDE-3s is still not known; there could be as many as 45. However, even after FAA revises the criteria, specific historical data describing airports' ground safety may not be part of the criteria for determining which airports qualify for ASDE-3.

-- Lastly, FAA's plan to enhance overall runway safety contains 44 projects and does not assign priorities to or estimate costs for projects still in development. Thus, funding and other resource decisions are difficult to make. Although ASDE-3 is part of the

plan, it is not affected by these problems because it is under a production contract. However, FAA could be risking timely completion of other projects that controllers say they need the most--such as better runway signs and improved lighting--by diluting its plan with projects that ultimately may not be funded to completion.

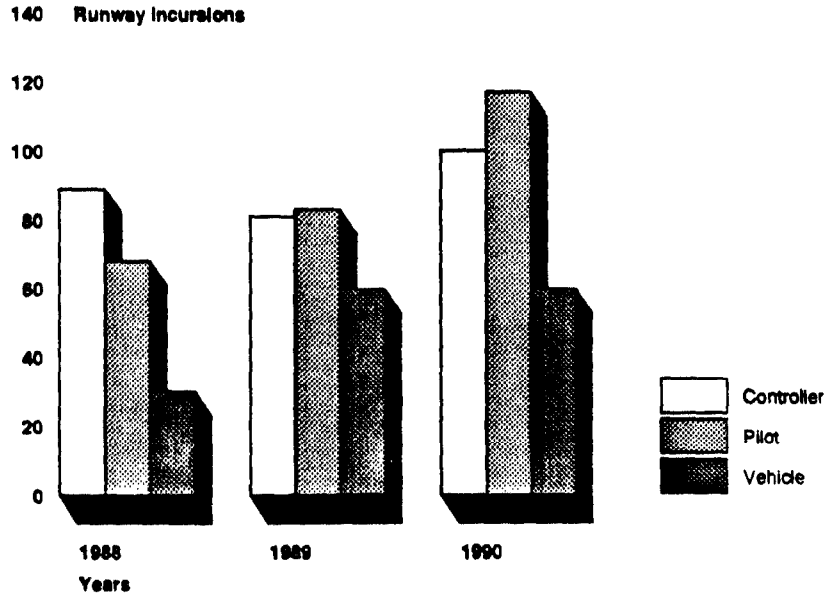
BACKGROUND

The purpose of ground radar surveillance is to prevent the catastrophe where two aircraft collide in a "runway incursion" during poor visibility, resulting in loss of life or injury. Technically, however, to be classified as a runway incursion, an incident does not have to involve a collision, only some combination of aircraft, vehicles, persons, or procedures that disrupts the smooth flow of air traffic on the airport surface. This definition covers a wide range of events and explains why most incursions do not result in injuries or even the contact of two vehicles. A pilot violating a flight procedure or oral communication from a controller, such as landing on the wrong runway--even though it is not in use--could be an incursion. Also, as we learned from the recent accident at the Los Angeles airport, the weather does not have to be inclement for accidents to happen. In fact, only 14 percent of all runway incursions occur during periods of rain, snow, fog, or other conditions when weather impairs tower controllers' ability to control traffic through visual contact.

To help prevent runway incursions, air traffic controllers at 13 U.S. airports make use of early model ASDE radars. The radar scans the airport's runways and displays the results of its search on a TV-like monitor in the air traffic control tower. Because most of the existing ASDEs are over 30 years old and are not meeting controllers' needs at many airports, FAA is procuring under a fixed-price contract with Norden Systems, Inc., the next

generation of ASDE. This equipment has been designed to provide clearer images, be more reliable, and cover a larger portion of the airport. It also will be installed at many more airports than its predecessor. Federal program costs for installing ASDE-3 at 29 airports total $131 million, of which $57 million has been paid to Norden thus far. Figure 1 shows that from 1988 through 1990, most incidents were the result of either controller or pilot error.

Figure 1: Causes of Runway Incursions (1988-1990)



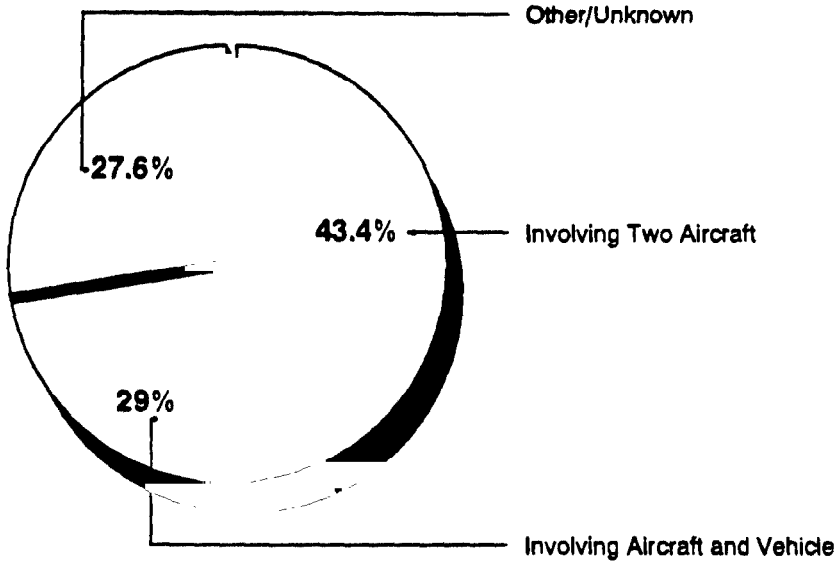
Source: GAO Analysis of FAA data

INCREASING NEED FOR AN IMPROVED GROUND RADAR

Most ground incursions do not result in the loss of life or an accident. And a relatively small percentage occur during periods of low visibility when an ASDE radar would be most useful. In fact, according to an FAA analysis, between 1970 and 1989 only 11 ground accidents occurred in the United States that could have been prevented if air traffic controllers had the benefits of an ASDE radar. These 11 do not include the recent accidents at Atlanta, Detroit, and Los Angeles. However, in the 11 accidents in FAA's analysis, 644 people were either killed or injured.

Moreover, many incursions carry the potential for this kind of tragedy. Figure 2 shows that almost half of all runway incursions from 1988 through 1990 involved two aircraft.

Figure 2: Runway Incursion by Type of Involvement (1988-1990)



Source: GAO analysis of FAA data

Compared to the 45,000 people who die annually on the nation's highways, many fewer people die in aviation accidents. Nevertheless, the threat that runway incursions pose has risen significantly over the last 3 years: incursions have increased from 187 in 1988 to 277 in 1990, or 48 percent. This increase could continue if the demand for air travel grows to over 737 million enplanements by the year 2002 as FAA forecasts. Therefore, improved ground surveillance of the airport surface is becoming more critical. As a result, the sooner an improved ground radar system becomes operational, the sooner the risk of accidents on the ground will be reduced.

While few of the controllers we spoke with have had the opportunity to see the new ASDE-3 operate or were familiar with the extent of its improvement over the ASDE-2, most expressed dissatisfaction with the ASDE-2. Many controllers find the ASDE-2's faint target display hard to interpret and momentarily confusing because the picture occasionally jumps about on the screen. They also find it to be of little use in light to moderate rain and almost useless in moderate to heavy rain, times when it should be of most value because that is when aircraft are the most difficult for controllers to see.

The reliability of existing models of ASDE also is a problem. Although most of the controllers we contacted believed that ASDE-2 would be operational when they needed it, FAA records show that the radar has had a spotty reliability record. In 1990, FAA's 12 existing models of ASDE suffered 23 outages lasting, on average, about 20 hours, ranging from 4 to 89 hours. Los Angeles operates a thirteenth ASDE that is a one-of-kind hybrid made by Texas Instruments. This model had a worse repair record in 1990 than the other 12; it alone suffered 19 outages lasting 1,769 hours, or about 74 days.

Because of performance and reliability problems, most controllers we spoke with do not use ASDE-2 as a primary means of locating aircraft on the runway during poor visibility. Instead, they use voice communications with pilots to locate the aircraft, and they verify this, if possible, by referring to the ASDE-2 monitor. And ineffective communication between pilots and controllers is the root cause of many ground incursions. On the other hand, during periods of better visibility or at night, controllers say that ASDE-2 still is useful to verify pilot-reported positions. Even though the radar's performance is limited, controllers frequently told us that it is better than nothing.

Despite ASDE-2's poor performance in low visibility, controllers told us of many instances where even this limited radar literally prevented serious accidents. In one instance, an aircraft made a wrong turn onto a runway where another aircraft was about to take-off. Noticing this on the ASDE-2 display, the controller delayed the takeoff until the errant aircraft exited. In another instance, an aircraft made a wrong turn and was holding for takeoff midway down a runway instead of at the end of it. Checking the ASDE-2 monitor, a controller noticed this mistake and redirected the pilot, preventing him from taxiing directly into the path of a departing aircraft. It is not surprising, therefore, that controllers are enthusiastic about the prospect of replacing their ASDE-2s with the more powerful and reliable ASDE-3s. In fact, some controllers told us that they viewed not having ASDE-3 as a safety risk at their airport. Thus, with the incursion rate rising and FAA forecasting increased air traffic, the need also has increased for a more reliable, all-weather ground radar to replace the ASDE-2 and to help prevent runway incursions.

ASDE-3'S 3-YEAR DEVELOPMENT SCHEDULE HAS TAKEN ALMOST 7 YEARS, AND MORE TIME COULD BE NEEDED

Acceptance by FAA of ASDE-3 at the first site was initially scheduled for March 1988 and at the last site for April 1990. These dates have slipped to December 1991 and October 1993, respectively. This nearly 4-year delay for first site acceptance occurred because (1) FAA and the contractor, Norden Systems, underestimated the complexity of developing the radar system's software, (2) FAA changed some of its requirements for the system, and (3) testing has uncovered some performance problems that required time to fix. In addition, further delays in airports' acceptance of ASDE-3s could occur because some airports are uncertain about where to place the ASDE-3 rotodome and are not prepared to accept the new radar.

Software Problems

One of the primary reasons for the 4-year delay for first site acceptance is that neither FAA nor Norden foresaw the time and effort needed to develop ASDE-3 software. This is a problem that has plagued other major systems in FAA's air traffic control modernization effort.[1] The heart of ASDE-3 is software that allows a controller to clearly and easily scan runways on a 17-inch display under all weather conditions. To provide this, Norden initially estimated that 37,000 lines of computer code would be needed. But this eventually tripled to over 93,000 lines. Under ideal conditions, a skilled programmer can write four to five lines of completely tested and documented code a day. Norden officials admit they underestimated the complexity of developing the ASDE-3 software, but after realizing this they could not hire additional programmers fast enough to avoid delaying the system's development schedule. Although most of the initial software problems have been solved now, the contractor attributes about one-third of the 4-year delay to this single miscalculation.

Changing Requirements

A second cause of ASDE-3 delays has been changing FAA requirements. For example, FAA decided in 1986 that ASDE-3 would not be placed on existing ASDE-2 pedestals because of the radar's sensitivity and the shape of the new radar's rotodome. If not properly attached to the tower, the ASDE-3 could be buffeted by strong winds because of its teacup shape and the radar's accuracy would suffer. To accommodate this change, Norden conducted research on tower cab movement in high winds and designed a new pedestal. FAA also required in 1986 that the new pedestal be made of steel instead of aluminum as originally planned. This raised

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[1] Air Traffic Control: Status of FAA's Modernization Effort (GAO/RCED-91-132FS, Apr. 15, 1991).

the radar's total weight from 3,330 pounds to 5,000 pounds and made it too heavy to be installed on some control towers. The time needed to redesign the pedestal also delayed the program for about a year and raised program costs by $310,000. An additional 4-month delay occurred when FAA required that Norden develop a menu-driven display that controllers could operate with a key pad more compact than the standard PC keyboard. While this simplified the system, it also added to the software problem and schedule delay and raised the cost by $277,000.

Testing Uncovers Significant Problems

Initial field testing at Pittsburgh has verified many aspects of the ASDE-3 technology, but it also has uncovered two problems that caused schedule delays: (1) delamination of the antenna and (2) split target--the more significant of the two because no solution has been proposed and any solution will take considerable time to design and implement.

The antenna reflector, which captures the returning radar energy, is composed of layers of fiberglass and honeycombed aluminum. Stress from revolving at 60 revolutions per minute and the extreme heat of the de-icer caused the reflector to blister, which eventually would impair the radar's performance. Norden has developed a new design and bonding process so that the antenna will withstand heat and stress and plans to complete testing this July. Solving the delamination problem has delayed system development by 19 months.

A more serious problem, especially for air traffic controllers, is the split target. This only occurs when a target, which is already on the radar display, is enhanced with the ASDE-3 "zoom" feature. The screen image of single targets--particularly aircraft with long fuselages--breaks into two or more targets, presenting a potentially confusing picture to controllers. Because

the ASDE-2 radar does not have the zoom feature, it also does not display split targets.

Testing of ASDE-3 by the contractor indicates that the split-image occurs, in part, because the radar produces such a high definition display. A Department of Transportation research report on the ASDE-3 engineering model mentioned this phenomenon as long ago as 1981[2]. The report noted that analysis of radar data printed on paper as aircraft images showed that the incidence of split targets was reduced from 43 percent with the old technology to 29 percent with the ASDE-3 technology. (Target separation could not be seen on the radar screen display because the zoom feature had not been developed.) Therefore, although the radar community has known about split targets as a radar phenomenon for years, this problem was not seen visually by a commercial airport surveillance radar until Norden's ASDE-3 was tested at the Pittsburgh airport.

Currently, FAA and Norden cannot agree on how long it will take to fix this problem or how much it will cost. According to Norden, a solution to the split target could be 2 years away, although FAA officials estimate as long as 4 years. If further testing in September confirms that the split target is a natural occurring phenomena and is not the result of a software or hardware defect inherent in Norden's design, Norden believes that FAA should bear the estimated $500,000 to $1.5 million cost to fix it because it would not have been Norden's fault. To date, however, Norden and FAA have not resolved who will pay to fix this problem or what the fix will be.

FAA is planning to install ASDE-3 with the split-target problem, but this will limit the system's potential for reducing

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[2]Detection Performance Evaluation of the ASDE-3 Using Fixed Frequency and Frequency-Agile Operation. U.S. Department of Transportation, Transportation Systems Center, Mar. 1981. (FAA-RD-81-41).

runway incursions. For example, controllers will be prevented from using the zoom feature. Even without the zoom feature, according to FAA and our own observations, the target detection and display clarity of ASDE-3 will be a significant improvement over existing systems because of its performance during heavy rain and fog.

Further Delays Due to Siting Uncertainty

Some airports may not be ready to accept the new radar. For example, Los Angeles is scheduled to receive ASDE-3 in July 1992, but FAA officials told us that the airport may not be ready to accommodate the two radars needed to have full airport coverage. Although the location of one radar is certain, the airport has not held planned hearings to discuss the environmental impact and aesthetics of the tower to support the second.

FAA officials also expect problems at La Guardia, Newark, and National airports because ASDE-3 implementation is scheduled at the same time other major construction will be underway. FAA is currently assessing other near-term ASDE-3 sites to determine if they will be ready to receive the new radar; results are expected later in July. FAA officials told us that if an airport is not ready to receive ASDE-3, the next airport in line will receive the system. This presumes that the next airport has made adequate preparations to install the radar. Table 1 shows the planned implementation of ASDE-3.

Table 1: ASDE-3 Installation Schedule

Airport	Acceptance date	Airport	Acceptance date
FAA Tech Center	07-15-91	Wash. - Andrews	12-31-92
FAA Academy	08-15-91	Miami	01-31-93
Pittsburgh	12-31-91	New York - La Guardia	01-31-93
San Francisco	03-15-92	St Louis	02-28-93
Dallas	06-30-92	Houston	02-28-93
Philadelphia	06-30-92	Wash. - National	03-31-93
Los Angeles	07-31-92	Memphis	03-31-93
Detroit	07-31-92	Minneapolis	04-30-93
Atlanta	08-31-92	Chicago	04-30-93
Boston	09-30-92	Tampa	05-31-93
Newark	09-30-92	Baltimore	05-31-93
New York - JFK	10-31-92	New Orleans	06-30-93
Cleveland	10-31-92	Kansas City	06-30-93
Portland	11-30-92	Anchorage	07-31-93
Seattle	11-30-92	Denver	07-31-93
Wash. - Dulles	12-31-92		

NEW CRITERIA FOR LOCATING ASDE-3s DO NOT CONSIDER HISTORICAL INCURSION RATES

In 1975, FAA based its first criteria for locating ASDE-3 primarily on the number of takeoffs and landings at airports and the incidence of poor weather that could hinder airport operations. More recently, however, FAA has been developing a more sophisticated cost-benefit approach that relies on, among other things, airport-specific weather forecasts, an evaluation of ASDE-preventable accidents worldwide, and passenger time savings from enhanced efficiency. The approach uses an economic analysis of the costs and benefits of installing the radar at specific airports and compares the present value of ASDE benefits at an airport with the present value of costs over a 20-year period. An airport is eligible for an ASDE-3 when the benefits of an ASDE-3 exceed installation and operating costs. Benefits include preventing accidents and reducing flight times; costs include operating and investment costs for installing and maintaining ASDE-3. FAA plans

to begin implementing this approach to selecting airports for ASDE-3 installation in September 1991.

On the basis of current and future aviation activity, preliminary FAA use of the new approach suggests that as many as 45 airports--including the 29 airports currently scheduled to receive the new radar--would qualify for ASDE-3. A problem we see with FAA's new approach, however, is that it does not take into account historical information on runway incursions for each airport. For example as shown in table 2, airports that have experienced a significant number of runway incursions, such as Cincinnati or Boeing Field in Seattle, are not yet qualified for an ASDE-3. FAA officials told us that they would consider building these data into their approach.

Table 2: U.S. Airports with the Highest Number of Runway Incursions During 1988-1991

Airport	Number of Incursions	ASDE-3 Planned?
Boston	18	Yes
JFK	14	Yes
Cincinnati	13	No
Denver	13	Yes
Atlanta	12	Yes
Boeing Field	11	No
Los Angeles	11	Yes
Phoenix	11	No
Dallas	10	Yes
San Antonio	10	No
Merrill Field	10	No

RUNWAY INCURSION PLAN HAS NOT SET PRIORITIES AND ITS COST IS UNKNOWN

To develop a more centralized approach to accomplishing numerous initiatives that address the runway incursion problem, FAA issued in January 1991 its Runway Incursion Plan. With it, FAA

has taken action to coordinate within the agency and with industry/user groups 44 projects--many of which are still in research and development--aimed at mitigating runway incursions. However, FAA has yet to assign priorities to projects or estimate the cost of its plan. Until FAA does so, FAA and the Congress will not have the information necessary to evaluate the cost and benefits of the plan and to fund only those projects that will most enhance airport safety, especially at those airports that do not qualify for an ASDE-3.

One problem with not having priorities assigned to projects is that the most urgent projects may not get the attention they deserve. And according to controllers we talked with, some projects are indeed more urgent than others. For example, in addition to ASDE-3, controllers suggested that projects to standardize runway signs/markings and improve lighting deserve high priority and immediate action. However, the 11 projects in the plan that cover signs and lighting have no more commitment to funding than the plan's other 33 projects. Although FAA maintains that the plan dedicates resources to complete each project, we found no evidence, such as out-year budget estimates or long-range planning documents, to show FAA's commitment to adequately funding the projects for fiscal year 1992 and beyond.

In addition, funding for many projects, including those for signs and lighting, depends on development grants from FAA's Airport Improvement Program, but FAA has not estimated how much grant money will be needed and has no plans to include these estimates in future updates of the Runway Incursion Plan. These estimates will be important for planning purposes because costs to reduce runway incursions at individual airports could be significant. For example, according to one FAA official, at Boston Logan International Airport it will cost approximately $50 million to complete those projects deemed necessary to reduce runway incursions. Costs, however, may be less at other airports.

Unless costs and relative priorities for all of the projects in the Runway Incursion Plan are determined at the outset, the potential exists that less worthy projects will be partially funded for a while at the expense of more critical projects. As we reported in June 1990, a similar problem occurred with an FAA plan entitled, Flight Plan for Training, in which 31 of 47 projects were behind schedule because of insufficient funding and lack of priorities. Although FAA agreed to revise that training plan, revisions have not been made and delays and cost overruns are likely to continue. Therefore, we believe FAA should identify these costs and priorities in its Runway Incursion Plan to ensure that sufficient funding exists to complete the best projects in a timely manner.

Another danger of incomplete planning is that many projects with limited benefits could be masking the importance of a few significant projects and diluting the available funds. For example, although FAA's Runway Incursion Plan mentions the concept of a "low-cost ASDE" with less range and fewer display features, we found that little work has been done to date and that no specification for this concept has been developed. Developing this concept so that the acquisition price would be perhaps one-third to one-half the cost of an ASDE-3 could benefit smaller and less active airports where, according to FAA, the benefits of ASDE-3 currently do not outweigh the costs.

CONCLUSIONS AND RECOMMENDATIONS

With a more effective ground radar, controllers can help prevent tragedies at our nation's airports. However, early problems in developing software for the ASDE-3 and later performance problems discovered during testing have caused delays in the radar's installation schedule. For example, early testing has revealed a split-target problem when the radar display operates

in the zoom mode. However, if further testing scheduled for September 1991 demonstrates satisfactory performance and reliability and no other safety concerns emerge, we believe that the new radar's potential safety benefits would help justify an FAA decision to install it without the use of the zoom feature while at the same time exploring solutions to the split target problem.

In addition, some airports also could be more prone to ground incursions regardless of their overall activity or weather. Therefore, by factoring each airport's historical runway incursion experience into FAA's approach for locating ASDE-3s, more assurance would exist that a particularly troublesome airport is given adequate consideration.

Although the Runway Incursion Plan is a positive step, FAA still needs to make improvements to the plan. Our discussions with controllers and other work we have done indicates that projects such as improved signage and a low-cost ground radar deserve increased attention. Establishing priorities and setting funding levels would strengthen the plan.

Accordingly, we recommend that the Secretary of Transportation direct the FAA Administrator to

-- factor into FAA's approach for locating ASDE-3s the experience of airports' regarding the incidence of runway incursions, including the severity of the incursions, and

-- establish priorities and set funding levels for the 44 projects in the agency's overall Runway Incursion Plan.

Madam Chair, this concludes our statement. We would be pleased to respond to questions at this time.

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