United States Government Accountability Office

GAO

Report to Congressional Requesters

November 2007

AVIATION RUNWAY AND RAMP SAFETY

Sustained Efforts to Address Leadership, Technology, and Other Challenges Needed to Reduce Accidents and Incidents

GAO-08-29

November 2007

AVIATION RUNWAY AND RAMP SAFETY

Sustained Efforts to Address Leadership, Technology, and Other Challenges Needed to Reduce Accidents and Incidents

GAO Accountability · Integrity · Reliability

Highlights

Highlights of GAO-08-29, a report to congressional requesters

Why GAO Did This Study

While aviation accidents in the United States are relatively infrequent, recent incidents have heightened concerns about safety on airport runways and ramps. As the nation's aviation system becomes more crowded every day, increased congestion at airports may exacerbate ground safety concerns. To safely handle the anticipated larger volumes of air traffic, the Federal Aviation Administration (FAA) is implementing the Next Generation Air Transportation System (NextGen) to better manage air traffic both in the air and on the ground. GAO was asked to evaluate (1) the progress being made in addressing runway safety and what additional measures, if any, could be taken and (2) the factors affecting progress in improving ramp safety and what is being done by FAA and others to address those factors. We reviewed runway and ramp safety data, interviewed agency officials and industry stakeholders, and surveyed experts.

What GAO Recommends

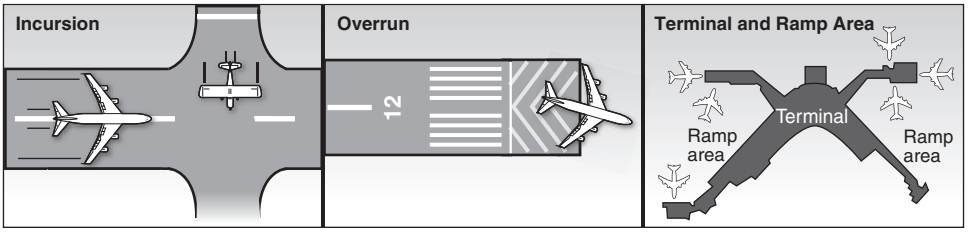
GAO recommends that FAA take several measures to enhance runway and ramp safety, such as updating its national runway safety plan, collecting data on runway overruns, and working with OSHA and industry to collect and analyze better information on ramp accidents. DOT agreed to consider the report's recommendations.

To view the full product, including the scope and methodology, click on GAO-08-29. For more information, contact Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov.

What GAO Found

FAA and aviation stakeholders have taken steps to address runway and ramp safety, including deploying and testing technology designed to prevent runway incursions, which occur when aircraft enter the runway without authorization, and overruns, which occur when aircraft run off the ends of runways; helping to change airport layout, markings, signage, and lighting; and providing training for pilots and air traffic controllers. In addition, FAA has made progress in addressing runway overruns and reports that 70 percent of the runways at U.S. commercial airports substantially comply with runway safety area standards, up from 55 percent in 2000. However, the rate of runway incursions has not decreased over the last 5 years. In addition, FAA has not prepared a national runway safety plan since 2002, despite agency policy that it be updated every 2 to 3 years, resulting in uncoordinated efforts within the agency. Runway safety technology currently being installed is experiencing some operational difficulties with its alerting function, while additional technology to prevent runway collisions is years away from deployment. FAA also lacks data on runway overruns that could be used to analyze the causes and circumstances of such incidents. Air traffic controller fatigue, which may result from regularly working overtime, continues to be a matter of concern for the National Transportation Safety Board (NTSB), which investigates transportation accidents, and other aviation stakeholders.

Efforts to improve safety in airport ramp areas, where departing and arriving aircraft are serviced by baggage, catering, and fueling personnel, are hindered by a lack of complete accident data and standards for ground handling, but the aviation industry is taking steps to address these problems with the goal of reducing ramp accidents. Data from 2001 through 2006 from the Occupational Safety and Health Administration (OSHA), which investigates occupational accidents, NTSB, and FAA indicated that these agencies had investigated 29 fatal ramp accidents during that time. The majority of the fatalities in these accidents were ramp workers. GAO found no comprehensive nonfatal injury data on ramp accidents and neither federal nor industrywide standards for ramp operations. The federal government has generally taken an indirect role overseeing ramp safety; airlines and airports typically control the ramp areas using their own policies and procedures. Meanwhile, some airlines and airports have initiated their own efforts to address ramp safety, and aviation organizations have begun collecting ramp accident data.



Source: Lincoln Laboratory, Massachusetts Institute of Technology, and GAO.

Contents

Tables

Figures

Abbreviations

ADS-B	Automatic Dependent Surveillance-Broadcast
AMASS	Airport Movement Area Safety System
ASDE-3	Airport Surface Detection Equipment, Model 3
ASDE-X	Airport Surface Detection Equipment, Model X
CAST	Commercial Aviation Safety Team
EMAS	Engineered Materials Arresting System
DOT	Department of Transportation
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
JPDO	Joint Planning and Development Office
NextGen	Next Generation Air Transportation System
NTSB	National Transportation Safety Board
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
OSH Act	Occupational Safety and Health Act

GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

November 20, 2007

The Honorable Jerry F. Costello
Chairman
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Frank R. Lautenberg
United States Senate

While aviation accidents in the United States are relatively infrequent, recent incidents have heightened concerns about safety on airport runways and ramps.[1] On August 16, 2007, for example, at Los Angeles International Airport—one of the nation's busiest airports—two commercial aircraft carrying 296 people came within 37 feet of colliding, resulting in an incident called a runway incursion. In another example, in 2005, an aircraft departing from Seattle-Tacoma International Airport, carrying 142 people, experienced sudden cabin depressurization caused by a ramp vehicle having punctured the aircraft fuselage while on the ramp. As the nation's aviation system becomes more crowded every day, increased congestion at airports may exacerbate ground safety concerns. To safely handle the anticipated larger volumes of air traffic, the Federal Aviation Administration (FAA) is implementing the Next Generation Air Transportation System (NextGen) to better manage air traffic both in the air and on the ground. At airports, FAA focuses its safety oversight on the movement areas—runways and taxiways[2]—where the chances of catastrophic accidents are greater than other areas. By contrast, safety oversight of operations in the ramp areas of airports is handled primarily by airlines and airports.

To respond to your request, our objective was to determine how well FAA and others are addressing runway and ramp safety issues. To accomplish this, we focused on the following questions: (1) What progress is being made in addressing runway safety, and what additional measures, if any,

[1]Ramps are areas of airports where aircraft are readied for arrival and departure.

[2]Taxiways are routes that aircraft follow to and from runways.

could be taken? and (2) What factors affect progress in improving ramp safety and what is being done by FAA and others to address those factors?

To answer these questions, we reviewed data on runway and ramp safety incidents and accidents from FAA, the National Transportation Safety Board (NTSB), and the Department of Labor's Occupational Safety and Health Administration (OSHA) and Bureau of Labor Statistics; relevant laws, regulations, and agency policies; and federal government and aviation industry efforts to address runway and ramp safety, including the development of new technology. We also looked at how taxiways affect runway safety. In addition, we interviewed FAA, NTSB, OSHA, airport, and aviation trade organization officials reflecting various segments of the industry, as well as pilots, air traffic controllers, and ramp workers and their union representatives. We also surveyed experts[3] on the causes of runway and ramp incidents and accidents, the effectiveness of measures that are being taken to address them, and what additional measures could be taken. A majority of the experts was selected with the assistance of the National Academy of Sciences, and we identified additional experts during our review. The individuals were selected on the basis of their expertise in areas such as technology and procedures used to address runway incursions, overruns, and ramp accidents; international aviation safety practices; human factors issues; general aviation; airports; and ground operations. We report the survey results in terms of actions that are most effective or future actions that have the greatest potential. Through our analyses, the actions that we report as being most effective or having the greatest potential were ones that a majority of respondents indicated were very or extremely effective for the effectiveness questions or great or very great potential for the questions asking about potential. Because we asked the experts to answer questions only within their areas of expertise, a different number of responses were received for various survey questions. Based on interviews with officials knowledgeable about the data contained in this report, we determined that runway and ramp safety data were sufficiently reliable for the types of analyses that we performed for this report such as trends in runway incursions, the incidence of fatalities in airport ramp areas, and frequency of air traffic controller overtime. We conducted our work in Atlanta, GA; Atlantic City, NJ; Boston, MA; Burbank, Long Beach, Los Angeles, and San Diego, CA; Newark, NJ; Seattle and Spokane, WA; and Washington, D.C. These locations included

[3]The survey consisted of two phases. Twenty-five experts responded to the first phase survey and 22 responded to the second phase survey.

airports that have experienced higher rates of runway incursions or where new aviation safety technology was being researched or tested. We conducted our work from October 2006 through November 2007 in accordance with generally accepted government auditing standards. Appendix I contains additional information about our methods. Detailed information about our survey methodology and the survey questions are contained in appendix II.

Results in Brief

FAA and other aviation stakeholders have taken steps to address runway and ramp safety, but the lack of coordination and leadership, technology challenges, the lack of data, and human factors-related issues impede further progress. Our analysis showed that FAA had completed or was in the process of implementing 34 of the 39 initiatives contained in its 2002 national runway safety plan; 4 initiatives were canceled and 1 pertaining to deploying certain technology was not met. The completed initiatives included deploying and testing other technology designed to prevent runway collisions and overruns; helping change airport layout, markings, signage, and lighting; and providing training for pilots and air traffic controllers. Of the measures that FAA is taking to address runway incursions, the results of our survey of experts indicated that the most effective actions were lower-cost ones, such as enhancing airport markings, lighting, and signage. In addition, FAA has made progress in addressing runway overruns and reported in May 2007 that 70 percent of the runways at U.S. commercial airports substantially comply with runway safety area standards, up from 55 percent in 2000. Runway safety areas reduce the chance of aircraft being damaged from overruns. While the number and rate of incursions declined after reaching a peak in fiscal year 2001 and remained relatively constant for the next 5 years, preliminary data for fiscal year 2007 indicate that the overall incursion rate increased during fiscal year 2007 and is nearly as high as the fiscal year 2001 peak. FAA's Office of Runway Safety has also not carried out its leadership role in recent years. The office's role is to lead the agency's runway safety efforts by coordinating and monitoring runway safety activities to ensure that goals are met. Those goals were established in 2002 in a national runway safety plan. However, FAA has not updated the plan, despite agency policy that such a plan be prepared every 2 to 3 years. The lack of an updated plan has resulted in uncoordinated runway safety efforts by individual FAA offices. Moreover, runway safety technology currently being installed, the Airport Surface Detection Equipment, Model X (ASDE-X), which is designed to provide air traffic controllers with the position and identification of aircraft and alerts of potential collisions, has faced cost increases and schedule delays from its original baselines and is

experiencing operational difficulties with its alerting function. At the same time, additional technology to prevent runway collisions is years away from deployment. FAA also lacks reliable runway safety data and the mechanisms to ensure that the data are complete. Furthermore, air traffic controller fatigue, which may result from regularly working overtime, continues to be a matter of concern for NTSB, which investigates transportation accidents, and other aviation stakeholders. We found that, as of May 2007, at least 20 percent of the controllers at 25 air traffic control facilities, including towers at several of the country's busiest airports, were regularly working 6-day weeks. FAA could take additional measures to improve runway safety. These measures include starting a nonpunitive, confidential, voluntary program for air traffic controllers to report safety risks in the national airspace system, which includes runways and taxiways, similar to a program that FAA has already established for pilots and others in the aviation community, and could help the agency to understand the causes and circumstances regarding runway safety incidents. The results of our survey of experts indicated that the action FAA could take with the greatest potential for preventing runway incursions was encouraging the use of lighting systems that guide aircraft on their airport taxi routes. The results of our survey of experts also indicated that the actions with the greatest potential that FAA could take to prevent runway overruns included addressing the causes and circumstances of overruns, such as improving communication of runway conditions and weather information to flight crews, and encouraging improvements in and use of runway condition and friction measurements, which provide data regarding the slickness of a runway.

Efforts to improve airport ramp safety are hindered by a lack of complete accident data and standards for ground handling. Such data could help FAA and the aviation industry to understand the nature and extent of the problem, as a first step to identifying what actions are needed to reduce ramp accidents. We found no complete source of data on ramp accidents, but reviewed ramp fatality data from 2001 through 2006 from FAA, OSHA, and NTSB, and found that these agencies had investigated 29 fatal ramp accidents during that time. The majority of the fatalities in these accidents were ramp workers. We found no complete nonfatal injury data on ramp accidents. In addition, we found no federal or industrywide standards for ramp operations. The federal government has generally taken an indirect role in overseeing ramp safety; airlines and airports typically control the ramp areas using their own policies and procedures. Meanwhile, some airlines and airports have initiated their own efforts to address ramp safety, and aviation organizations have begun collecting ramp accident data. We asked experts to provide their views on those industry efforts,

and they indicated that the most effective ones were being taken mainly by airlines, for example, by setting safety targets and using ramp towers. In addition, an international aviation association plans next year to start a safety audit program of companies with employees who work in airport ramp areas, which would be a step toward applying standardized criteria to these companies. Officials from a union representing ramp workers said that FAA should increase its safety oversight of ramp areas, while other aviation industry officials said that FAA's resources are more appropriately focused on the runways and taxiways, where there are greater safety risks to passengers. The results of our survey of experts indicated that the action FAA, OSHA, airport, or airlines could take with the greatest potential for preventing ramp accidents was promoting a safety culture in the ramp area.

We are recommending that FAA take several measures to enhance runway and ramp safety, which include preparing a new national runway safety plan, improving data collection on runway overruns and ramp accidents, and addressing air traffic controller overtime and fatigue issues that may affect runway safety. We provided the Department of Transportation (DOT) and the Department of Labor with drafts of this report for their review and comment. DOT agreed to consider the report's recommendations and provided technical corrections and clarifications, which we incorporated as appropriate. The Department of Labor had no comments but provided a technical correction, which we incorporated.

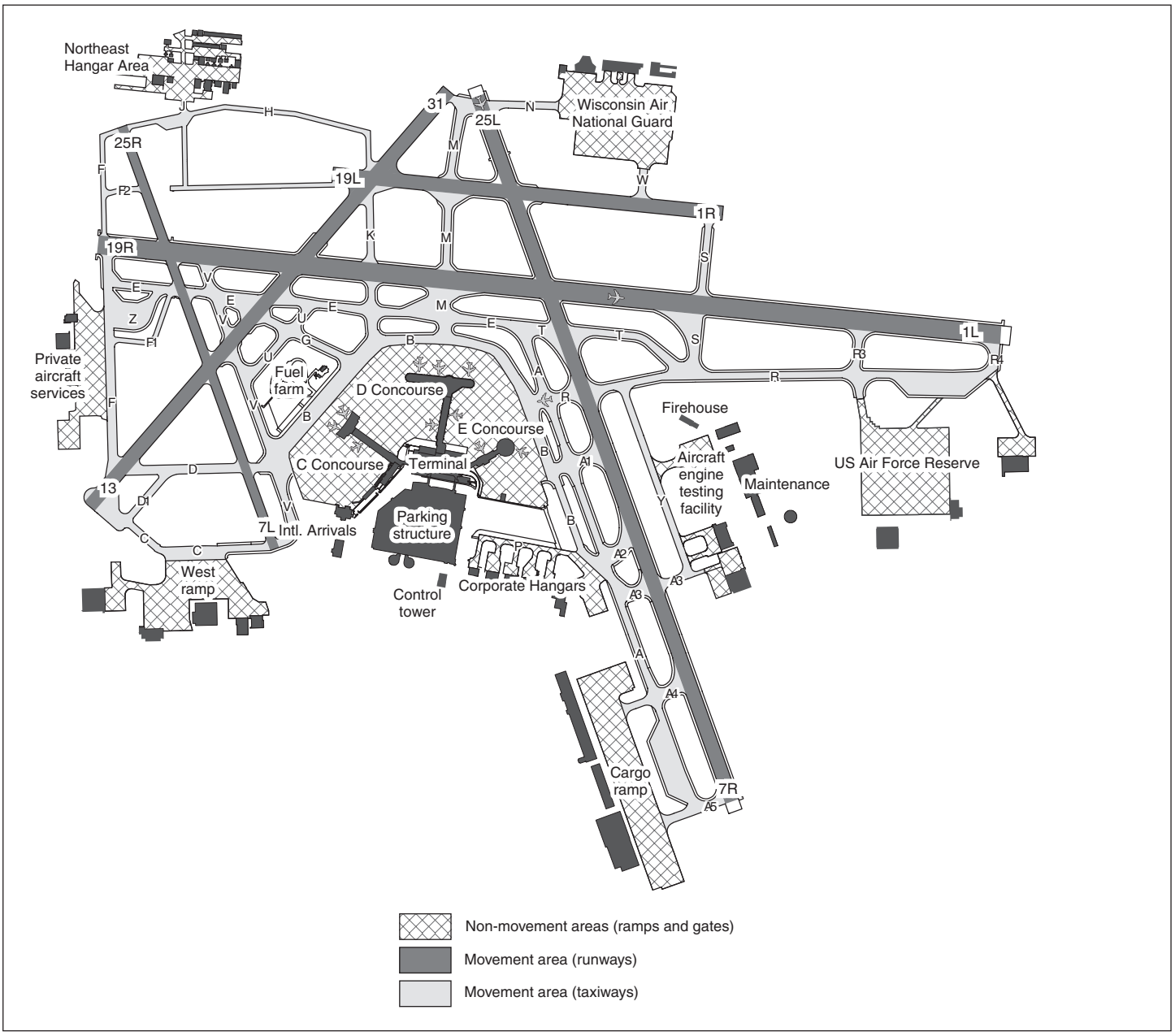
Background

Demand for air travel has increased in recent years, with over 740 million passengers flying in the United States in fiscal year 2006, and is expected to climb to an estimated 1 billion passengers per year by 2015. To meet this demand, the Joint Planning and Development Office (JPDO), housed within FAA and created to plan and coordinate the transition to NextGen, has developed a strategy to establish the needed national airspace system infrastructure, including airports. JPDO's objectives include providing air traffic control and airport authorities with greater flexibility to match capacity with demand, reducing congestion, and establishing a comprehensive safety management approach. Implementing the plan will include deploying Automatic Dependent Surveillance-Broadcast (ADS-B), a satellite-based technology that broadcasts aircraft identification, position and speed with once-per-second updates, which will provide pilots with greater situational awareness and help to keep aircraft at safe distances from each other on the runways.

Safety at airports in the United States is a shared responsibility among FAA, airlines, and airports. FAA air traffic controllers oversee activity in the movement areas—runways and taxiways—but airlines and airports provide primary safety oversight in the nonmovement areas—ramps and gates.[4] Figure 1 shows the movement and nonmovement areas of the General Mitchell International Airport in Milwaukee, WI.

[4]Ramp towers, staffed by airline, airport, or contractor personnel, are used to control the ramps at some airports.

Figure 1: Movement and Nonmovement Areas of the General Mitchell International Airport in Milwaukee, WI



Source: General Mitchell International Airport and GAO.

Runway safety is a major aviation safety concern that involves measures to prevent runway incursions and overruns. Through September 2007, FAA defined a runway incursion as "any occurrence in the runway environment involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation when an aircraft is taking off, intending to take off, landing, or intending to land." On October 1, 2007, FAA began using a definition of a runway incursion developed by the International Civil Aviation Organization (ICAO), a United Nations specialized agency.[5] ICAO's definition of an incursion is any occurrence at an airport involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing or take-off of aircraft. Runway incursion prevention has been on NTSB's list of most wanted transportation improvements since 1990 because runway collisions can have serious consequences. Six runway collisions have occurred in the United States since 1990, resulting in 63 deaths. The worst runway accident in the United States occurred at the Los Angeles International Airport in 1991, when an aircraft that was landing collided with another that was holding on the same runway, killing 34 people. The most recent fatal runway collision in the United States occurred in 2000, when two general aviation aircraft collided on the runway at the Sarasota Bradenton International Airport in Florida, resulting in 4 fatalities.[6] Other runway incidents, which FAA did not classify as incursions, also can have serious consequences. On August 27, 2006, for example, a Comair regional jet crashed in Lexington, KY, after taking off from a wrong runway that was too short for the aircraft, killing all but one of the 50 people onboard.[7]

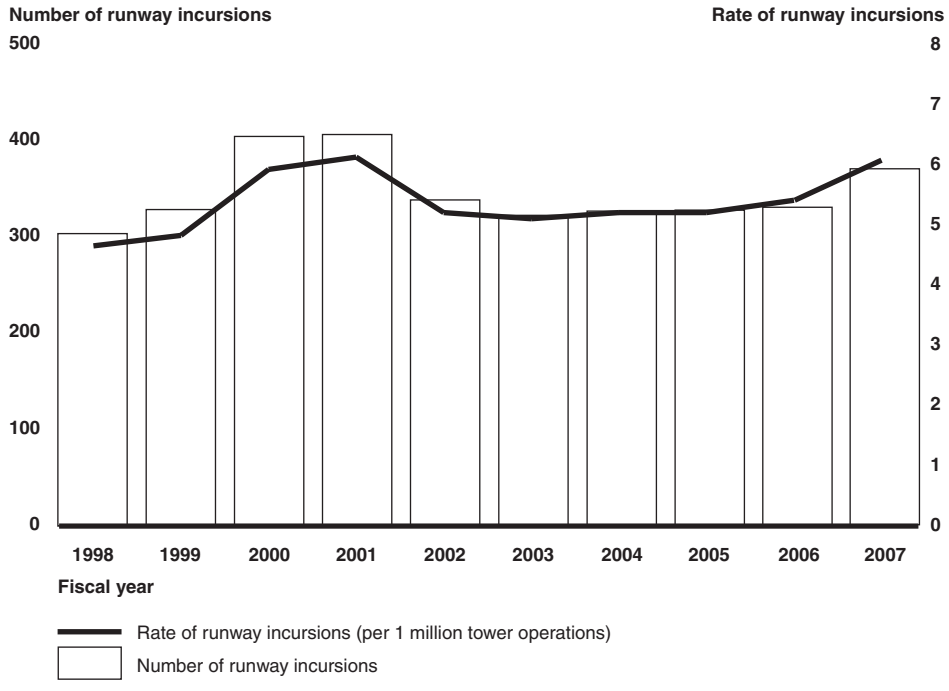
[5]Among other things, ICAO develops standards and recommended practices, procedures, and guidance material related to all aspects of civil aviation, including safety and security.

[6]The worst accident in aviation history occurred in 1977 when a KLM Boeing 747 collided with a Pan Am Boeing 747 on a runway in Tenerife, the Canary Islands, killing 583 passengers and crew. The Spanish government, which investigated the accident, determined that the accident was caused by a miscommunication between the KLM pilot and the control tower that take-off clearance had been provided, as well as several other factors.

[7]FAA classified this accident as a surface incident, which it had defined as any event where unauthorized or unapproved movement occurs within a movement area associated with the operation of an aircraft that affects or could affect the safety of flight. After adopting ICAO's definition of a runway incursion, FAA began classifying some incidents formerly classified as surface incidents as incursions.

The number and rate of runway incursions rose in the 1990s before peaking in fiscal year 2001 (see fig. 2). In fiscal year 2001, there were 407 incursions at a rate of 6.1 incursions per 1 million air traffic control tower operations, compared to fiscal year 2006, when there were 330 incursions at a rate of 5.4 incursions per 1 million tower operations. As shown in fig. 2, the rate of incursions remained relatively constant from fiscal year 2002 through fiscal year 2006, at an average rate of 5.2 incursions per 1 million tower operations. However, preliminary FAA data indicate 370 incursions occurred during fiscal year 2007, representing a rate of 6.05 incursions per 1 million air traffic control tower operations. The preliminary rate of incursions for fiscal year 2007 is about 12 percent higher than during fiscal year 2006 and is nearly as high as when the rate of incursions reached a peak in fiscal year 2001.

Figure 2: Number and Rate of Runway Incursions from Fiscal Year 1998 through Fiscal Year 2007



Source: FAA.

Note: Fiscal year 2007 data are preliminary.

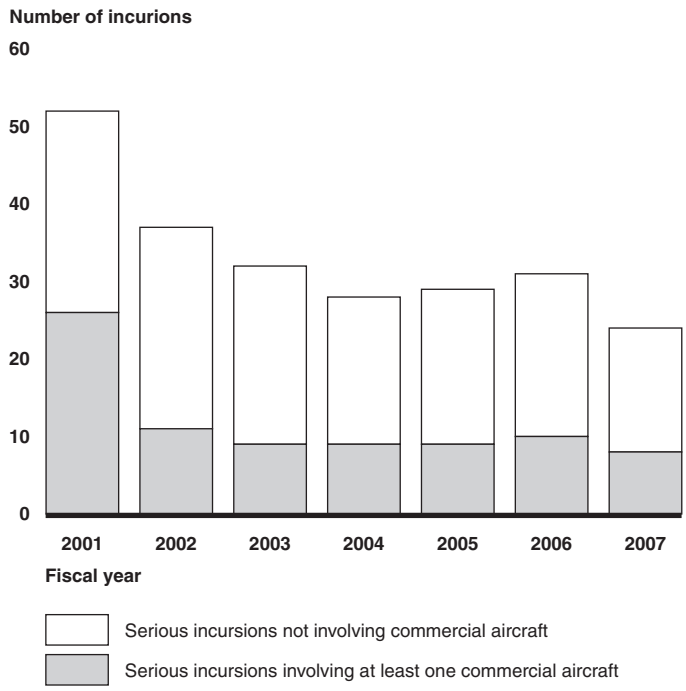
Since 2001, FAA has classified the severity of runway incursions into four categories—A through D.[8] The number and rates of serious incursions—categories A and B, where collisions were narrowly or barely avoided—have continued to occur at about the same level from fiscal year 2002 through fiscal year 2006 at an average of about 30 serious incursions per year and an average rate of 0.5 serious incursions per 1 million air traffic control tower operations. Preliminary data indicate that 24 serious incursions occurred during fiscal year 2007, compared to 31 during fiscal year 2006. The preliminary rate of serious incursions for fiscal year 2007 is 0.39 per 1 million air traffic control tower operations, which is about 24 percent less than during fiscal year 2006, when the rate of serious incursions was 0.51 per 1 million tower operations.

Although most runway incursions involve general aviation aircraft,[9] about one-third of the most serious incursions from fiscal year 2002 through fiscal year 2007 (categories A and B)—about 9 per year—involved at least one commercial aircraft that can carry many passengers (see fig. 3). For example, on July 11, 2007, a collision between two aircraft carrying 172 people was narrowly averted at the Fort Lauderdale-Hollywood Airport in Florida, when a Boeing 757 that had just touched down was able to become airborne again to avoid hitting an Airbus A320 aircraft that was approaching the same runway. An NTSB preliminary report indicated that the two aircraft missed each other by less than 100 feet. According to NTSB, it has investigated several near collisions in recent years that could have been catastrophic if they had not been averted through pilot skill and luck. Appendix III contains a list of serious incursions involving at least one commercial aircraft during fiscal year 2006 and fiscal year 2007.

[8]FAA defines category A as separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision; category B, separation decreases and there is a significant potential for a collision; category C, separation decreases but there is ample time and distance to avoid a potential collision; and category D, there is little or no chance of collision.

[9]According to FAA, 72 percent of incursions from fiscal year 2003 through fiscal year 2006 involved at least one general aviation aircraft.

Figure 3: Total Number of Serious Incursions, Fiscal Year 2001 through Fiscal Year 2007



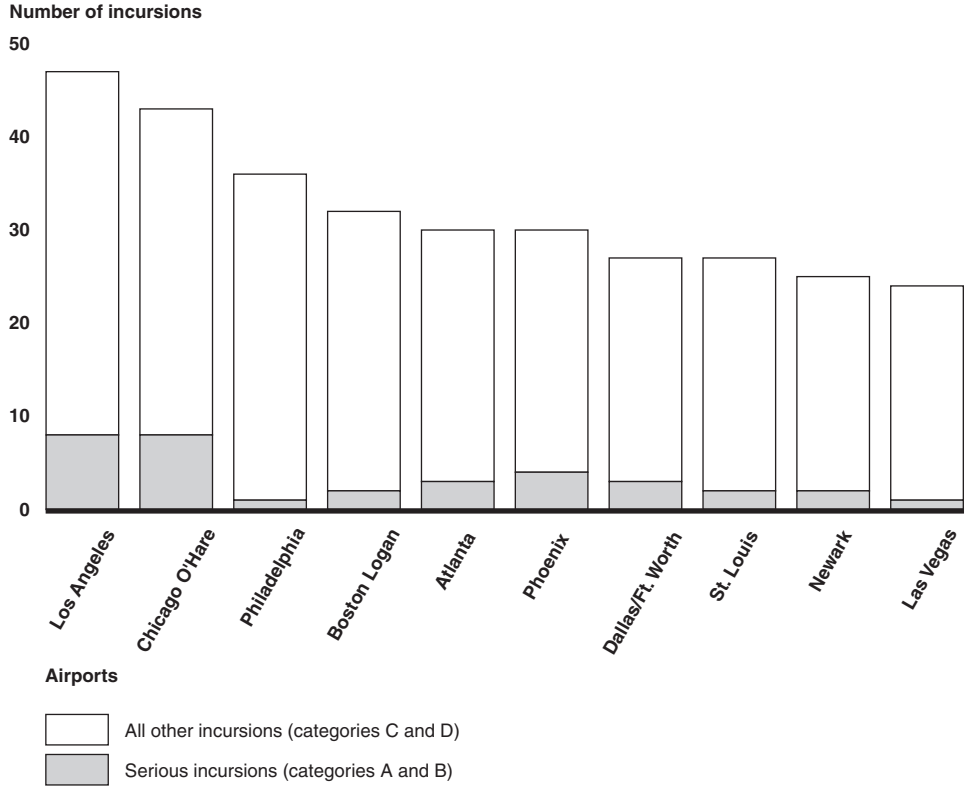
Source: FAA.

Note: Fiscal year 2007 data are preliminary.

FAA officials, experts we surveyed, and officials at some airports that have experienced the most incursions said that runway incursions were caused by many different factors, including airport complexity, frequency of runway crossings, the amount of air traffic, miscommunication between air traffic controllers and pilots, a lack of situational awareness on the airfield by pilots, and performance and judgment errors by air traffic controllers and pilots. According to FAA, 54 percent of incursions from fiscal year 2003 through fiscal year 2006 were caused by pilot errors, 29 percent were caused by air traffic controller errors, and 17 percent were caused by vehicle operator or pedestrian errors.

In the United States, most runway incursions have occurred at major commercial airports. Figure 4 shows the 10 U.S. commercial airports that have experienced the most runway incursions from fiscal year 2001 through fiscal year 2006 and the overall number of incursions and the number of serious incursions that occurred at those airports during that time.

Figure 4: U.S. Commercial Airports that Experienced the Most Runway Incursions from Fiscal Year 2001 through Fiscal Year 2006



Source: GAO analysis of FAA data.

In addition to incursions, overruns are a runway safety concern. When an aircraft overruns the end of a runway during an aborted takeoff or while landing, the results can be serious. In December 2005, for example, a Southwest Boeing 737 overran the runway at the Chicago Midway Airport during a snowstorm, ran through airport fencing, and collided with a car on an adjacent roadway, resulting in one fatality (see fig. 5).[10] Since 2001, NTSB has investigated 12 runway overruns that resulted in 18 fatalities, usually involving smaller general aviation aircraft. NTSB attributed the overruns primarily to pilot error, such as misjudgments of speed and distance.

[10]NTSB determined that the probable cause of that accident was the pilots' failure to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing.

Figure 5: Photograph of the December 2005 Runway Overrun at Chicago Midway Airport

Source: © Allan Goldstein, Aerial Images Photography (Illinois). Reprinted with permission. All rights reserved.

FAA has established standards for runway safety areas, which are unobstructed areas surrounding a runway, to enhance safety in the event that an aircraft overruns, undershoots, or veers off a runway. FAA airport design standards generally require commercial airports to establish, to the extent practicable, 1,000-foot runway safety areas at both ends of a runway.[11] In 1999, FAA established its Runway Safety Area Program, administered by the Office of Airport Safety and Standards, to help commercial airports meet runway safety area standards.[12] In 2005, FAA set a goal of having commercial service airports make all practicable

[11]The 1,000-foot runway safety area standard was based on the results of an FAA study of overruns from 1975 to 1987, which indicated that about 90 percent of overruns occurred within 1,000 feet of the runway end. FAA runway safety area standards depend on the type of aircraft using a runway and range from 120 feet wide by 240 feet beyond the end of the runways used for smaller aircraft to 500 feet wide by 1,000 feet beyond the end of the runways for larger aircraft.

[12]In 2000, FAA started a program to accelerate the construction of runway safety area improvements. Prior to 2000, FAA required that when certificated airports undertook a major runways construction project, the runway safety areas would be brought up to current standards to the extent practicable.

improvements to runway safety areas by 2015.[13] Also in 2005, Congress enacted legislation requiring the owner or operator of a commercial service airport[14] to meet FAA runway safety area standards by December 31, 2015. The importance of establishing a runway safety area was demonstrated during the crash of an American Airlines MD-82 in Little Rock, AR, on June 1, 1999, when it overran the runway, went down a rock embankment, and collided with a structure supporting a lighting system, killing 11 passengers and crew. According to NTSB, the airport had a runway safety area that was only 550 feet in length beyond the end of the runway. Experts we surveyed said that runway overruns are caused by factors such as pilot misjudgments about speed, altitude, or distance; inadequate information on weather and runway conditions; and aircraft equipment failure.

Although not considered part of the movement area of an airport, ramp areas can be dangerous for ground workers and passengers. Airport ramps are typically small, congested areas in which departing and arriving aircraft are serviced by ramp workers, including baggage, catering, and fueling personnel. Other personnel present on ramps include airport police, FAA officials, and other airport, airline, and vendor staff. The presence of a large number of people utilizing equipment in a relatively small area, often under considerable time pressure, creates an environment in which injuries and fatalities and aircraft and equipment damage can occur. Figure 6 shows an example of a ramp accident.

[13]In a May 24, 2007, report to Congress, FAA indicated that it had hoped that all runway safety area improvements would be complete by 2010 but that 42 projects would not be completed until after 2010 because they are often large and complex, requiring several years to complete.

[14]The runway safety area requirement in Public Law 109-115, 119 Stat. 2401 (2005) is applicable to owners or operators of an airport that have received an operating certificate under 49 U.S.C. § 44706.

Figure 6: Example of an Accident in an Airport Ramp Area

Source: © Rogério Carvalho. Reprinted with permission. All rights reserved.

Activities in the ramp area can also affect the safety of air crew and passengers once they leave the ramp area. Undetected aircraft damage from ramp activities can cause in-flight emergencies. In December 2005, for example, an Alaska Airlines MD-80 that had departed from Seattle to Burbank, CA, experienced a sudden cabin depressurization. After the aircraft safely returned to Seattle, it was discovered that a ramp vehicle had punctured the aircraft fuselage, but the incident had not been reported.

Aviation organizations have attempted to quantify the nature, extent, and cost of ramp accidents. According to the experts we surveyed, these errors occur as a result of multiple causes, such as carelessness, distractions, confusion, and inadequate training of ramp workers; lack of supervision; and time pressure. The Flight Safety Foundation, an aviation safety research organization, has estimated that ground accidents worldwide cost air carriers $10 billion annually, including costs associated with

injuries and fatalities and other indirect costs such as cancelled flights.[15] However, these research efforts have also been hindered by a lack of data. In a 2002 study of ramp worker accidents, FAA noted the difficulty of obtaining nonfatality data.[16] The Flight Safety Foundation also noted the limited amount of data available for its 2004 study of damage and injury on airport ramps.[17]

Federal Roles in Runway and Ramp Safety

FAA has primary federal responsibility for runway safety. Several FAA offices carry out these responsibilities, including

- the Air Traffic Organization, which manages air traffic control—including the hiring, training, and managing of more than 14,300 air traffic controllers—and develops and maintains runway safety technology;
- the Office of Runway Safety, created in 1999 as part of the Air Traffic Organization to lead and coordinate the agency's runway safety efforts—including developing a national runway safety plan and metrics for runway safety—and evaluate the effectiveness of runway safety activities;
- the William J. Hughes Technical Center in Atlantic City, NJ, which conducts aviation safety research;[18]
- the Office of Airports—which, as of July 2007, employed 45 safety inspectors to check airports' compliance with regulations—develops standards for airport signage, markings, and lighting, and manages the agency's Runway Safety Area Program to address runway overruns;
- the Office of Aviation Safety, which conducts safety inspections of airlines, audits air traffic safety issues, and administers a program to obtain

[15]Flight Safety Foundation officials noted that this estimate assumes 27 million departures annually, includes only International Air Transport Association airlines, and is based mostly on foreign airline data. They also noted that to determine injury costs, they extrapolated U.S. injury costs across the world, perhaps resulting in injury cost estimates higher than they actually would be.

[16]FAA, *Report to Congress: Injuries and Fatalities of Workers Struck by Vehicles on Airport Aprons*, (Washington, D.C.: July 2002).

[17]Flight Safety Foundation, *Equipment Damage and Human Injury on the Apron: Is It a Cost of Doing Business?* (Alexandria, VA: 2004).

[18]Other federal agencies such as DOT's Volpe National Transportation Systems Center and the National Aeronautics and Space Administration also conduct runway safety research.

information from pilots about the circumstances of runway incursions; and

- the Civil Aerospace Medical Institute in Oklahoma City, which conducts aerospace medical and human factors research.

FAA's oversight of ramp areas is provided indirectly through its certification of airlines and airports.[19] FAA has statutory authority to investigate aviation accidents including those that occur in ramp areas.[20] Pursuant to an FAA order, it is responsible for "ensuring that all facts, conditions, and circumstances leading to the accident are recorded and evaluated and action is taken to prevent similar accidents."[21] According to NTSB officials, that agency also investigates aviation accidents, including incursions and overruns that result in accidents, and selected runway incursions—those that are the most severe or those that the board believes represent the most safety benefit. NTSB investigates ramp accidents when someone is onboard the aircraft, when flight is intended or when a death or serious injury or substantial damage to the aircraft occurs. Under the Occupational Safety and Health Act (OSH Act), OSHA has statutory authority to govern the occupational safety and health of employees.[22] According to OSHA officials, the agency investigates ramp accidents when they involve fatalities or the hospitalization of three or more employees and conducts workplace inspections in response to complaints from workers.[23] According to a 2000 memorandum of understanding between OSHA and FAA relating to coordination and enforcement of the OSH Act, OSHA does not investigate accidents involving crew members on aircraft in operation.

[19]Primarily through 14 C.F.R. parts 119, 121, 135, and 139.

[20]49 U.S.C. § 46101(a)(2).

[21]FAA Order 8020.11B.

[22]29 U.S.C. §§651 et seq.

[23]OSHA conducts its work pursuant to the 1970 Occupational Safety and Health Act and the general industry safety and health standards outlined in 29 C.F.R. part 1910; however, neither contains provisions that pertain specifically to the aviation industry.

Challenges Remain Despite Numerous Efforts to Address Runway Safety

FAA has undertaken a number of efforts to address runway safety problems involving incursions and overruns. The agency has taken a layered approach to meet many of the runway safety strategic objectives it set in 2002. However, the lack of coordination and leadership among FAA's runway safety efforts, technology challenges, the lack of data, and human factors issues impede further progress in addressing runway safety. Because the number and rate of runway incursions did not decrease from fiscal year 2002 through fiscal year 2006 and remains at a level higher than any time during the 1990s, FAA could take additional cost-effective measures to improve runway safety. These measures include ensuring that FAA's Office of Runway Safety operates as a coordinating entity for the agency's runway safety efforts, as well as establishing a new voluntary safety incident reporting program for air traffic controllers.

FAA Uses a Layered Approach to Reduce the Risks of Runway Incursions and Overruns

FAA's layered approach to addressing runway safety includes a range of actions, such as deploying, researching, and testing new technology; encouraging airport improvements, such as changes to layout, markings, signage, and lighting; and providing human factors training for pilots and air traffic controllers. Our analysis found that FAA completed or was in the process of implementing 34 of the 39 runway safety objectives it set in its most recent national runway safety plan, issued in 2002, as a means of reducing the severity, number, and rate of runway incursions[24] (see app. IV). Most of the completed objectives involved (1) developing and distributing runway safety education and training materials to controllers, pilots, and other airport users; (2) supporting and developing new technologies intended to reduce the potential for runway collisions; and (3) assessing and modifying procedures to enhance runway safety.[25] The results of our survey of experts indicated that the most effective actions that FAA was taking were lower-cost measures, such as enhancing airport markings, lighting, and signage (see table 1). Some experts noted that markings, lighting, and signage help keep aircraft from becoming lost on the airfield and accidentally entering an active runway. The testing of runway status lights—technology that is more expensive to deploy than

[24]FAA's 2002 national runway safety plan was developed in cooperation with the Commercial Aviation Safety Team (CAST), a joint government-aviation industry group formed to study aviation safety issues, and encompassed 11 of the safety enhancements CAST identified as having the greatest potential for improving runway safety from its Runway Incursion Joint Safety Implementation Team.

[25]Of the remaining 5 objectives not implemented, 4 were cancelled, and 1 objective concerning the deployment of technology was not met.

improving airport markings, lighting, and signage—is another action that a majority of the experts rated as being most effective. Further, one expert noted that all of FAA's actions in addressing runway incursions must be continued because one fix alone will not improve safety.

Table 1: Experts' Ranking of the Most Effective FAA Actions to Address Runway Incursions

Ranking	Action
1	Enhancing airport markings and lighting
2	Enhancing airport signage
3	Approving perimeter taxiways, which provide aircraft with access to gates without crossing active runways
4	Establishing Runway Safety Action Teams, groups of airport safety stakeholders to identify and implement safety improvements
4	Testing runway status lights, which provide a visible warning when runways are not clear to enter or cross

Source: GAO analysis of responses from survey of experts.

Note: Rankings are based on responses from 22 experts and reflect the actions that a majority of experts indicated were "very effective" or "extremely effective."

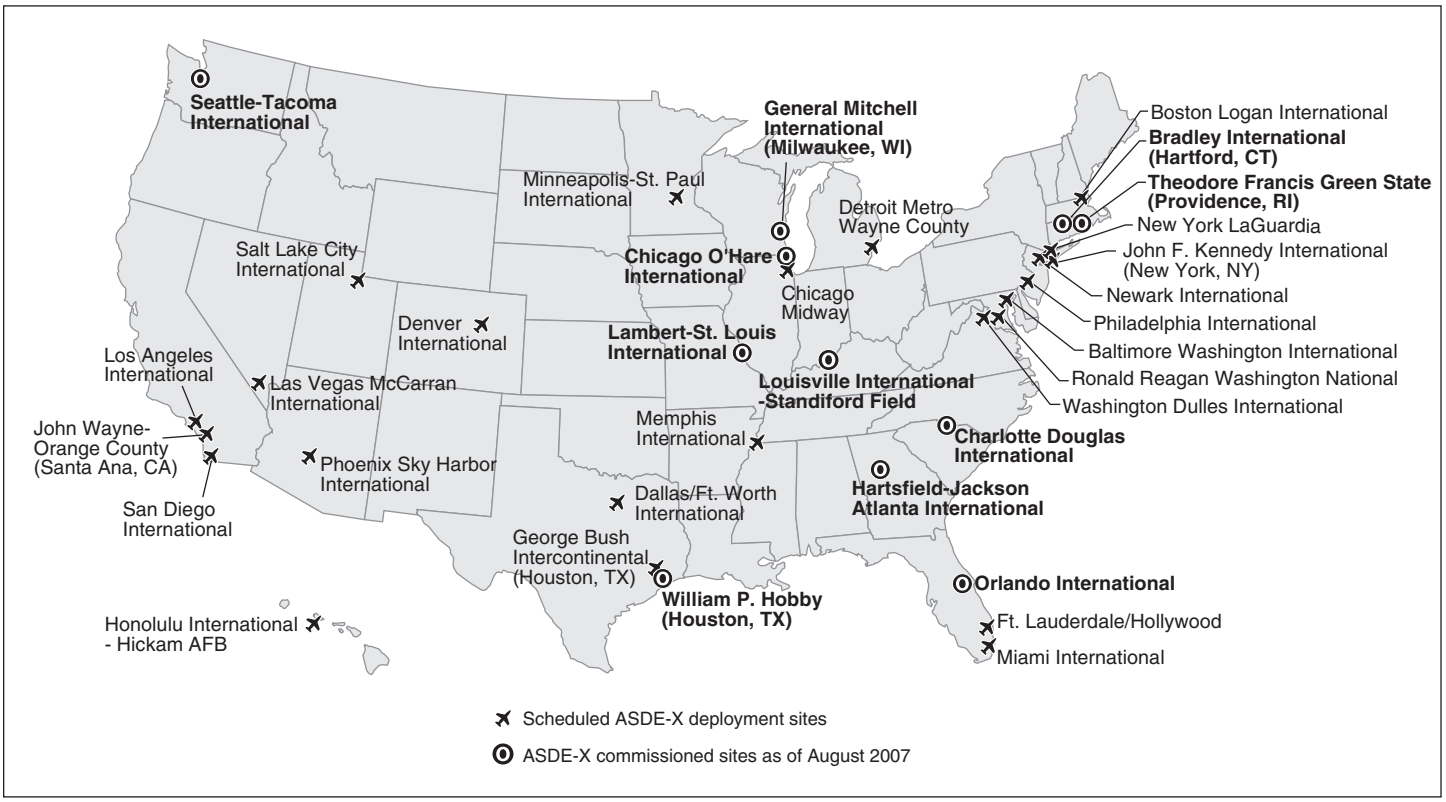
FAA Is Using Technology as a Major Part of its Risk Reduction Strategy

Surface surveillance technology is a major part of FAA's strategy to improve runway safety. FAA has deployed the Airport Movement Area Safety System (AMASS), which uses the Airport Surface Detection Equipment, model 3 (ASDE-3) radar,[26] and is deploying the Airport Surface Detection Equipment, Model X (ASDE-X) to provide ground surveillance, both of which give air traffic controllers better visibility of activity on the airfield and could help prevent collisions. FAA completed the deployment of ASDE-3/AMASS at 34 of the nation's busiest airports (see app. V) in 2003, and is now deploying ASDE-X at 35 major airports (see fig. 7). Although ASDE-3/AMASS and ASDE-X are both radar-based, ASDE-X integrates data from a variety of sources, including radars and aircraft and vehicle transponders, to give controllers a more complete view of airport activities.[27] ASDE-3/AMASS and ASDE-X are both designed to provide controllers with alerts when the system detects a possible collision.

[26]AMASS is essentially the safety logic, which is designed to detect potential collisions, for ASDE-3. This combined technology is usually referred to as ASDE-3/AMASS.

[27]Other sources of ASDE-X data include multilateration, which is a group of antennas used to obtain position information on aircraft. Each ASDE-X airport has between 10 and 20 antennas.

Figure 7: Airport Surface Detection Equipment, Model X (ASDE-X) Deployment Sites



Source: FAA and GAO.

Note: ASDE-X-commissioned airports identified in bold.

Runway status lights, which FAA is testing at the Dallas-Ft. Worth International Airport and the San Diego International Airport, are a series of lights embedded in the runways that give pilots a visible warning when runways are not clear to enter, cross, or depart on.[28] They are a fully automatic, advisory safety system requiring no input from controllers, and

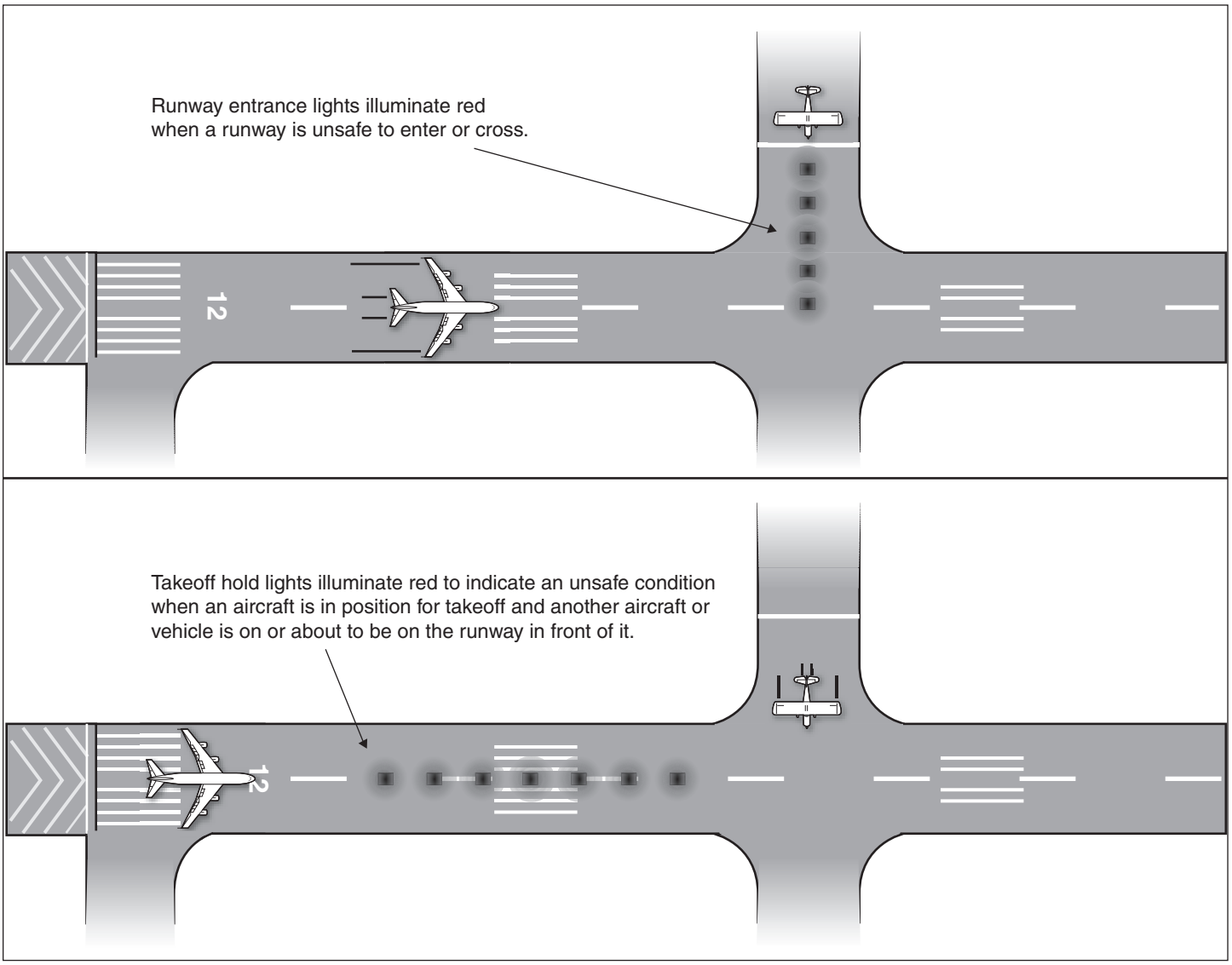
[28]FAA is testing both takeoff hold lights and runway entrance lights with ASDE-X at the Dallas-Ft. Worth International Airport and is testing runway entrance lights with AMASS at the San Diego International Airport.

currently consist of takeoff hold lights and runway entrance lights (see fig. 8).[29] Ten of 17 experts[30] we surveyed indicated that FAA's testing of runway status lights was very or extremely effective in addressing runway incursions. Surface surveillance systems, such as ASDE-3/AMASS and ASDE-X, provide the data needed to operate runway status lights, and the systems' safety logic assesses any possible conflicts on the airfield and provides alerts of potential collisions.

[29]According to FAA, future additions to the runway status lights system could include runway intersection lights and lights to warn pilots exiting at high speeds about traffic on closely-spaced parallel runways.

[30]Twenty-two experts responded to our survey, but the number of respondents for each question varies because we asked them to answer questions only within their areas of expertise. In addition, some respondents answered "don't know/no basis to judge" to certain questions.

Figure 8: Runway Status Lights System



Source: Lincoln Laboratory, Massachusetts Institute of Technology, and GAO.

Another technology that FAA is testing, the Final Approach Runway Occupancy Signal, is designed to provide a visible warning to aircraft on approach. This system, which is being tested at the Long Beach (Daugherty Field) airport in California, activates a flashing light visible to aircraft on approach as a warning to pilots when a runway is occupied and hazardous for landing. FAA is also testing low cost surface surveillance systems for small to medium airports at the Spokane International

Airport.[31] FAA would need to certify a low cost surface surveillance system before it could be used at airports in the United States. A low cost surface surveillance system is being used at 44 airports outside of the United States.

Infrastructure Improvements and Research Efforts Are Being Made to Prevent the Risk of Collisions

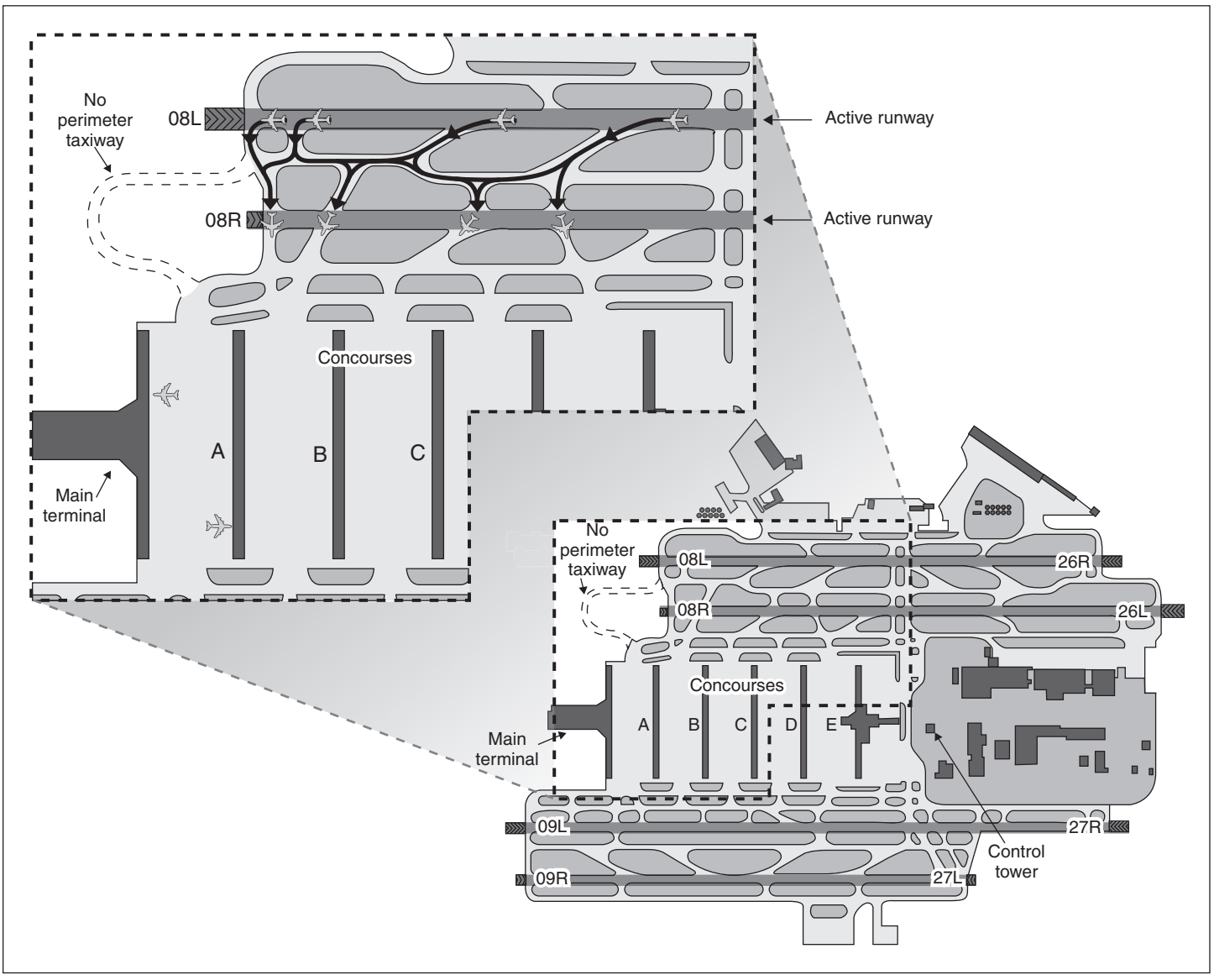
Some airports are also making changes to their runways and taxiways to reduce the risk of collisions. FAA has helped fund, for example, the construction of perimeter taxiways (also called end-around taxiways) that provide aircraft with access to gates without crossing active runways. As discussed earlier in this report, the crossing of active runways is one of the many causes of incursions. The Hartsfield-Jackson Atlanta International Airport opened a perimeter taxiway in April 2007, and the Dallas-Ft. Worth International Airport plans to open one in October 2008.[32] According to Atlanta airport officials, use of the perimeter taxiway eliminates about 560 aircraft runway crossings per day, or about one-third of the airport's total daily runway crossings.[33] Figure 9 shows the typical route that aircraft landing on the northern runways at the Hartsfield-Jackson Atlanta International Airport would take to taxi to the gate without using the perimeter taxiway. Figure 10 shows that, by using the perimeter taxiway, aircraft landing on the northernmost runway no longer need to cross a parallel runway to reach the gates. Eleven of 16 experts we surveyed indicated that FAA's approval of perimeter taxiways was very or extremely effective in addressing runway incursions.

[31]According to an FAA official, by contrast to ASDE-X, which uses multiple sensors, low cost surface surveillance systems collect data using a single sensor.

[32]Hartsfield-Jackson Atlanta International Airport officials said the perimeter taxiway cost $48 million. An official from the Dallas-Ft. Worth International Airport said its perimeter taxiway will cost about $63.8 million. FAA indicated that it provided about $26 million in Airport Improvement Program funds for the perimeter taxiway at the Hartsfield-Jackson Atlanta International Airport and about $47.3 million for the perimeter taxiway at the Dallas-Ft. Worth International Airport.

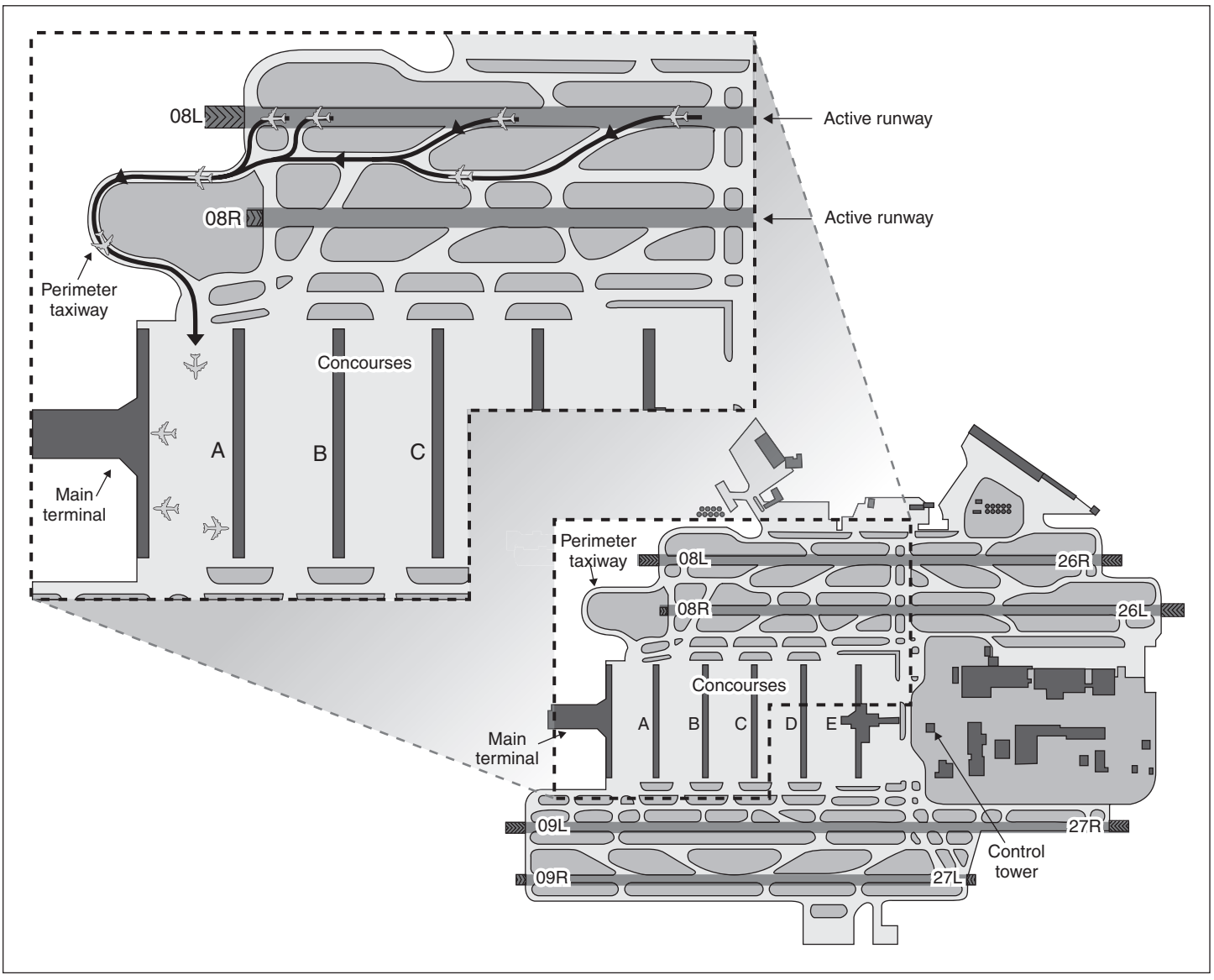
[33]Certain large aircraft, such as the Boeing 747, Boeing 777, Airbus A330, and Airbus A340 cannot use the perimeter taxiway because of their large wingspans.

Figure 9: Aircraft Taxiing Routes at the Hartsfield-Jackson Atlanta International Airport Without Using the Perimeter Taxiway



Source: Hartsfield-Jackson Atlanta International Airport and GAO.

Figure 10: Aircraft Taxiing Route at the Hartsfield-Jackson Atlanta International Airport Using the Perimeter Taxiway



Source: Hartsfield-Jackson Atlanta International Airport and GAO.

FAA has also helped fund other runway and taxiway changes at various airports. For example, the Los Angeles International Airport, the U.S. commercial airport that has experienced the most runway incursions in

recent years, is modifying its runway and taxiway configuration in an area where many of the incursions have occurred.[34] FAA and airports have made many runway safety improvements at airports that were identified by local and regional Runway Safety Action Teams, which are groups of FAA and airport officials, as well as other aviation safety stakeholders, which were formed as part of the agency's runway safety program in 2002. In addition, FAA has standardized airport signage and markings, including issuing new standards for surface markings that require the use of glass beads for better reflectivity, requiring new taxiway markings that alert pilots that they are approaching runway entrances, and doubling the size of markings indicating where aircraft should hold before proceeding onto the runway. A majority of the experts we surveyed confirmed the measures' effectiveness, indicating that FAA's enhancement of airport markings, lighting, and signage was very or extremely effective.[35]

FAA has funded runway safety research that has led to the testing and deployment of new technology and other measures. During fiscal year 2006, FAA spent about $3.5 million on runway incursion prevention research at its William J. Hughes Technical Center on projects such as visual guidance, including signs and lighting; and about $55,000 on research at its Civil Aerospace Medical Institute regarding vehicle incursions and operational errors. Also during fiscal year 2006, FAA funded about $1 million for runway safety-related research that was conducted at DOT's Volpe National Transportation Systems Center on projects such as runway status lights, analyses of runway incursion data, FAA's runway incursion severity calculator, and the electronic flight bag.[36]

[34]This modification is being made by moving the southernmost runway 55 feet farther away from its parallel runway to accommodate the construction of a centerfield taxiway between the two runways. According to a Los Angeles World Airports official, the Los Angeles International Airport is spending $333 million for the south airfield improvements, of which FAA funded $98 million, including $29.6 million for the new center taxiway.

[35]Fifteen of 22 respondents indicated that FAA's enhancement of airport markings and lighting was very or extremely effective and 14 indicated that FAA's enhancement of airport signage was very or extremely effective.

[36]An electronic flight bag is an electronic display system that gives pilots a variety of aviation data such as aircraft operating manuals and navigational charts. Electronic flight bags range from laptop-like devices that are independent of the aircraft for use on existing fleets to displays permanently installed in the cockpits of newer aircraft.

FAA Training and Industry Outreach Includes Human Factors Issues

Because most incursions are caused by human error, FAA is making outreach and awareness efforts to address errors made by pilots, air traffic controllers, and airport vehicle operators. The agency issued booklets in 2004 and 2005 for pilots that highlight communication procedures for safe surface operations at towered and nontowered airports. In collaboration with the aviation industry, FAA helped to create two online courses that educate pilots on runway safety and conducts safety seminars for pilots across the country to encourage safe practices on the airfield. To enhance air traffic supervisor and controller education, FAA is developing for training purposes simulated recreations of actual incursions. In addition, in recent years, FAA developed and initiated controller training on human factors, including skills enhancement regarding teamwork, communication, problem solving, situational awareness, and managing workloads. FAA also provided airline maintenance personnel operating "tug and tow" vehicles with best practices while operating on the airport surface and requires driver training programs for all airport workers who access the airfield movement areas at commercial airports. Many of the items implemented as a result of recommendations made by Runway Safety Action Teams also involved human factors. FAA data indicated that Runway Safety Action Teams recommended 4,441 action items for implementation between April 2001 and mid-December 2006. Of these, 3,338 actions, or about 75 percent, were completed, with the largest combined grouping (945 actions) relating to pilots, air traffic controllers, and vehicle drivers regarding actions such as training and improved procedures. Ten of 19 experts we surveyed indicated that FAA's establishment of Runway Safety Action Teams was very or extremely effective in addressing runway incursions. Only 5 of 22 experts we surveyed indicated that FAA's pilot educational initiatives were very or extremely effective and 8 of 21 experts said that FAA's air traffic controller training was very or extremely effective in addressing runway incursions.

FAA and Airports Have Improved Runway Safety Areas in Case of Overruns

To address runway overruns, FAA and airports have made progress in recent years to bring runway safety areas into compliance with FAA standards. According to FAA, as of May 2007, 70 percent of the 1,014 runways at 573 commercial airports in the United States substantially comply[37] with runway safety area standards, up from 55 percent in 2000. Progress has also been made in bringing runways at the nation's busiest airports into compliance with FAA runway safety area standards pursuant

[37]FAA considers runway safety areas that meet 90 percent of the standards to be in substantial compliance.

to the congressional mandate to have all airports in compliance by December 31, 2015. As of June 2007, 21 of 47 runways at the 10 busiest U.S. commercial airports did not meet FAA runway safety area standards,[38] down from 30 runways at those airports that did not meet standards in October 2006. Increased compliance with runway safety area standards reduces the chance of aircraft being damaged from overruns.

Recognizing the difficulties of meeting the runway safety area standards at airports that do not have enough space to establish 1,000-foot runway safety areas, FAA conducted research during the 1990s that led to the development of the Engineered Materials Arresting System (EMAS), a bed of crushable concrete designed to stop overrunning aircraft. In 1999, FAA began accepting EMAS as an alternative to constructing a runway safety area when its construction is not practicable and, in 2004, began considering EMAS as generally equivalent to a full-length runway safety area. As of June 2007, EMAS was installed at 24 runway ends at 19 U.S. airports and 12 additional EMAS systems were under contract at 8 airports. In addition, EMAS had successfully stopped four aircraft that had overrun runways, including a Boeing 747 that overran a runway at the John F. Kennedy International Airport in January 2005 and was traveling at an exit speed of about 70 knots, or about 80 miles per hour. Figure 11 shows an example of how EMAS can stop an aircraft. The effectiveness of this measure was supported by a majority of experts we surveyed, who indicated that FAA's acceptance of EMAS as an alternative to constructing a runway safety area when its construction is not practical was very or extremely effective in addressing runway overruns.[39] One expert, for example, said that because many airports no longer have the ability to expand existing runway safety areas, EMAS may be the only practical solution. Other experts noted that preventive measures, such as training to improve pilot skills, are also needed.

[38]Those airports include Chicago O'Hare International Airport, with six runways that did not meet runway safety area standards as of June 2007; Houston's George Bush Intercontinental Airport, with five runways that did not meet standards; and Los Angeles International Airport, with four runways that did not meet standards. Busiest airports were identified from preliminary 2006 enplanement data.

[39]Twelve of 16 experts indicated that FAA's acceptance of EMAS as an alternative to constructing a runway safety area when its construction is not practical was very or extremely effective in addressing runway overruns.

Figure 11: Example of How EMAS Can Stop an Aircraft

Source: Bob Hope Airport, Burbank, CA. Reprinted with permission.

Since 2000, about $300 million per year from FAA's Airport Improvement Program has been spent on runway safety area improvements, and $1.1 billion is expected to be needed to complete the remaining 207 projects. FAA officials told us that, if the current funding levels are maintained for the Airport Improvement Program, sufficient resources will be available to complete the planned runway safety area improvements. An official from an airport association said that even if sufficient airport improvement funds are available for runway safety area improvements, all airports will not be able to acquire the land needed to establish the safety areas. Eleven of 14 experts we surveyed indicated that FAA's use of airport improvement funds to construct runway safety areas was very or extremely effective in addressing runway overruns.

Lack of Coordination and Leadership, Technology Challenges, Lack of Data, and Human Factors Issues Impede Further Progress in Improving Runway Safety

Although FAA took many steps to address runway safety problems involving incursions and overruns, especially since the number and rate of incursions peaked in fiscal year 2001, its efforts have waned in recent years, and the number and rate has remained steady. Additional measures by FAA would enhance the coordination and leadership of runway safety issues, technology, data collection and analysis, and human factors issues.

FAA's Office of Runway Safety Is Not Carrying Out its Coordination and Leadership Functions

FAA is not following its order, issued in 2002, that directs the Office of Runway Safety to coordinate and monitor activities throughout the agency to ensure that runway safety goals are met.[40] The absence of coordination and national leadership impedes further progress on runway safety because no single office is taking charge of assessing the causes of runway safety problems and taking the steps needed to address those problems. Under the FAA order, FAA's Office of Runway Safety is to prepare a national runway safety plan every 2 to 3 years and to provide updates as needed. However, we found that the most recent national runway safety plan, issued in 2002, is no longer being used and the status of its objectives are not being tracked. FAA officials told us the national runway safety plan has been replaced by the FAA Flight Plan, which is a high-level planning document covering all of FAA's programs. However, we agree with the conclusion in a May 2007 audit report by the DOT Office of Inspector General[41] that replacing the national runway safety plan by the higher-level FAA Flight Plan, with the goal of having each FAA office separately include its runway safety initiatives in its own business plan, does not have the same national focus and emphasis on runway safety that a national plan for runway safety provides. In addition, although the Airports Office and the Air Traffic Organization included runway safety objectives in their business plans, the Office of Aviation Safety's business plan for fiscal year 2007 did not include plans to reduce runway incursions.[42] Moreover, the lack of a comprehensive, targeted plan has resulted in uncoordinated efforts that may not be the most effective.

[40]FAA Order 7050.1.

[41]DOT Office of Inspector General, *Progress Has Been Made in Reducing Runway Incursions, but Recent Incidents Underscore the Need for Further Proactive Efforts*, Report No. AV-2007-050 (Washington, D.C.: May 24, 2007).

[42]Under the 2002 national runway safety plan, 11 of the 39 objectives were assigned to the Office of Aviation Safety's Flight Standards Service.

In addition, although FAA hired a permanent director at the Senior Executive Service (SES) level for the Office of Runway Safety in August 2007, the Office of Runway Safety did not have a permanent director for the previous 2 years, resulting in a lack of national program leadership, and its staff was reduced by about 45 percent over the last 4 years. Before 2004, the runway safety office had 66 full-time staff led by an SES-level manager in headquarters, compared to about 37 full-time runway safety staff led by a non-SES-level acting director as of May 2007.[43] Moreover, although contractors represented about 60 percent of the Office of Runway Safety staff in 2004,[44] funding for the office's contract employees was reduced from about $4 million in 2005 to about $2.5 million per year in 2007. An FAA official told us that because the Office of Runway Safety relied heavily on contractors for staff, it lacked a career path for potential managers in the field and at headquarters and lost expertise that the contractors had developed when their contracts expired. In addition, as of May 2007, the Office of Runway Safety no longer had as many full-time detailees from other FAA offices with runway safety responsibilities, including FAA's Airports and Air Traffic Organization's Terminal Service offices, as it had in the past.

Several FAA officials and others said that the lack of leadership in the Office of Runway Safety had negatively affected the program. A regional runway safety program manager said, for example, that having had no permanent director for the office resulted in a lack of direction from headquarters, leaving regions to carry out runway safety efforts in different ways. This situation prevents FAA from identifying systemwide causes of runway safety problems that may require coordinated solutions. Furthermore, an official currently working on the runway safety program said that no quarterly performance review meetings were held between the Acting Director of Runway Safety and the regional runway safety program managers for over a year during 2006 and 2007. These meetings had been held, for example, to discuss regional initiatives. Such sharing of information between regions could help address runway safety issues from a national perspective and implement changes systematically. FAA research officials also told us that after having completed a study for the

[43]In addition to his duties as acting director of the Office of Runway Safety, this official was also a regional runway safety director. Officials in the Air Traffic Organization's Office of Safety Services assisted the acting director in carrying out his duties.

[44]Contractors represented 40 of the 66 Office of Runway Safety employees before 2004 and 21 of the 37 employees in 2007.

Runway Safety Office, they could not find anyone to give it to in FAA headquarters. The new permanent director of the Office of Runway Safety indicated that the office plans to restart some initiatives, including conducting quarterly runway safety performance reviews, starting in December 2007. However, other plans for the office are still being developed.

Technology Challenges Impede Progress in Improving Runway Safety

FAA has faced significant challenges in deploying and developing technology for runway safety. Technology currently being installed, ASDE-X, has experienced cost increases and schedule delays from its original baselines, and is encountering some operational difficulties.[45] At the same time, additional technology to prevent runway collisions is years away from deployment. Because FAA relies heavily on technology as part of its runway safety strategy to supplement a controller's vision of the airfield, these challenges impede progress in addressing runway safety.

FAA has revised its cost and schedule plans twice since 2001 to deploy ASDE-X at 35 airports by 2011. The current program costs have increased by about $125 million over the 2001 estimate, as FAA added nine airports to its deployment schedule (see table 2). FAA currently estimates that the total ASDE-X program cost will be about $806 million, including the cost to operate and maintain the system through fiscal year 2030. This includes facilities and equipment costs of about $550 million, which is approximately $40 million more than what we reported in 2005, plus about $257 million in operations and maintenance costs. As of August 2007, ASDE-X was commissioned[46] at 11 airports. Regarding their plans to deploy ASDE-X to the remaining 24 airports by 2011, FAA officials said that they had focused their efforts at the beginning of the program on software development, which is nearly complete, and on system enhancements, which have been completed, allowing them now to concentrate on system deployment. In addition, FAA officials said in November 2007 that ASDE-X deployment is ahead of the agency's revised 2005 schedule and that costs have remained consistent with its revised 2005 cost estimate. Nonetheless, as discussed below, our concerns about the schedule plans for ASDE-X remain.

[45]We are conducting ongoing work on how FAA factors cost increases and schedule delays for systems such as ASDE-X into its acquisition performance measurement.

[46]FAA refers to ASDE-X as being commissioned after the system has been tested at an airport and demonstrated that the field site personnel can fully operate and maintain it.

Table 2: Changes in ASDE-X Equipment Cost and Deployment Completion Dates

	2001 estimate	2002 estimate	2005 estimate	2007 estimate
Cost targets	$424.3	$505.2	$549.8	$549.8
Number of planned operational systems	26	33	35	35
Deployment completion targets	2007	2007	2011	2011

Source: GAO analysis of FAA data.

Note: Cost is millions of dollars.

Although it took about 4 years for ASDE-X to be commissioned at those 11 airports, FAA plans to deploy the system at the remaining 24 additional airports in less than 4 years (see app. V). Furthermore, not all 11 ASDE-X commissioned airports have key safety features of the system. For example, as of August 2007, three of the ASDE-X commissioned airports did not have safety logic, which generates a visible and audible alert to an air traffic controller regarding a potential runway collision. Moreover, five airports, including the three lacking safety logic, do not have a system enhancement that allows ASDE-X to alert controllers of potential collisions on intersecting runways or runways intersecting taxiways during inclement weather (see table 3). Because of these issues, the DOT Inspector General reported,[47] and we agree, that the program is at risk of not meeting its current cost and schedule plans to deliver ASDE-X systems at 35 airports by 2011.

[47]DOT Office of Inspector General, *Actions Needed To Reduce Risk with the Next Generation Air Transportation System*, CC-2007-047 (Washington, D.C.: May 9, 2007) and *FAA Needs to Improve ASDE-X Management Controls to Address Cost Growth, Schedule Delays, and Safety Risks*, AV-2008-004 (Washington, D.C.: Oct. 31, 2007).

Table 3: ASDE-X Commissioned Airports as of August 2007

Airport	Commissioned date	Safety logic	System enhancements[a]
General Mitchell International Airport (Milwaukee, WI)	October 30, 2003	Yes	Yes
Orlando International Airport	September 30, 2004	Yes	Yes
Theodore Francis Green State Airport (Providence, RI)	May 16, 2005	No	No
William P. Hobby Airport (Houston, TX)	August 31, 2005	No	No
Seattle-Tacoma International Airport	February 24, 2006	Yes	No
Lambert-St. Louis International Airport	May 24, 2006	Yes	No
Hartsfield-Jackson Atlanta International Airport	June 7, 2006	Yes	Yes
Bradley International Airport (Hartford, CT)	June 21, 2006	No	No
Louisville International-Standiford Field	July 19, 2007	Yes	Yes
Chicago O'Hare International Airport	August 29, 2007	Yes	Yes
Charlotte Douglas International Airport (Charlotte, NC)	August 30, 2007	Yes	Yes

Source: FAA.

[a]These enhancements include rain configuration, which maintains the system functioning during inclement weather such as moderate or heavy rain; converging taxiway logic, which generates an alert when an aircraft or vehicle on a taxiway is predicted to enter a runway; intersecting runway alerts, which generate alerts when aircraft are predicted to collide at intersecting runways; and tower configuration, which directs an alert regarding potential conflicts on particular runways to certain controllers.

Recent serious runway incursions at airports with fully operational runway safety technology reveal persistent problems with their alerting functions. For example, air traffic controllers at eight airports with ASDE-3/AMASS told us that the alerting function does not work well during heavy precipitation and that they disable the alerting function during inclement weather.[48] As a result, air traffic controllers at those airports with ASDE-3/AMASS do not have the benefit of an incursion alerting system in poor weather conditions, when it may be most needed. Furthermore, the ASDE-X commissioned airports are experiencing problems with false alerts, which occur when the system incorrectly predicts an impending collision, and false targets, which occur when the system incorrectly identifies something on the airfield as an aircraft or vehicle and could generate a false alert. (These problems are discussed in more detail below.) Although FAA officials acknowledged that ASDE-X is experiencing problems with false alerts, they said the system is operating

[48]FAA officials said that due to the nature of radar, heavy rain has the potential to degrade system performance, but that all radar systems have similar limitations. However, they also said that ASDE-X performs much better in all levels of rain than the ASDE-3/AMASS system.

within specifications. An April 2007 FAA internal audit of the ASDE-3/AMASS and ASDE-X safety logic systems concluded that the runway safety logic system was not providing consistent information to controllers, creating a lack of confidence in the system.[49] Furthermore, NTSB, after several investigations of incursions at airports equipped with ASDE-3/AMASS, determined that the alerting process was ineffective because the delay was too long before pilots would receive the alert relayed by controllers. As a result, NTSB asked that FAA develop a system that provides a direct warning to the cockpit.[50]

Of the 11 ASDE-X commissioned airports, the control tower at the Seattle-Tacoma International Airport reported the most problems with false targets.[51] In addition, of the eight ASDE-X commissioned airports with the alerting function, the control tower at the Hartsfield-Jackson Atlanta International Airport reported the most problems with false alerts.[52] When an ASDE-3/AMASS or ASDE-X alert sounds, air traffic controllers are required to instruct landing aircraft to follow a go-around procedure, sending the aircraft back into the airspace for another landing attempt, even if nothing is visible on the runway that could cause a collision.[53] The controllers said the effect of this practice is to increase air traffic and flight times. Officials from the ASDE-X manufacturer said an elevated number of false targets, on average, at the Seattle-Tacoma International Airport is caused primarily by the location of the surface movement radar relative to the airport facility structures, the movement area, and the airport's configuration. The location of these structures is determined by FAA and the airports. Officials from the manufacturer also said ASDE-X at the Hartsfield-Jackson Atlanta International Airport is experiencing an

[49]*Audit of Runway Safety Logic Systems*, FAA Air Traffic Safety Oversight Service, Audit Project Number: ADT-FY-07-001 (Washington, D.C.: April 16, 2007).

[50]According to NTSB, simulations of ASDE-3/AMASS performance using data from actual incursions showed that alerts may occur as little as 8 to 11 seconds before a potential collision.

[51]The air traffic control tower at the Seattle-Tacoma International Airport reported 306 false targets from January 27, 2006, though May 17, 2007. According to FAA, 261 of these false targets have been addressed by an adaptation or software change, and very few were related to system malfunctions.

[52]We reviewed the daily records of air traffic control tower operations at the Hartsfield-Jackson Atlanta International Airport and found that 41 false alerts were recorded from June 7, 2006, to May 16, 2007.

[53]FAA Order 7110.65R.

elevated number of nuisance alerts, which are caused by real conditions that are not safety threats, such as a vehicle on a runway, but landing aircraft are far enough from the airport not to constitute a threat. They said the nuisance alerts being experienced at the Hartsfield-Jackson Atlanta International Airport are caused by the site-specific configuration parameters of the system, and that they are working with air traffic controllers, FAA engineers, and the ASDE-X program office to adjust the parameters of the system to minimize the nuisance alerts while maintaining the required performance. The officials noted the difference between nuisance alerts and false alerts, which are issued after the system detects potential threats that are not real. The officials said they examine false alerts very closely with FAA and determine whether to make design modifications to the system to ensure that they are minimized.

FAA ASDE-X program officials said that the problems with false alerts and false targets are site-specific, rather than systemic issues, relating to the location of sensors and radar towers. The officials said they are working to address the problems by adjusting the sensitivity of the systems, which they described as a time-consuming, continuous process with no single fix. For example, they said that at the Seattle-Tacoma International Airport, the system's level of sensitivity was increased at the site's request because of its experience with heavy fog, and that a certain number of false targets cannot be eliminated without sacrificing the sensitivity. At the same time, FAA officials acknowledged that the location of the ASDE-X surface movement radar at the Seattle-Tacoma International Airport has affected system performance much more than originally anticipated. FAA also noted that all radar systems experience false targets as a function of detection and that the majority of false targets at the Seattle airport occurred on taxiways near the terminal. They also said that new software being deployed at airports starting in September 2007 would help address the problems involving false alerts and that with the addition of the new software, ASDE-X is operating under system requirements not to generate more than two false alerts within 24 hours. This software enhancement was deployed at the Hartsfield-Jackson Atlanta International Airport in September 2007, and FAA program officials said they believe it has resulted in improved ASDE-X system performance. We were not able to confirm this information.

Only 3 of 17 experts we surveyed indicated that FAA's deployment of ASDE-3/AMASS was very effective,[54] and 4 of 17 experts said that ASDE-X was very or extremely effective in addressing runway incursions.[55] One expert, for example, said that ASDE-X appears to be a great technology to aid controllers, but is not trustworthy at this point because the rate of false alerts is somewhat high. In addition, this expert said that because ASDE-X has been deployed only to a few airports, it is not doing much to address runway incursions within the national airspace system as a whole. Another expert said that ASDE-X and runway status lights would greatly enhance both pilot and air traffic controller awareness, particularly at complex airports.

Most airports in the United States have no runway safety technology to supplement a controller's vision of the airfield and will not have such technology even after FAA completes its plan to deploy ASDE-X at 35 major airports. FAA's original plans called for 34 airports to receive ASDE-3/AMASS and 35 airports to receive ASDE-X. In total, 59 airports[56] were to receive either technology, but this number was reduced to 44 in August 2006 after FAA canceled plans to deploy ASDE-X at 15 of the originally scheduled airports.[57] The 35 major airports to receive ASDE-X handle 70 percent of the enplanements at U.S. airports but represent only 6 percent of all U.S. commercial airports,[58] leaving most airports without this type of

[54]Of the 17 respondents, 3 said ASDE-3/AMASS was very effective, 9 moderately effective, 4 slightly effective, and 1 not at all effective.

[55]Of the17 respondents, 1 said ASDE-X was extremely effective, 3 said it was very effective, 10 said it was moderately effective, and 3 said it was slightly effective.

[56]Ten airports that were scheduled to receive ASDE-X already had ASDE-3/AMASS.

[57]FAA's rebaseline of the ASDE-X program, which was approved by the agency's Joint Resources Council, was conducted on the basis of analyzing the safety and efficiency benefits of deploying the system at the 59 top-tier airports. The analysis assumed that maximum benefit was derived from deploying ASDE-X at airports with larger traffic counts and/or more complex operations. Sunk costs, such as site preparation that was already underway, were also considered. However, we found that FAA's ASDE-X business case did not include year-by-year estimates of benefits and costs or a sensitivity analysis, as required for all investment decisions by Office of Management and Budget (OMB) Circular A-94. A sensitivity analysis is a quantitative assessment of the effect that a change in an assumption—the numerical value of a single parameter—will have on net present value. In commenting on a draft of this report, FAA officials said that they had computed year-by-year analyses and conducted a sensitivity analysis. However, this information was not included in FAA's business case for ASDE-X for the entire 30-year lifecycle investment, as required by OMB.

[58]There were approximately 570 airports used by commercial service aircraft in 2006.

technology. Six of 12 experts who indicated that they had knowledge of or experience with the deployment of ASDE-X indicated that, considering the benefits and problems with ASDE-X, including false alerts and false targets, deployment of the system at the remaining 27 airports[59] by 2011 should be kept as planned, 4 said that deployment should be accelerated, and 2 said that deployment should be slowed down. One expert, for example, who indicated that the deployment of ASDE-X should be kept as planned, said that the problems with the system will be worked out as the system is deployed.

FAA is testing additional runway safety technology, but these systems are still years from being deployed in the United States. Runway status lights, which warn pilots when runways are unsafe to enter or cross, have had positive preliminary test evaluations, but need a surface surveillance system such as ASDE-3/AMASS or ASDE-X to operate. FAA officials expect to decide in 2007 whether to deploy runway status lights at the 35 ASDE-X airports at an estimated cost of $300 million but do not expect to make a final investment decision on another runway safety lighting technology, the Final Approach Runway Occupancy Signal, which provides a visible warning to aircraft on approach, for another 2 years. In addition, an FAA official said the agency is still exploring the capabilities of the low cost surface surveillance system and does not yet have a deployment schedule. Only 2 of the experts we surveyed indicated that FAA's testing of the low cost surface surveillance system was very effective in addressing runway incursions.[60] FAA announced in March 2007 that it was changing the certification process to enable the use of electronic flight bags (electronic display systems that give pilots a variety of aviation data such as aircraft operating manuals and navigational charts) and airport moving maps,[61] which can show an aircraft's position on an airfield, but a system that shows the location of other aircraft on the airfield is still under development. In addition, although officials from the Hartsfield-Jackson Atlanta International Airport cited the benefit of reducing aircraft runway crossings from using the airport's new perimeter taxiway, FAA officials said that few U.S. airports have the space to

[59]At the time the survey was administered, ASDE-X had not yet been commissioned at 27 of the 35 airports.

[60]Of 8 respondents, 2 said it was very effective, 3 moderately effective, and 3 slightly effective.

[61]Most electronic flight bags contain moving maps, which help pilots identify and anticipate an airplane's location on runways and taxiways.

construct perimeter taxiways and noted that they are expensive to construct.

Lack of Runway Incident Data Impedes Causal Analysis

In addition to its technological challenges, FAA lacks reliable runway safety data and the mechanisms to ensure that the data are complete. FAA's tabulation of the number of incursions does not reflect the actual number of incidents that occur. FAA only counts incursions that occur at airports with air traffic control towers, so the actual number of incursions, including those that occurred at airports without air traffic control towers, is higher than FAA reports. In addition, FAA's information on incursions that occurred at towered airports may not be complete, according to some experts we surveyed. For example, one expert said that the airline industry's reporting of runway incursions is higher than FAA's data and that most or all air carriers are aware of significant events that controllers failed to report. Although the airline industry provides data to FAA on safety incidents that may involve runway incursions, the information lacks sufficient specificity for FAA to use in its tabulation of incursions.

Furthermore, although FAA requires errors[62] that may result in incursions to be reported, the information collected does not always contain complete data on the causes and circumstances involved. Without more complete data, FAA cannot conduct in-depth analyses to ensure that the most effective corrective measures that address the causal factors are being implemented. An FAA program to obtain detailed information about the circumstances regarding runway incursions by administering questionnaires to pilots involved in incursions—the Runway Incursion Information and Evaluation Program—could help to identify root causes of pilot deviations and provides a mechanism to obtain information that may not otherwise be reported. However, only 19 percent of pilots involved in runway incursions and surface incidents participated in the

[62]These errors include operational errors, which FAA defines as an action by an air traffic controller that results in less than the required minimum separation between two or more aircraft, or between an aircraft and an obstacle (e.g., vehicles, equipment, personnel on runways); operational deviations, which are defined as an occurrence attributable to an element of the air traffic system in which applicable separation minima were maintained, but an aircraft, vehicle, equipment, or personnel encroached upon a landing area that was delegated to another position of operation without prior coordination or approval; pilot deviations, which are defined as actions by pilots that violate any Federal Aviation Regulation; and vehicle/pedestrian deviations, which are defined as vehicles, pedestrians, or other objects interfering with aircraft operations by entering or moving on the movement area without authorization from air traffic control.

program during 2004 through 2006, and FAA did not provide any evidence that it analyzed the data that were collected.

Certain FAA efforts that are in the early stages have the potential to improve runway safety data. For example, FAA plans to start a nonpunitive, confidential, voluntary reporting program for air traffic controllers, similar to the Aviation Safety Action Program[63] as part of the FAA safety management system.[64] The program will enable air traffic controllers to report anything that they perceive could contribute to safety risks in the national airspace system. The benefit of such program is that the information obtained might not be reported otherwise, and could increase the amount of data collected on the causes and circumstances of runway incursions. Many industry stakeholders such as the National Air Traffic Controllers Association, the Air Transport Association, the Air Line Pilots Association, and the Air Safety Foundation, support establishing such a program, which could also help reduce any underreporting of incidents. FAA has been working on establishing such a program since 2004, and indicated at a runway incursion meeting with the aviation community in August 2007 that it would implement a short-term runway safety plan that included implementing such a voluntary self-reporting program. According to FAA, it signed a partnership agreement with the National Air Traffic Controllers Association regarding the program in October 2007; however, the agency did not indicate when the plan would be implemented.

We also found that FAA's categorization of the severity of runway incursions involves a level of subjectivity, raising questions about the accuracy of the data. An internal FAA audit of 2006 runway incursion data

[63]This program seeks to improve aviation safety through the voluntary self-reporting of safety incidents. Participants include employees of air carriers and repair stations that have entered into a memorandum of understanding with FAA. FAA does not take enforcement action against employees who voluntarily self-reported safety violations for reports that are sole-source and will pursue administrative action only for reports that are not sole-source. Incidents that involve alcohol, drugs, criminal activity, or intentional disregard for safety are not eligible for self-reporting under the program. See GAO, *Aviation Safety: FAA's Safety Oversight System Is Effective but Could Benefit from Better Evaluation of Its Programs' Performance*, GAO-06-266T (Washington, D.C.: Nov. 17, 2005) and *Aviation Safety: Better Management Controls are Needed to Improve FAA's Safety Enforcement and Compliance Efforts*, GAO-04-646 (Washington, D.C.: July 6, 2004).

[64]Safety management is a systematic, explicit, and comprehensive approach for managing safety risk at all levels and throughout the entire scope of an operation and lifecycle of a system.

found that the subjectivity of the severity classifications has the potential to affect the accuracy of the classifications. The audit found that incursion severity classifications were subjective and partially incomplete. In addition, 18 percent of the incursion severity classifications for 2006 were found not to be in compliance with FAA severity classification requirements or could not be classified accurately.[65] The audit also found that since August 31, 2006, the Office of Runway Safety has been using a computer program called Runway Incursion Severity Classification to calculate initial assessments of severity.[66] FAA indicated that use of the computer program ensures consistent ratings based on available data. However, most of the information regarding incursions, which is entered into the computer model, is based on observations of incidents, rather than instrument readings, because many airports do not have the technology needed to collect such information or the information is not available to FAA, according to agency officials.[67] Observations regarding matters such as how close two aircraft came to colliding on a runway may be less accurate than instrument readings and, therefore, raise questions about the accuracy of the severity assessments. These findings were supported by the experts we surveyed. The majority of the experts who responded to a question about the accuracy of FAA's incursion severity classifications indicated that, based on their knowledge of specific incidents, FAA classified the incidents as being less severe than they actually were.[68]

[65]Auditors found that 82 percent of the runway incursion assessments complied with the severity classifications, 4 percent were not in compliance, and that 13 percent of the incursions could not be accurately classified due to insufficient guidance contained in FAA Order 7050.1, which defines the severity classification categories.

[66]The current method of evaluation is for the program to assign a severity rating and then have the Air Traffic Organization assessment team members vote to reach a consensus. If the assessment team's rating is different from the program, then the Air Traffic Organization's Director of Operational Services will make the final determination of severity. FAA plans to complete its validation of the computer program in fiscal year 2008.

[67]An FAA official said, for example, that the agency usually does not receive information from aircraft flight recorders for its runway incursion assessments.

[68]Seven of 11 experts questioned the classifications and 4 said that the incidents tended to be correctly classified.

Furthermore, FAA does not have complete information on ASDE-3/AMASS and ASDE-X system abnormalities, which could be used to analyze the performance of the systems' alerting functions. An internal FAA audit[69] concluded that 54 percent of all alerts—false and real—from the ASDE-3/AMASS and ASDE-X systems and 40 percent of instances when the systems' alerting functions were disabled were not recorded.[70] The audit also found no evidence of alerting standards for the runway safety logic systems, which limits the systems' capability of assessing risks and providing timely alerts to air traffic controllers.

We also found that FAA does not systematically collect data on the number of runway overruns that do not result in damage or injury that could be used for analytical purposes to study trends and causes of these incidents. FAA officials said it would be useful to collect such data because it would help them tailor standards to what has actually occurred, for example, how far an aircraft overran a runway before stopping.

Controller Fatigue Continues to Be a Runway Safety Concern

Air traffic controller fatigue continues to be a human factors issue affecting runway safety. In April 2007, for example, NTSB recommended that FAA mitigate concerns about air traffic controller fatigue by (1) working with the National Air Traffic Controllers Association to revise controller work-scheduling policies and practices so controllers would have enough sleep and to modify shift rotations to minimize disrupted sleep patterns for controllers, and (2) developing a fatigue awareness and countermeasures training program for controllers and for the personnel involved in scheduling their work. In supporting its recommendation, NTSB cited four instances from 2001 through 2006 when tired controllers made errors while performing their duties that resulted in serious incursions. NTSB said that although FAA regulations and policies place limits on controller work schedules, for example, by requiring that controllers be provided at least one full 24-hour day off per week, they do not adequately consider the potential effect of work scheduling on fatigue and performance. FAA officials said they were analyzing NTSB's recommendations on air traffic controller fatigue but that implementing them would require renegotiating the agency's contract with the union representing the controllers.

[69]*Audit of Runway Safety Logic Systems*, FAA Air Traffic Oversight Service, Audit Project Number: ADT-FY-07-001 (Washington, D.C.: April 16, 2007).

[70]FAA Order 7210.3 requires that when the safety logic system generates any alert or is offline, it should be documented on the facility's air traffic log.

According to FAA data, as of May 2007, at least 20 percent of the controllers at 25 air traffic control facilities, including towers at several major airports, were working 6-day weeks,[71] which could cause fatigue. FAA officials said that it may take 2 to 3 years before controller overtime can be reduced at some facilities, as the agency acts to replace retiring controllers. In the meantime, the agency officials indicated that they had no plan to mitigate the effects of air traffic controller fatigue.

While FAA has taken some actions to address controller fatigue, problems have been identified with some efforts. For example, an FAA human factors initiative, the National Air Traffic Professional Program, is aimed at identifying how controllers' performance can be affected by factors such as fatigue and distraction. The program consists of training designed to sharpen and maintain controllers' mental skills most closely associated with visual attention and scanning. However, the DOT Inspector General reported in May 2007[72] that the program had not been implemented at towers where visual attention and scanning are key factors in preventing runway incursions. Although FAA has taken some steps to address human factors issues through the educational initiatives that were discussed earlier, progress on addressing runway safety will be impeded until the human factors issues involving fatigue are addressed.

[71]FAA identified 25 facilities with 20 percent or greater of the employees working a 6-day week and 4 percent or greater of the hours were covered by overtime. The 25 facilities included 21 control towers and 4 terminal radar approach control facilities. Of 25 facilities, 12 had between 20 and 29 percent of their controllers working 6-day weeks, 7 had between 30 and 39 percent of their staff working 6-day weeks, and 6 facilities had between 40 to 52 percent of their controllers working 6-day weeks. The 25 facilities included 7 control towers at airports that were ranked among the 50 busiest FAA air traffic control towers in the country, including Hartsfield-Jackson Atlanta International Airport, which is the busiest airport in the country and had 52 percent of its controllers regularly working 6-day weeks.

[72]DOT Office of Inspector General, *Progress Has Been Made in Reducing Runway Incursions, but Recent Incidents Underscore the Need for Further Proactive Efforts*, Report No. AV-2007-050 (Washington, D.C.: May 24, 2007).

FAA Has Not Implemented NTSB's Runway Safety Recommendations

FAA has not implemented any of NTSB's six runway incursion prevention recommendations, made in 2000,[73] that FAA

- require all airports with scheduled passenger service to deploy a ground movement safety system that will prevent runway incursions and provide a direct warning capability to flight crews;
- require that all runway crossings be authorized by specific air traffic control clearance;
- require that, when aircraft need to cross multiple runways, air traffic controllers issue an explicit crossing instruction for each runway;
- discontinue the practice of allowing departing aircraft to hold on active runways at night or at any time when visibility conditions preclude arriving aircraft from seeing traffic on the runway in time to initiate a safe go-around maneuver;
- adopt an ICAO landing clearance procedure that forbids multiple landing clearances for the same runway; and
- require the use of ICAO phraseology for airport surface operations, and periodically emphasize to controllers the need to use this phraseology and to speak at reasonable rates when communicating with flight crews.

Since NTSB made these recommendations 7 years ago, FAA has made some efforts to address them, but NTSB has not accepted FAA's responses. Regarding NTSB's recommendation that a direct incursion warning capability be developed for flight crews, FAA indicated in 2006 that, among other efforts, it had successfully completed promising initial field tests of runway status lights at the Dallas-Ft. Worth International

[73]On August 28, 2007, NTSB made five additional runway safety recommendations to FAA and others. These recommendations included (1) requiring crewmembers on the flight deck to positively confirm and cross-check the airplane's location at the assigned departure runway before crossing the hold short line for takeoff, (2) requiring aircraft operators install on their aircraft cockpits moving map displays or an automatic system that alert pilots when a takeoff is attempted on a taxiway or a runway other than the one intended, (3) requiring airports implement enhanced taxiway centerline markings and surface painted holding position signs at all runway entrances, (4) prohibiting the issuance of a takeoff clearance during an airplane's taxi to its departure runway until after the airplane has crossed all intersecting runways, and (5) suggesting that controllers refrain from performing administrative tasks, such as the traffic count, when moving aircraft are in the controller's area of responsibility.

Airport but that additional tests would be needed to determine if the system could be deployed to airports throughout the country. An NTSB official told us that the board would need to evaluate the runway status lights system before it could determine whether the system would satisfy this recommendation. Regarding NTSB's recommendations that FAA change certain air traffic control procedures, FAA said that implementing the recommendations could possibly transfer the risk to another segment of the operation by increasing pilot and controller workload and radio frequency congestion, and causing unexpected and unnecessary go-around procedures. However, NTSB disagreed, indicating that it remained concerned about situations where pilots may be lost, or believed they have received permission to move to different positions other than those that air traffic controllers intended and that air traffic controllers should not clear aircraft to land on runways that are occupied by other aircraft.

Regarding NTSB's recommendation that FAA adopt ICAO phraseology, FAA indicated in 2004 that adopting certain ICAO phraseology would create inconsistency and nonstandardization throughout the national airspace system. However, NTSB noted that by not adopting the ICAO phraseology, FAA has not harmonized its phraseology with the rest of the world. Two of our survey respondents also suggested that FAA adopt ICAO phraseology in communications between the air traffic controllers and pilots. In August 2007, FAA announced that it plans to assess whether it needs to change the phraseology of taxi clearances given by controllers to better align with ICAO standards, among other planned actions.

FAA Has Opportunities to Improve Runway Safety

The results of our survey of experts indicated that the actions that FAA could take with the greatest potential to prevent runway incursions, considering costs, technological feasibility, and operational changes, were measures to provide information or alerts directly to pilots (see table 4). For example, the actions that FAA could take with the most potential were lighting systems that guide pilots as they taxi at the airport and technology that provides enhanced situational awareness on the airfield and alerts of potential incursions.

Table 4: Experts' Ranking of the Actions that FAA Could Take with the Most Potential to Address Runway Incursions

Ranking	Action
1	Encourage the use of a taxi guidance lighting system
2	Encourage the development of runway incursion warnings in the cockpit
2	Encourage the development of cockpit moving maps that show the location of other aircraft and vehicles on the airfield
2	Encourage the use of yellow embedded lights for hold short lines[a]
3	Encourage the use of Runway Awareness and Advisory System technology, which provides aural situational advisories to pilots on the airfield
3	Improve airport markings

Source: GAO analysis of responses from survey of experts.

[a]Hold short lines are markings indicating where aircraft should hold before receiving permission from air traffic control to enter a runway.

Note: Rankings are based on responses from 22 experts and reflect actions that a majority of experts indicated had "great potential" or "very great potential." Although other actions also received a majority of positive responses, this table reports those that received the highest number of positive responses.

Our survey respondents and international aviation safety experts also said that certain runway safety procedures in other countries have the potential, if adopted, to improve runway safety in the United States. International aviation organization officials said that there is some benefit to having air traffic controllers clear aircraft to holding points—a practice being followed at some airports outside of the United States—rather than directly to runways but that it would increase already-busy radio communications between pilots and the air traffic control tower. In addition, some experts suggested that because of the safety risks involved, FAA should stop using land and hold short procedures, which are mainly used in the United States and involve instructing landing aircraft to land and hold on their runway before crossing an intersection or another runway. Officials from an international aviation organization said that U.S. carriers are generally comfortable with land and hold procedures and understand that they are necessary to manage the large volume of traffic at certain airports. However, they added that the procedures would be greatly improved if they could be agreed upon and promulgated internationally. An expert also suggested that FAA consider deploying progressive taxiway lights that activate as aircraft taxi to or from the runway to help keep aircraft from making wrong turns or entering the runway environment. However, other experts said that progressive taxiway lights are difficult to see in the daytime.

Recognizing the need for additional actions to improve runway safety, on August 15, 2007, FAA met with the aviation community and agreed on a short-term plan, which included some measures that our experts had also recommended. The participants decided to take the following actions during the subsequent 60 days: (1) conduct safety reviews at the airports where runway incursions and wrong runway departures are the greatest concern, (2) disseminate runway safety information and training across the entire aviation industry, (3) accelerate the deployment of improved airport signage and markings at the top 75 airports, and (4) review cockpit and air traffic control procedures, which could include changing cockpit procedures to minimize pilot activities and distractions while an aircraft is moving on the ground and to make air traffic control procedures more precise. On October 22, 2007, FAA announced that among the actions taken, (1) safety reviews at 20 airports had been completed, (2) 104 of 112 air carriers provided pilots with simulator and other training incorporating runway scenarios, (3) runway markings had been upgraded at 52 of 75 medium- and large-sized airports, and (4) 101 of 112 air carriers had reviewed cockpit procedures to identify and develop a plan to address pilot distractions when taxiing to runways. In addition, FAA indicated that it had completed analyzing air traffic control procedures regarding taxi clearances and found that more explicit taxi instructions were needed.

The experts we surveyed also provided suggestions to prevent runway overruns. They said the actions that FAA could take with the greatest potential, considering costs, technological feasibility, and operational changes, included improving communication of runway conditions and weather to flight crews and encouraging improvements in and use of runway condition and friction measurements (data regarding the slickness of a runway). Regarding overseas practices to help prevent overruns, some survey respondents said that more detailed information about runway conditions is provided to pilots in some other countries, which could be communicated to pilots in the United States as they prepare to land. Furthermore, on October 4, 2007, NTSB recommended that FAA require pilots to conduct landing distance assessments before every landing on the basis of existing aircraft performance data, actual conditions, and incorporating a minimum 15 percent safety margin. FAA has not yet responded to this recommendation.

Progress in Addressing Ramp Safety Is Affected by a Lack of Data and Standards, but the Industry Is Taking Action to Address these Issues

The aviation industry has made efforts in recent years to address the incidence of ramp accidents. However, these efforts have been hindered by a lack of data on the nature, extent, and cost of ramp accidents and the absence of industrywide ground handling standards. In response, the federal government and the aviation industry have undertaken additional steps to collect data and develop standards as a means of understanding the problem and reducing the number of accidents.

Lack of Complete Accident Data Hinders Efforts to Address Ramp Safety

We found no source of comprehensive data on airport ramp accidents. Various aviation entities collect ramp accident data, but they are not complete enough to be useful for industrywide analyses, and, in many cases, the entities were not willing for competitive reasons to publicly disclose the data. Many industry stakeholders indicated to us that they lack complete ramp accident data. Without such data, it will be difficult for the aviation industry to understand the nature, extent, and cost of ramp accidents and to allocate appropriate resources and methods to improve ramp safety.

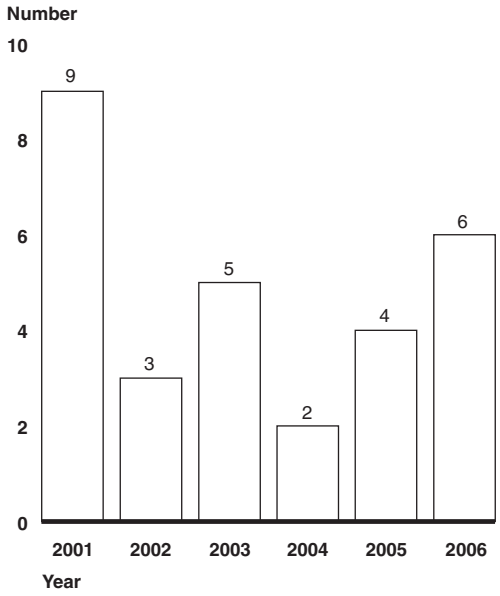
We found that data on ramp fatalities was more readily available than data on nonfatal injuries and accidents without injuries. We reviewed FAA, NTSB, and OSHA ramp fatality data[74] from 2001 through 2006 and determined that these agencies investigated 29 fatal ramp accidents during that time. (See fig. 12.) These accidents occurred at airports of various sizes—from large hubs to small general aviation airports.[75] No airport experienced more than 2 fatalities during this time period. (See app. VI.) Of the 29 fatalities, 17 were ground workers, 8 were passengers, and 4 were pilots. The ramp fatalities generally occurred when these employees were struck by objects (such as vehicles), were crushed, or fell. Most aviation safety officials told us that ramp accidents represent little or no danger to passengers, although a potential danger exists if, for example,

[74]FAA, NTSB, and OSHA have the authority to investigate accidents that occur on the ramp.

[75]Primary commercial service airports are categorized based on the percentage of total annual passenger boardings (enplanements) for all operations of U.S. carriers within the United States. General aviation airports are small airports that do not receive scheduled commercial service.

damage to an aircraft is left unreported. Of the 8 passengers who were killed in ramp accidents from 2001 through 2006, 5 were struck by propellers. Although we obtained data on fatal accidents, it is difficult to determine the true nature and extent of all ramp accidents, including those that result in injuries, because OSHA, the primary source of ramp fatality data, does not collect or report data on occupational injuries other than fatalities that occur in ramp areas. Furthermore, because FAA and NTSB only investigate certain ramp accidents, as discussed earlier, they do not have complete ramp accident data.

Figure 12: Annual Number of Ramp Fatalities at U.S. Airports from 2001 through 2006



Source: GAO analysis of FAA, NTSB, and OSHA data.

Lack of Standards for Ramp Operations Could Hinder Safety

We found no federal or industrywide standards for ramp operations. Each airport authority has its own rules and regulations, which may be based on local ordinances or state laws. In the United States, airlines typically control the ramp areas, and each operates its ramps with its own specific set of policies and procedures. In addition, in recent years, more airlines have been contracting out some or all of these services, and often one ground handling company services the aircraft of several airlines at an airport. In this situation, ground handling companies must carry out their duties in accordance with each airline's policies and procedures, and, because there is no standard for ramp operations, this could lead to

confusion about operating procedures and safety rules and increases the likelihood of accidents.

The Federal Government and the Aviation Industry Are Taking Some Measures to Address Ramp Safety

FAA, OSHA, airports, and airlines are taking various measures to address ramp accidents. According to experts we surveyed, three of the four most effective actions are being taken by airlines, for example, by setting safety targets and using ramp towers (see table 5).

Table 5: Experts' Ranking of the Most Effective Actions by FAA, OSHA, Airports, and Airlines to Address Ramp Accidents

Ranking	Action
1	Airlines setting safety targets for reducing injuries in ramp areas
1	FAA's use of Runway Safety Action Teams
2	Airlines' use of ramp towers
2	Airlines entering into safety alliances with OSHA

Source: GAO analysis of responses from survey of experts.

Note: Rankings are based on responses from 15 experts and reflect the actions that received the highest number of responses indicating that they were "very effective" or "extremely effective." However, none of these actions received a majority of positive responses.

The federal government has generally taken an indirect role in addressing ramp safety. Since August 2000, FAA and OSHA have operated under a memorandum of understanding that gives FAA responsibility for investigating occupational accidents involving flight attendants; in the memorandum, OSHA agreed to continue its enforcement efforts on behalf of other aviation employees, such as ramp workers. However, neither agency has developed a plan or policy to reduce ramp accidents and address ramp safety in a strategic, coordinated manner. FAA's primary tool for enhancing ramp safety is the promotion of a safety management system for aviation service and airport operators through advisory circulars issued in 2006 and 2007.[76] FAA defines a safety management system as the application of a systematic, proactive approach to identifying and mitigating safety risks. The use of safety management systems increases the likelihood that safety problems would be detected and corrected before they result in an accident. However, advisory circulars are voluntary in nature. Although FAA expects to issue a Notice

[76]Advisory Circular 120-92 (June 22, 2006) and Advisory Circular 150/5200-37 (February 28, 2007).

of Proposed Rulemaking in 2008, which would make this guidance mandatory for airport operators, rulemakings often take years to complete.

According to an official with the Air Transport Association, a trade organization representing the airline industry, the safety management system concept invites FAA's acceptance of the continuous improvement process adopted by the carrier and its airport stakeholders. The official added that measuring the effectiveness of mitigation efforts is an essential part of safety management systems. However, only two of the experts we surveyed indicated that FAA's issuance of advisory circulars on safety management systems for airport operators and aviation service providers was very effective in addressing ramp accidents.[77] One expert said that FAA's issuance of an advisory circular does not prompt change, but is a way to reduce the agency's inspection workload. However, another expert said that when safety management systems are required, airports and air carriers will assume a larger role in oversight, data collection, and safety assurance.

OSHA uses industry participation in its voluntary programs to promote ramp safety while also conducting workplace inspections and taking enforcement actions when needed. Twelve[78] airlines and the National Safety Council, a nonprofit, nongovernmental, public service organization dedicated to protecting life and promoting health, maintained a national alliance addressing ergonomic issues associated with customer checked baggage handling with OSHA from November 2002 to November 2006. This alliance resulted in several tools for enhancing ramp safety, including an OSHA e-Tool on baggage handling safety and an OSHA Web page detailing the agency's assistance for the airline industry. The Air Transport Association has initiated discussions with OSHA about forming an alliance to address ramp vehicle safety. Three of 13 experts we surveyed indicated that airlines entering into safety alliances with OSHA to address ramp

[77]Of the 14 respondents to the question regarding the effectiveness of FAA's issuance of advisory circulars on safety management systems for airport operators, 2 said that it was very effective, 3 moderately effective, 7 slightly effective, and 2 not at all effective. Of the 13 respondents to the question regarding the effectiveness of FAA's issuance of advisory circulars on safety management systems for aviation service providers, 2 said it was very effective, 3 moderately effective, 7 slightly effective, and 1 not at all effective.

[78]Thirteen airlines originally entered into this alliance with OSHA. When the alliance was renewed, 12 airlines participated in the alliance.

accidents was very or extremely effective.[79] One expert, for example, said that OSHA safety alliances are an extremely effective way for air carriers to develop mitigation strategies in concert with OSHA. However, another expert said that airlines entering into alliances with OSHA have no real effect on ramp safety because OSHA's focus is on preventing personal injury, not aircraft damage.

OSHA's workplace inspections—which are initiated in response to fatalities or serious injuries, such as amputations, complaints, or data indicating that an industry is experiencing a high rate of illness or injury—may result in OSHA proposing that the employer be fined. For example, on July 25, 2007, OSHA proposed fines totaling about $72,500 against an airline for alleged violations of workplace safety standards in its ramp area at one airport.[80] According to OSHA safety enforcement officials, proposed fines are intended to serve as a deterrent to unsafe practices in the workplace and are sometimes reduced after the employers take corrective actions, show good faith, or have a favorable safety history.[81] However, as we reported in 2005 on FAA's safety enforcement efforts, reductions in proposed fines may weaken any deterrent effect that would be expected from sanctions.[82] Only 2 of 13 experts we surveyed indicated that OSHA's safety enforcement actions were very effective in addressing ramp accidents.[83]

[79]Of the 13 respondents, 1 said it was extremely effective, 2 very effective, 3 moderately effective, 6 slightly effective, and 1 not at all effective.

[80]OSHA's inspection of this airline's worksite was done as part of the agency's Site-Specific Targeting Program. The worksites that OSHA inspects under this program are identified from data on employee illness and injuries that the agency collects each year from about 80,000 nonconstruction employers.

[81]OSHA does not routinely maintain data on the number of safety inspections conducted in airport ramp areas or the amount of fines that it proposed regarding violations in those areas. At our request, OSHA officials broke out how much the fine indicated above pertained to violations in the ramp area. According to the 2005 Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses, scheduled air transportation industry employees had the eighth highest rate compared to other industries, but the data are not broken out to identify the portion represented by ramp workers.

[82]GAO, *FAA's Safety Oversight System is Effective but Could Benefit from Better Evaluation of Its Programs' Performance*, GAO-06-266T (Washington, D.C.: Nov. 17, 2005).

[83]Of the 13 respondents, 2 said it was very effective, 4 moderately effective, 3 slightly effective, and 4 not at all effective.

Several airport officials we interviewed had initiated efforts to improve ramp safety at their airports, even though their ramp areas are typically under the control of one or more airlines. For example, a Massachusetts Port Authority official said that ramp accidents at the Boston Logan International Airport were reduced by 50 percent during a 6-month period during 2004 and 2005 after they implemented a ramp safety program. Other airport officials said they had used their local Runway Safety Action Teams as forums or initiated their own efforts for addressing ramp safety issues. In addition, the Seattle-Tacoma International Airport uses a ramp tower and ASDE-X surface movement radar to monitor ramp activities. Of 15 survey respondents, 4 experts indicated that the use of Runway Safety Action Teams was very or extremely effective in addressing ramp accidents, and 2 indicated that surface surveillance technology was very effective.[84] One expert indicated that Runway Safety Action Teams are an extremely important venue that can involve all airport stakeholders in a collaborative process to identify hazards, perform a risk assessment, and develop mitigation strategies and measure their effectiveness. Of 15 survey respondents, 2 experts indicated that airports' use of ramp towers was very or extremely effective in addressing ramp accidents,[85] and 3 indicated that airlines' use of ramp towers was very effective.[86] One expert said that ramp towers improve operational safety but that all operations are still not completely visible.

We spoke with officials from two U.S. airlines about measures they were taking to improve ramp safety. One of those airlines is using and the other plans to use a Web-based surface surveillance system at certain hubs to track the movements of ground vehicles and aircraft. Although the airline's purpose for purchasing the system was for greater efficiencies in its ground operations, an official from that airline said he believed that increased safety was an additional benefit of the system because it significantly improved situational awareness. Although not specifically tracked, the airline believes it has had fewer ground accidents and

[84]Of the 15 respondents, 1 said the use of Runway Safety Action Teams was extremely effective, 3 very effective, 7 moderately effective, and 4 slightly effective. In addition, of 15 respondents, 2 said that airports' use of surface surveillance was very effective, 8 moderately effective, and 5 slightly effective.

[85]Of the 15 respondents, 1 said it was extremely effective, 1 very effective, 7 moderately effective, 4 slightly effective, and 2 not at all effective.

[86]Of the 15 respondents, 3 said it was very effective, 7 moderately effective, 3 slightly effective, and 2 not at all effective.

incidents since implementing the system. Officials at another airline said they were addressing ramp safety further by incorporating a safety management system into the ramp procedures in the airline's operations manual, including specific ground safety training as a component of recurrent training required annually. In addition, the airline has established annual goals for reducing employee injuries and ground damage. The airline reported the setting of a goal appears effective and has resulted in a significant decrease in employee injuries and ground damage over the prior year. Officials from this airline also said that the airline had formed a safety action team to share best practices with its ground handling partners and to review their safety performance, resulting in an incident rate for the airline's partners that has been greatly reduced in the last two years and continues to improve. The experts we surveyed had mixed views on the effectiveness of airlines setting safety targets for reducing injuries in ramp areas in addressing ramp accidents. Four of 15 experts indicated that it was very effective, 6 said it was moderately effective, and 5 indicated it was slightly or not at all effective. One expert said that airlines have set safety targets for reducing injuries in ramp areas for years and failed to achieve discernable results.

Aviation industry groups also have efforts under way to address the lack of data for ramp accidents as well as the lack of standards for ramp operations. In 2003, the Flight Safety Foundation, an international nonprofit membership organization that researches and promotes aviation safety, started the Ground Accident Prevention Program to "analyze equipment damage and human injuries and develop methods of preventing such accidents." The program is now in its third phase, in which it will identify and encourage technical solutions to ramp safety problems along with continued data collection and analysis. Next year, the International Air Transport Association, an international airline association, plans to start a safety audit program of ground handling companies with the aim of improving operational safety by establishing a "worldwide ground operational safety benchmark and standard." The program will be available to all ground service providers, who, after successfully completing the audit, will be placed on a registry for an agreed-upon period. In addition, the National Air Transportation Association, which represents companies that own, operate, and service aircraft primarily for the general aviation community, has launched an industry-wide effort to collect ramp incident data and has goals of identifying best practices, reducing insurance claims, and lowering insurance costs. The Airports Council International, an organization that represents airports worldwide, publishes the *Airside Safety Handbook* as one component of its efforts to help airports operate more safely. Finally, the Air Transport Association

collects, aggregates, and shares ground incident damage and injury data to its members. The data are reviewed at the association's quarterly Ground Safety Committee meetings and form a basis for assessing risk, developing mitigation strategies, and measuring effectiveness. According to the association, airlines freely share best practices concerning safety and many airlines perform ground servicing of aircraft (fuel, potable water, baggage handling, etc.) for one another.

Additional Measures May Improve Ramp Safety

The results of our survey of experts indicated that the actions that FAA, OSHA, airports, or airlines could take with greatest potential of preventing ramp accidents, considering costs, technological feasibility, and operational changes, included promoting a safety culture, standardizing airport ramp markings, improving or increasing training of ramp workers, increasing the supervision of ramp workers, and developing safer equipment designs (see table 6).

Table 6: Experts' Ranking of the Actions that FAA, OSHA, Airports, or Airlines Could Take with the Most Potential to Address Ramp Accidents

Ranking	Action
1	Promote a safety culture in ramp areas
2	Standardize airport ramp markings
2	Improve or increasing training of ramp workers
2	Increase supervision of ramp workers
3	Develop safer designs of ramp equipment

Source: GAO analysis of responses from survey of experts.

Note: Rankings are based on responses from 15 experts and reflect the actions that a majority of respondents indicated had "great potential" or "very great potential."

One expert said that as part of an improved safety culture—which experts in our survey indicated was the most effective action to address ramp accidents—management must recognize the connection between the occurrence of ramp incidents and accidents and its demand for quick aircraft turnaround times. Turnaround times are an important cost factor for airlines. Another expert said that standardizing ramp markings would be beneficial because the markings can be confusing for pilots. One of the experts indicated, however, that while improving and increasing the training of ramp workers would be beneficial, high job turnover among ramp employees is also part of the problem. Furthermore, a report

prepared by an aviation industry group in 2004[87] cited inadequate training and high turnover of ramp workers, particularly aircraft fuelers, as contributing factors in ramp accidents. The report also indicated that low wages contributed to high rates of employee turnover. One of the experts we surveyed indicated that poor pay attracts a group of ramp workers that exhibit high turnover rates, language issues, and work ethic challenges. Similarly, in reports that we issued before the September 11, 2001, terrorist attacks, we cited high turnover and low wages among airport security screeners as factors affecting the effectiveness of performing their security duties.[88]

Some aviation industry officials and experts said that ramp safety in the United States might be improved through the use of new technology. One example is a ground pop-up system[89] to handle aircraft fueling and other ramp services, which is used at airports in Zhuhai, China, and Stockholm, Sweden. An expert said that a ground pop-up system reduces ramp congestion and the chance of vehicle collisions and injuries. In addition, some aviation officials said that new baggage loading technology could help make the ramp environment safer for ramp workers. New baggage loading technologies include the sliding carpet[90] and RampSnake®.[91] However, an international aviation safety official said that although these new baggage loading devices could improve working conditions and effort required by baggage loaders, it is not readily apparent how such devices could help prevent ramp accidents. This official also noted the high cost of a ground pop-up system and that it is inflexible to accommodate changed aircraft parking arrangements and different aircraft types. The potential effectiveness of safer designs of ramp equipment was supported by the experts we surveyed, the majority of whom said that developing safer

[87]Airport Operations Safety Panel, *Reducing Accidents and Improving Safety on the Ramp* (Palm Beach Gardens, FL: June 15, 2004).

[88]GAO, *Aviation Security: Long-Standing Problems Impair Airport Screeners' Performance*, GAO/RCED-00-75, (Washington, D.C.: June 28, 2000) and *Aviation Security: Vulnerabilities Still Exist in the Aviation Security System*, GAO/T-RCED/AIMD-00-142 (Washington, D.C.: April 6, 2000).

[89]Equipment to service aircraft pops up from beneath the ramp when needed and returns below afterwards.

[90]The sliding carpet is an aircraft-based system for positioning cargo once it is placed in the hold of a commercial aircraft.

[91]The RampSnake® is a ramp-based system that delivers cargo into the cargo hold and is capable of turning 90 degrees once inside the aircraft.

designs of ramp equipment had great or very great potential in addressing ramp accidents.[92] An International Air Transport Association official also indicated that high-density airports outside of the United States typically have a higher degree of control and coordination between the ramp and air traffic controllers, which can contribute to safety.

Aviation industry stakeholders expressed diverse views about whether the federal government should increase ramp safety oversight and if so, which agency should carry out that increased oversight. Officials from a union representing ramp workers favored increased FAA and OSHA oversight of ramp operations because they felt this would lead to more and better training for ramp workers, the implementation of standardized procedures, and a focus on ramp safety equal to that provided to runway safety. However, an airport association official said that increasing FAA's oversight in the ramp area would not be the best use of the agency's resources because the safety risks are greater on the airfield, where an aircraft collision could result in many fatalities. In addition, a Flight Safety Foundation official said that additional FAA ramp safety oversight is not needed because FAA's focus is on passenger safety and that the agency would have difficulty identifying additional resources to oversee ramps. An author of reports on ramp accidents issued by an aviation industry group said that OSHA should do more to regulate safety on the ramp because, in his view, FAA lacks knowledge of industrial safety issues. However, an airline association official said that increased OSHA oversight of ramp operations would have little potential until OSHA develops national standards and appropriate regulations for airport ramp operations. This airline association official also said that the lack of a voluntary disclosure reporting program for OSHA-regulated incidents impedes improving safety in the ramp area. OSHA officials, however, said that very few industries have their own workplace safety standards, and that the agency is devoting the appropriate amount of resources for inspecting airport ramps because its safety inspections overall are selected largely on the basis of injury and illness data and complaints. However, they were not able to identify how many inspections of ramp areas were prompted by data. FAA officials said that they do not have responsibility for ramp safety and that their jurisdiction is limited to the movement areas. They also noted that ramp areas are normally under the jurisdiction of state and local authorities but that ultimately the airport operator has

[92]Of 15 respondents, 10 said that it had great or very great potential, 3 moderate potential, and 2 little potential.

responsibility for ramp safety unless the area is leased to an air carrier or fixed-base operator.

Conclusions

FAA took a number of actions to address runway safety since the number and rate of incursions reached a peak in fiscal year 2001. However, as runway safety incidents declined, FAA's runway safety efforts subsequently waned. During that period of decreased attention, the number and rate of incursions remained relatively constant and at a level higher than any time during the 1990s. Moreover, preliminary data for fiscal year 2007 indicate the overall incursion rate increased to a level nearly as high as the 2001 peak. In addition, serious incursions, where collisions were narrowly or barely avoided, continue to occur—about 30 per year since fiscal year 2002—suggesting a high risk of a catastrophic runway collision occurring in the United States. Furthermore, in recent years, FAA's Office of Runway Safety has not been fulfilling its mission to coordinate and lead the agency's runway safety efforts. The absence of national leadership and a current national runway safety plan impede further progress on runway safety because no single office is taking charge of assessing the causes of runway safety problems. This situation has resulted in uncoordinated runway safety efforts by individual FAA offices. FAA recently hired a runway safety director, which is a good first step. However, other plans for the program are still being developed, and it is too early to know if the office will provide sustained attention to runway safety problems.

FAA's runway safety program also lacks certain data on the causes and circumstances of incursions and overruns. FAA has planned since 2004 to develop a voluntary reporting system for air traffic controllers, which would increase the amount of data available on runway incursions, but it is not clear when such a program will be established. Without additional data, FAA cannot conduct additional analysis of the causes and circumstances of runway incidents to ensure that the most effective corrective measures that address the causal factors are used. In addition, the fact that air traffic controllers at some of the nation's busiest airports are regularly working 6-day weeks due to staffing shortages raises questions about the extent to which regularly working overtime may cause fatigue, which NTSB has cited as a contributing factor in air traffic control errors. Furthermore, the nature and scope of ramp accidents are unknown. FAA is not working with the aviation industry and OSHA to help collect and analyze ramp accident data, which could identify the causes and circumstances of ramp accidents, and identify corrective actions. Without such data, FAA and the aviation industry will be hindered in

understanding the nature and extent of ramp accidents, which would help identify measures to improve ramp safety.

Recommendations

To advance efforts to improve runway safety, we recommend that the Secretary of Transportation direct the FAA Administrator to take the following five actions:

- Implement the FAA order establishing the Office of Runway Safety to lead the agency's runway safety efforts, including preparing a new national runway safety plan. The plan should include goals to improve runway safety; near- and longer-term actions designed to reduce the severity, number, and rate of runway incursions; timeframes and resources needed for those actions; and a continuous evaluative process to track performance towards those goals. The plan should also address the increased runway safety risk associated with the expected increased volume of air traffic.
- Develop an implementation schedule for establishing a nonpunitive voluntary safety reporting program for air traffic controllers.
- Develop and implement a plan to collect data on runway overruns that do not result in damage or injury for analyses of trends and causes such as the locations, circumstances, and types of aircraft involved in such incidents.
- Develop a mitigation plan for addressing controller overtime that considers options such as shift changes and incentives to attract controllers to facilities with high volumes of air traffic and high rates of controller overtime.
- Work with the aviation industry and OSHA to develop a mechanism to collect and analyze data on ramp accidents and, if the analysis shows it is warranted, develop a strategic plan aimed at reducing accidents involving workers, passengers, and aircraft in the ramp area. The plan should include a discussion of roles and responsibilities, performance measures, data collection and analysis, and milestones, and consider ramp safety practices being followed in other countries.

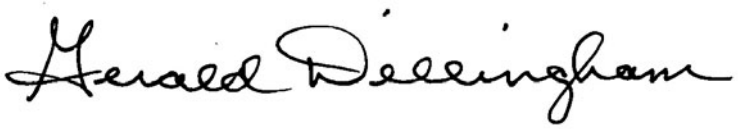
Agency Comments

We provided DOT and the Department of Labor with drafts of this report for their review and comment. FAA agreed to consider the report's recommendations and provided technical corrections and clarifications,

which we incorporated as appropriate. The Department of Labor had no comments but provided a technical correction, which we incorporated.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies of this report to interested congressional committees and to the Secretary of Transportation and the Secretary of Labor. We will make copies available to others upon request. In addition, this report will be available at no charge on our Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me on (202) 512-2834 or at dillinghamg@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix VII.



Gerald L. Dillingham, Ph.D.
Director, Physical Infrastructure Issues

Appendix I: Objective, Scope, and Methodology

Our objective was to review how well the Federal Aviation Administration (FAA) and others are addressing runway and ramp safety issues. To accomplish this, we established the following questions: (1) What progress is being made in addressing runway safety, and what additional measures, if any, could be taken? and (2) What factors affect progress in improving ramp safety and what is being done by FAA and others to address those factors?

For background information on runway and ramp safety issues, we reviewed reports prepared by FAA, the National Transportation Safety Board (NTSB), the Department of Transportation's (DOT) Inspector General, and others; FAA orders, advisory circulars, and regulations; and applicable laws. We also determined the roles and responsibilities involving runway and ramp safety of FAA, NTSB, the Occupational Safety and Health Administration (OSHA), airports, and airlines. Regarding runway incursions, we obtained data on the number and rates of incursions from fiscal year 1998 through fiscal year 2007 and reviewed NTSB accident reports on incursions that resulted in collisions during that time. We also obtained runway incursion data from fiscal year 2001 through fiscal year 2006 broken down by severity, error types, and frequency of incursions involving general aviation and commercial aircraft. Regarding runway overruns, we collected data on overruns that NTSB investigated from fiscal year 2001 through fiscal year 2006. Regarding ramp accidents, we obtained information on ramp accident fatalities that were investigated by FAA, NTSB, and OSHA from 2001 through 2006. Based on interviews with officials knowledgeable about the data contained in this report, we determined that runway and ramp safety data were sufficiently reliable for the types of analyses that we performed for this report such as trends in runway incursions, the incidence of fatalities in airport ramp areas, and frequency of air traffic controller overtime.

To determine what progress is being made in addressing runway safety and what additional measures could be taken, we reviewed the status of FAA's implementation of objectives contained its 2002 national runway safety plan and the status of the runway safety recommendations that NTSB made to FAA. We also evaluated FAA's compliance with orders establishing the agency's runway safety and runway safety area programs; FAA's collection and analysis of runway safety data, including the process that the agency follows to assess the severity of runway incursions; and findings made by FAA's Air Traffic Safety Oversight Service on the agency's runway incursion severity classification process and runway safety technology. We also looked at how taxiways affect runway safety.

To help identify the causes of runway incursions and measures being taken to prevent them, we interviewed FAA and airport officials at five airports that have experienced more runway incursions than other airports in recent years.[1] Because technology is a major part of FAA's strategy to improve runway safety, we discussed the agency's efforts to develop and deploy technology with program officials, visited five airports where new technology was being tested and used to observe their operation, reviewed data on the systems' performance, and interviewed FAA air traffic controllers and managers and aviation industry officials about their views on the effectiveness of the technology. In addition, we reviewed the implementation status of Public Law No. 109-115, which requires commercial service airports to bring their runway safety areas into compliance with FAA standards by 2015. We also interviewed officials from FAA's William J. Hughes Technical Center, DOT's Volpe National Transportation Systems Center, and the National Aeronautics and Space Administration's Ames Research Center about their runway safety research projects. In addition, we interviewed officials from international aviation organizations about runway safety practices and technologies being used overseas that could be used in the United States.

To determine the factors affecting progress in improving ramp safety and what is being done by FAA and others to address those factors, we interviewed officials from FAA, airports, and aviation industry organizations; members of the Airport Operations Safety Panel, an aviation industry group that issued reports on ramp accidents in 2004 and 2005; union officials representing ramp workers and pilots; and other individuals knowledgeable about ramp safety. In addition, we interviewed OSHA officials about the agency's industry alliance program and enforcement efforts. We also interviewed officials from international aviation organizations about ramp safety practices and technologies being used overseas that could be used in the United States.

Table 7 lists the organizations that we visited or contacted regarding runway and ramp safety.

[1]They included Los Angeles International Airport, Boston Logan International Airport, Dallas-Ft. Worth International Airport, Hartsfield-Jackson Atlanta International Airport, and Newark Liberty International Airport. These five airports were among the 10 U.S. airports that experienced the most runway incursions from fiscal year 2001 through fiscal year 2006.

Table 7: List of Organizations that GAO Visited or Contacted Regarding Runway and Ramp Safety

Industry category	Organization interviewed
U.S. government agencies	Department of Labor Bureau of Labor Statistics
	Department of Labor Occupational Safety and Health Administration
	Department of Transportation Volpe National Transportation Systems Center
	Federal Aviation Administration
	Joint Planning and Development Office
	National Aeronautics and Space Administration
	National Transportation Safety Board
FAA regional runway safety program managers	Eastern Region
	New England Region
	Southeast Region
	Western Region
FAA air traffic control personnel	Bob Hope Airport, Burbank, CA
	Bradley International Airport, Hartford, CT
	Dallas-Ft. Worth International Airport
	General Mitchell International Airport, Milwaukee, WI
	Hartsfield-Jackson Atlanta International Airport
	Lambert-St. Louis International Airport
	Long Beach Airport, Long Beach, CA
	Los Angeles International Airport
	Newark Liberty International Airport
	Orlando International Airport
	San Diego International Airport
	Seattle-Tacoma International Airport
	Spokane International Airport, Spokane, WA
	Theodore Francis Green State Airport, Providence, RI
	William P. Hobby Airport, Houston, TX
Airports	Bob Hope Airport, Burbank, CA
	Boston Logan International Airport
	Dallas-Ft. Worth International Airport
	Hartsfield-Jackson Atlanta International Airport
	Long Beach Airport, Long Beach, CA
	Los Angeles International Airport

Industry category	Organization interviewed
	Newark Liberty International Airport
	San Diego International Airport
	Spokane International Airport, Spokane, WA
Industry organizations	Air Line Pilots Association
	Air Safety Foundation
	Air Transport Association
	Airports Council International
	International Air Transport Association
	International Association of Machinists and Aerospace Workers
	National Air Traffic Controllers Association
	National Air Transportation Association
	Regional Airline Association
Others	Airport Operations Safety Panel
	Boeing
	Commercial Aviation Safety Team
	Continental Airlines
	Flight Safety Foundation
	International Civil Aviation Organization
	Northwest Airlines
	Robinson Aviation
	Sensis Corporation

Source: GAO.

We conducted our work from October 2006 through November 2007 in accordance with generally accepted government auditing standards.

Appendix II: Survey Methodology

We administered a 2-phase Web-based survey to gather the professional views of experts on runway incursions, runway overruns, and ramp safety. The structured survey questions ensured that all individuals had the opportunity to provide information in response to the same questions and enabled us to quantify the results. Moreover, the iterative nature of the 2-phase survey provided the experts with the opportunity to identify future actions that could be taken to prevent incursions, overruns, and ramp accidents and then to evaluate the potential of the future actions that they and the other experts identified.

We contracted with the National Academy of Sciences to identify experts to participate in our survey. Using criteria to ensure adequate representation across the criteria that we had specified, the National Academy identified 19 experts and we identified ten. The criteria ensured that we achieved

- balance in terms of the type and depth of expertise (i.e., pilots, airline officials, aircraft manufacturing officials, association representatives, academics, foreign civil aviation authorities, unions representing airlines, air traffic controllers, ramp workers, Federal Aviation Administration (FAA) maintenance and safety inspectors, professors and researchers involved in aviation safety);

- balance of knowledge across relevant content areas (i.e., effectiveness of measures being used to address runway incursions, overruns, and ramp accidents; technology research, testing, and use; FAA air traffic control practices and procedures; international aviation safety practices, human factors issues; general aviation; airports; and ground operations); and

- balance in representing relevant organizations (i.e., academia, business, government, and professional organizations).

The survey responses represent the professional views of the experts. Their expertise can be derived from formal education, professional experience, or both. The experts were identified by the National Academy and us as individuals who are recognized by others who work in the same subject matter area as having knowledge that is greater in scope or depth than that of most people working in the area.

We recognize that it is likely that no one individual possessed complete knowledge in each of the content areas addressed in the survey: runway incursions, runway overruns, and ramp accidents. However, through our selection criteria, we attempted to identify a set of individuals who, when

their responses were considered in the aggregate, could be viewed as representing the breadth of knowledge in each of the areas addressed in the survey.

We identified the information to collect in our surveys based on our congressional request, Internet and literature searches, professional conferences we attended, and background interviews. A social science survey specialist collaborated with staff with subject matter expertise on the development of the surveys.

We developed a 2-phase Web-based survey. The first survey contained open-ended questions asking respondents to identify the primary causes of runway incursions, runway overruns, and ramp accidents; overseas practices and technologies that could be used in the United States; and future actions, including the development of new technology that FAA could take in the future to prevent incursions, overruns, and ramp accidents. The responses to the questions on future actions were analyzed and coded into categories that were then used as the basis for the questions on future actions in the second survey. A reviewer checked the resulting categories and coded responses and, where interpretations differed, agreement was reached between the initial coder and the reviewer. As an extra step to check the completeness of the list of future actions that was generated by the experts we corroborated the list with other evidence we had collected as a part of our study and found that many of the same actions the experts identified were also identified through our other study efforts.

The same set of respondents was also sent the second survey. As mentioned above, the second survey contained closed-ended questions asking respondents to evaluate the potential of the future actions that could be taken to prevent runway incursions, runway overruns, and ramp accidents. Other closed-ended questions addressed the effectiveness of specific actions that FAA and others are taking to address runway incursions, runway overruns, and ramp accidents; the accuracy of FAA reporting on runway incursions that have occurred since January 1, 2001; and whether the deployment schedule of the Airport Surface Detection Equipment, Model-X (ASDE-X) at 27 additional airports by 2011 should be kept as planned or changed, considering some of the benefits and problems associated with the system.

Both surveys were pretested to ensure that the questions appropriately addressed the topics, were clearly stated, easy to comprehend, unbiased, and did not place undue burden on respondents. We also evaluated the

usability of the Web-based surveys. Based on the pretest results, we made necessary changes to the surveys prior to implementation.

We administered the Web-based surveys between June and September 2007. We used e-mail to inform the respondents of the survey administration, and provided them with the Web link for the survey and their log-in name and password. In the e-mail message, we informed respondents that our report will not contain individual survey responses; instead, it would present the aggregated results of all participants. To maximize the response rate, we sent follow up e-mail reminders and followed up by telephone as necessary to encourage survey participation.

The first survey was sent to 27 experts. Two experts did not respond and were not included in the second survey. As a result, 25 of 27 experts responded to the first survey for a response rate of 93 percent.

The second survey was sent to the 25 experts who responded to the first survey. Twenty-two of the 25 experts responded for a response rate of 88 percent.

The number of responses varied for each of the survey content areas—runway incursions, runway overruns, and ramp accidents—because we asked the experts to answer questions only within their areas of expertise. In addition, the number of responses may vary by question because we do not report the number of experts who responded "Don't know" or "No basis to judge." We report the survey results in terms of actions that are most effective or future actions that have the most potential. For tables 1 and 6, the actions that we report as being the most effective or having the most potential were the ones that a majority of respondents indicated were very or extremely effective for the effectiveness questions or great or very great potential for the questions asking about potential. For table 4, the actions that we report as having the most potential reflect the ones that a majority of experts indicated as having great potential or very great potential. Although other actions also received a majority of positive responses, this table reports the ones that received the highest number of positive responses. For table 5, the actions that we report received the highest number of responses indicating that they were very effective or extremely effective. However, none of these actions received a majority of positive responses.

The first survey, which was administered via the Web, included 12 questions shown in figure 13.

Figure 13: Questions Asked in First Survey

1.	Do you have expertise in runway incursions to be able to answer the following three questions on the causes of runway incursions, overseas practices and technology, and future actions to prevent runway incursions?
2.	In your opinion, what are the primary causes of runway incursions?
3.	What practices or technologies that are currently being used overseas could be used in the United States to prevent runway incursions?
4.	What actions, including the development of new technologies, could FAA take in the future to prevent runway incursions?
5.	Do you have expertise in runway overruns to be able to answer the following three questions on the causes of runway overruns, overseas practices and technology, and future actions to prevent runway overruns?
6.	In your opinion, what are the primary causes of runway overruns?
7.	What practices or technologies that are currently being used overseas could be used in the United States to prevent runway overruns?
8.	What actions, including the development of new technologies, could FAA take in the future to prevent runway overruns?
9.	Do you have expertise in ramp accidents to be able to answer the following three questions on the causes of ramp accidents, overseas practices and technology, and future actions to prevent ramp accidents?
10.	In your opinion, what are the primary causes of ramp accidents?
11.	What practices or technologies that are currently being used overseas could be used in the United States to prevent ramp accidents?
12.	What actions, including the development of new technologies, could FAA take in the future to prevent ramp accidents?

Source: GAO.

The second phase of the survey was also administered via the Web and is reproduced as a graphic image on the following pages.

Survey on Runway and Ramp Safety - Second Phase

U.S. Government Accountability Office

Click here to learn more about navigating, saving, and exiting the survey, copying and pasting text responses, and printing all your responses at one time.

Please be aware that you can print your responses to all the questions at one time using the link at the end of the survey.

RUNWAY INCURSIONS

1. **Do you have expertise in *runway incursions* to be able to answer questions on actions to address *runway incursions*?**
   (Check one.)
   1. ○ Yes
   2. ○ No (Click here to skip to question 7.)

Actions to address runway incursions

2. **In your opinion, how effective, if at all, are the following FAA actions to address *runway incursions*?**
   (Choose one answer for each row.)

		Extremely effective	Very effective	Moderately effective	Slightly effective	Not at all effective	Don't know/No basis to judge
2a.	Deploying the Airport Movement Area Safety System (AMASS) and Airport Surface Detection Equipment-3 (ASDE-3) (AMASS and ASDE-3 work together)	○	○	○	○	○	○
2b.	Deploying the Airport Surface Detection Equipment, Model X (ASDE-X)	○	○	○	○	○	○
2c.	Testing the Final Approach Runway Occupancy Signal (FAROS), which provides a visual warning to aircraft that the runway is occupied	○	○	○	○	○	○

2d.	Testing the Low Cost Surface Surveillance System (LCSS)	○	○	○	○	○	○
2e.	Enhancing airport markings	○	○	○	○	○	○
2f.	Enhancing airport signage	○	○	○	○	○	○
2g.	Enhancing airport lighting	○	○	○	○	○	○
2h.	Establishing Runway Safety Action Teams	○	○	○	○	○	○
2i.	Testing the Runway Status Lights System	○	○	○	○	○	○
2j.	Approving perimeter taxiways	○	○	○	○	○	○
2k.	Conducting pilot educational initiatives, such as seminars	○	○	○	○	○	○
2l.	Conducting air traffic controller training	○	○	○	○	○	○

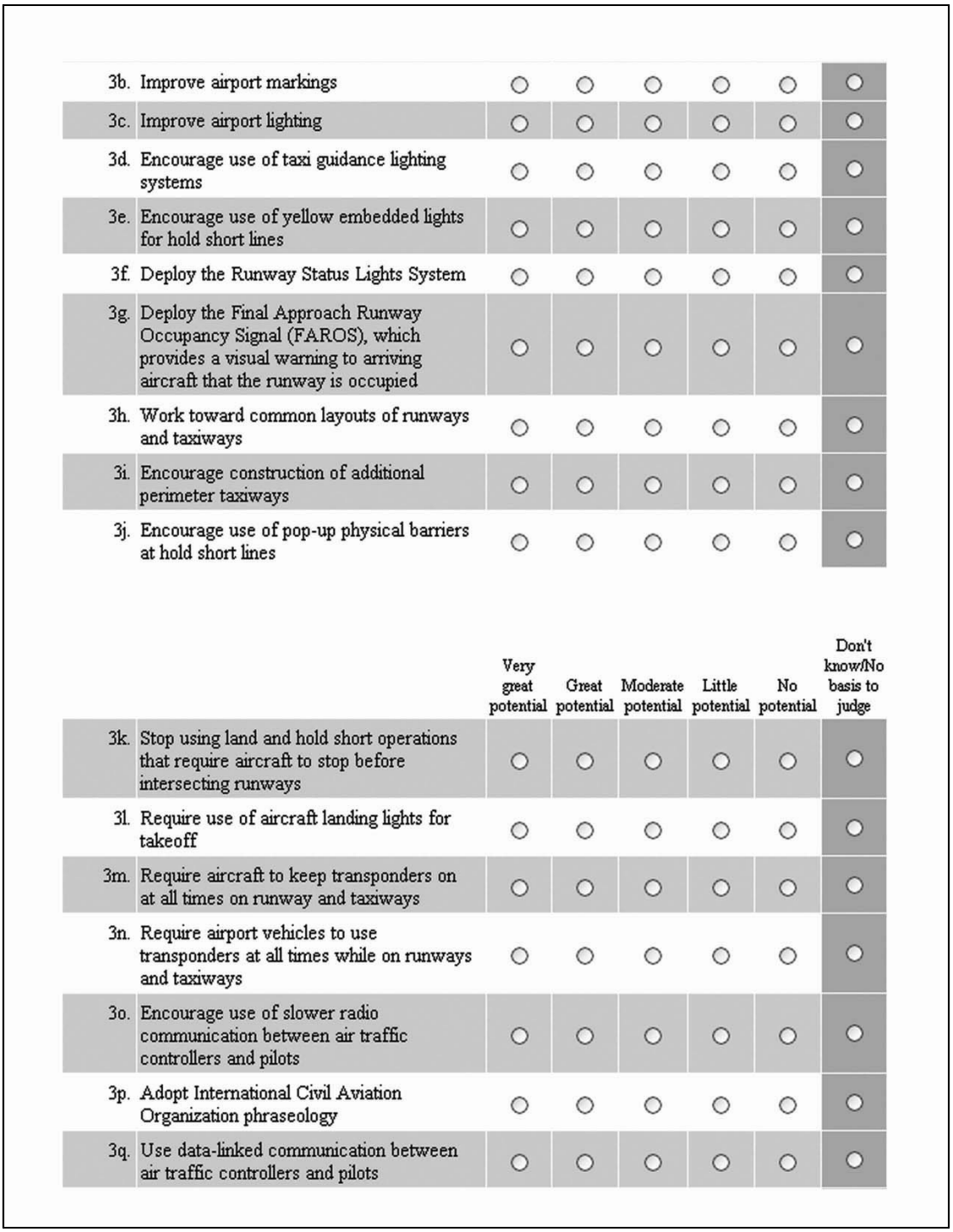
If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which FAA action you are discussing.

Future actions to prevent runway incursions

3. **In your opinion, what is the potential--considering costs, technological feasibility, and operational changes--of the following actions that FAA could take to prevent *runway incursions*?**

(Choose one answer for each row.)

		Very great potential	Great potential	Moderate potential	Little potential	No potential	Don't know/No basis to judge
3a.	Improve airport signage	○	○	○	○	○	○



3b.	Improve airport markings	○	○	○	○	○	○
3c.	Improve airport lighting	○	○	○	○	○	○
3d.	Encourage use of taxi guidance lighting systems	○	○	○	○	○	○
3e.	Encourage use of yellow embedded lights for hold short lines	○	○	○	○	○	○
3f.	Deploy the Runway Status Lights System	○	○	○	○	○	○
3g.	Deploy the Final Approach Runway Occupancy Signal (FAROS), which provides a visual warning to arriving aircraft that the runway is occupied	○	○	○	○	○	○
3h.	Work toward common layouts of runways and taxiways	○	○	○	○	○	○
3i.	Encourage construction of additional perimeter taxiways	○	○	○	○	○	○
3j.	Encourage use of pop-up physical barriers at hold short lines	○	○	○	○	○	○

		Very great potential	Great potential	Moderate potential	Little potential	No potential	Don't know/No basis to judge
3k.	Stop using land and hold short operations that require aircraft to stop before intersecting runways	○	○	○	○	○	○
3l.	Require use of aircraft landing lights for takeoff	○	○	○	○	○	○
3m.	Require aircraft to keep transponders on at all times on runway and taxiways	○	○	○	○	○	○
3n.	Require airport vehicles to use transponders at all times while on runways and taxiways	○	○	○	○	○	○
3o.	Encourage use of slower radio communication between air traffic controllers and pilots	○	○	○	○	○	○
3p.	Adopt International Civil Aviation Organization phraseology	○	○	○	○	○	○
3q.	Use data-linked communication between air traffic controllers and pilots	○	○	○	○	○	○

3r.	Deploy ASDE-X at more airports than the *8 that currently have the system and the 27 scheduled to receive it* (Click link to see list of airports.)	○	○	○	○	○	○

		Very great potential	Great potential	Moderate potential	Little potential	No potential	Don't know/No basis to judge
3s.	Refine the ASDE-X safety logic (alerting system)	○	○	○	○	○	○
3t.	Deploy ground radar at all FAA-controlled airports	○	○	○	○	○	○
3u.	Deploy the Low Cost Surface Surveillance System	○	○	○	○	○	○
3v.	Encourage development of certified cockpit heads up display	○	○	○	○	○	○
3w.	Encourage the development of cockpit moving map displays that show the location of other aircraft and vehicles on the airfield	○	○	○	○	○	○
3x.	Encourage the development of runway incursion warnings in the cockpit	○	○	○	○	○	○
3y.	Encourage the use of Runway Awareness and Advisory System technology, which provides aural runway situational advisories to flight crews	○	○	○	○	○	○
3z.	Require greater emphasis on ground operations training for pilots	○	○	○	○	○	○

If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which action you are discussing.

FAA reporting on runway incursions

4. **Based on your knowledge of specific incidents, how accurate or inaccurate are the severity classifications FAA has made regarding runway incursions that have occurred since January 1, 2001?**

(Check one.)

1. ○ Incident(s) tend to be classified as more severe than they actually were
2. ○ Incident(s) tend to be correctly classified
3. ○ Incident(s) tend to be classified as less severe than they actually were
4. ○ Don't know/No basis to judge

Please explain your answer.

ASDE-X deployment

5. **Do you have knowledge of and/or experience with the deployment of ASDE-X?**

(Check one.)

1. ○ Yes
2. ○ No (Click here to skip to question 7.)

6. **The preliminary information GAO has gathered indicates that, to varying extents, at the 8 airports where ASDE-X has been deployed, there have been operational problems with false targets and false alerts. We have also learned that for airports that did not previously have ground radar, ASDE-X now provides them with that capability. Considering the benefits and problems of ASDE-X, what is your opinion of FAA's plan to deploy ASDE-X at 27 additional airports by 2011?**

(Check one.)

1. ◯ Deployment should be accelerated
2. ◯ Deployment should be kept as planned
3. ◯ Deployment should be slowed down
4. ◯ Deployment should be stopped
5. ◯ Don't know/No basis to judge

Please explain your answer.

RUNWAY OVERRUNS

7. **Do you have expertise in *runway overruns* to be able to answer questions on actions to address *runway overruns*?**

(Check one.)

1. ◯ Yes
2. ◯ No (Click here to skip to question 10.)

Actions to address runway overruns

8. **In your opinion, how effective, if at all, are the following FAA actions to address *runway overruns*?**

(Choose one answer for each row.)

		Extremely effective	Very effective	Moderately effective	Slightly effective	Not at all effective	Don't know/No basis to judge
8a.	Accepting Engineered Materials Arresting Systems (EMAS) as an alternative to constructing a runway safety area when its construction is not practicable	○	○	○	○	○	○
8b.	Using Airport Improvement Funds to construct runway safety areas	○	○	○	○	○	○

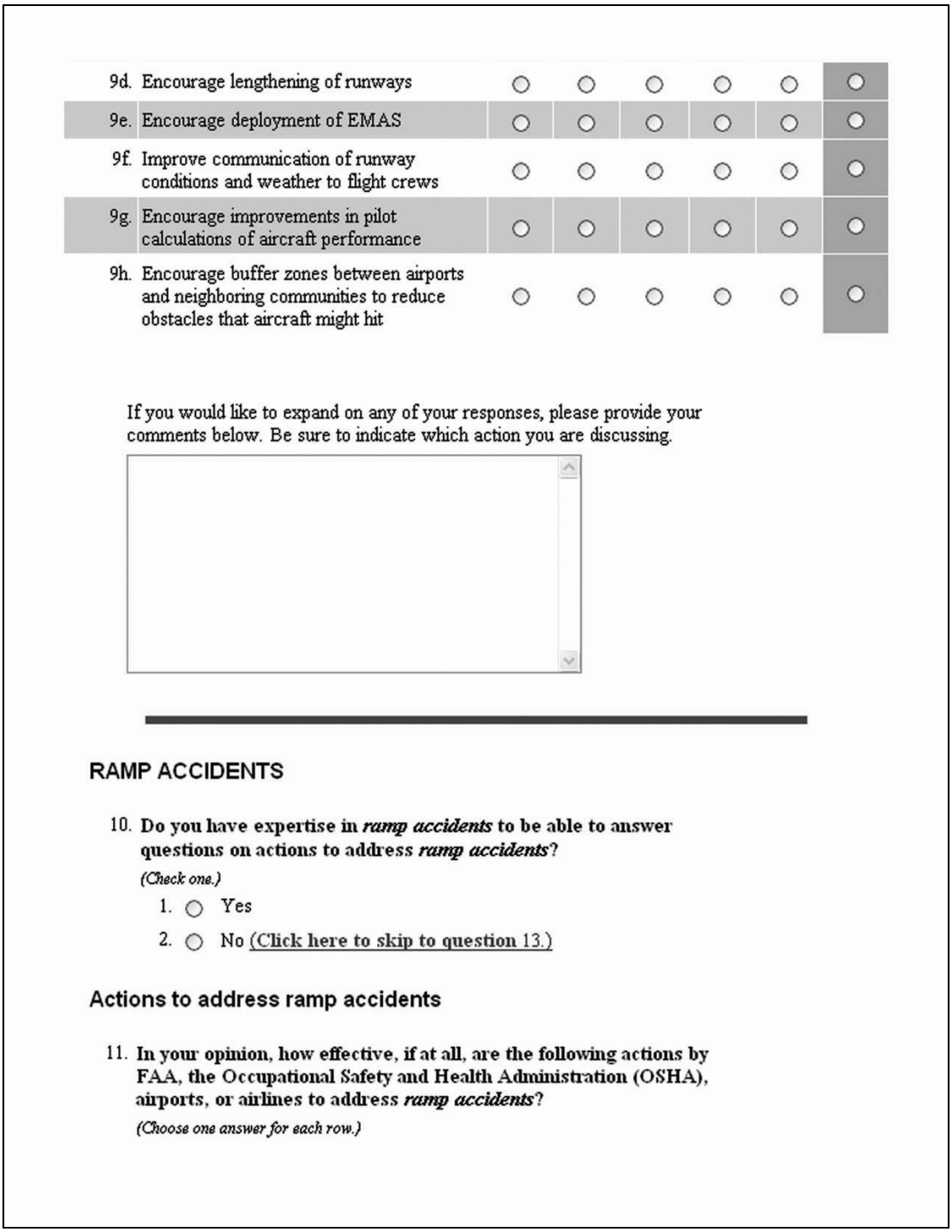
If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which FAA action you are discussing.

Future actions to prevent runway overruns

9. **In your opinion, what is the potential--considering costs, technological feasibility, and operational changes--of the following actions that FAA could take to prevent *runway overruns*?**

(Choose one answer for each row.)

		Very great potential	Great potential	Moderate potential	Little potential	No potential	Don't know/No basis to judge
9a.	Encourage improvements in and use of runway condition and friction measurements	○	○	○	○	○	○
9b.	Encourage development of improved airport lighting	○	○	○	○	○	○
9c.	Encourage development of improved airport markings	○	○	○	○	○	○



9d.	Encourage lengthening of runways	○	○	○	○	○	○
9e.	Encourage deployment of EMAS	○	○	○	○	○	○
9f.	Improve communication of runway conditions and weather to flight crews	○	○	○	○	○	○
9g.	Encourage improvements in pilot calculations of aircraft performance	○	○	○	○	○	○
9h.	Encourage buffer zones between airports and neighboring communities to reduce obstacles that aircraft might hit	○	○	○	○	○	○

If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which action you are discussing.

RAMP ACCIDENTS

10. **Do you have expertise in *ramp accidents* to be able to answer questions on actions to address *ramp accidents*?**

(Check one.)

1. ○ Yes
2. ○ No (Click here to skip to question 13.)

Actions to address ramp accidents

11. **In your opinion, how effective, if at all, are the following actions by FAA, the Occupational Safety and Health Administration (OSHA), airports, or airlines to address *ramp accidents*?**

(Choose one answer for each row.)

		Extremely effective	Very effective	Moderately effective	Slightly effective	Not at all effective	Don't know/No basis to judge
11a.	FAA's use of Runway Safety Action Teams	○	○	○	○	○	○
11b.	Airports' use of surface surveillance technology	○	○	○	○	○	○
11c.	Airports' use of ramp towers	○	○	○	○	○	○
11d.	Airlines' use of ramp towers	○	○	○	○	○	○
11e.	FAA's issuance of advisory circulars on Safety Management Systems for airport operators	○	○	○	○	○	○
11f.	FAA's issuance of advisory circulars on Safety Management Systems for aviation service providers	○	○	○	○	○	○
11g.	Airlines setting safety targets for reducing injuries in ramp areas	○	○	○	○	○	○
11h.	Airlines entering into safety alliances with OSHA	○	○	○	○	○	○
11i.	OSHA's safety enforcement actions, such as its Site-Specific Targeting Program	○	○	○	○	○	○

If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which FAA action you are discussing.

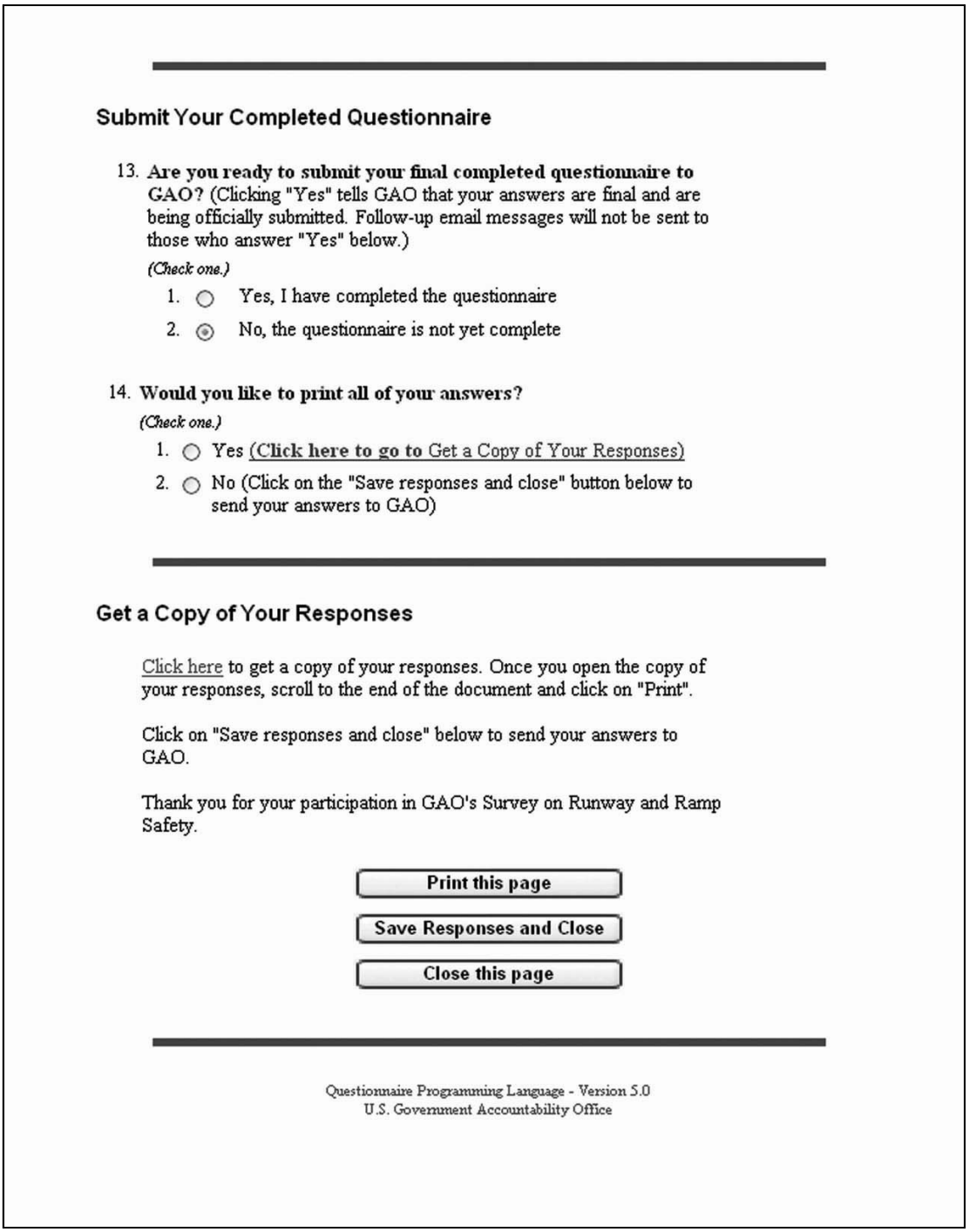
Future actions to prevent ramp accidents

12. **In your opinion, what is the potential--considering costs, technological feasibility, and operational changes--of the following actions that FAA, OSHA, airports, or airlines could take to prevent *ramp accidents*?**

(Choose one answer for each row.)

		Very great potential	Great potential	Moderate potential	Little potential	No potential	Don't know/No basis to judge
12a.	Standardize airport ramp markings	○	○	○	○	○	○
12b.	Use moving maps on aircraft	○	○	○	○	○	○
12c.	Use moving maps on airport vehicles	○	○	○	○	○	○
12d.	Improve or increase training of ramp workers	○	○	○	○	○	○
12e.	Increase supervision of ramp workers	○	○	○	○	○	○
12f.	Require certification of ramp workers	○	○	○	○	○	○
12g.	Promote safety culture in the ramp area	○	○	○	○	○	○
12h.	Use transponders on airport vehicles	○	○	○	○	○	○
12i.	Use collision warning systems for airport vehicles	○	○	○	○	○	○
12j.	Increase FAA oversight of ramp operations	○	○	○	○	○	○
12k.	Increase OSHA oversight of ramp operations	○	○	○	○	○	○
12l.	Develop safer designs of ramp equipment	○	○	○	○	○	○

If you would like to expand on any of your responses, please provide your comments below. Be sure to indicate which action you are discussing.



Submit Your Completed Questionnaire

13. **Are you ready to submit your final completed questionnaire to GAO?** (Clicking "Yes" tells GAO that your answers are final and are being officially submitted. Follow-up email messages will not be sent to those who answer "Yes" below.)

(Check one.)

1. ○ Yes, I have completed the questionnaire
2. ◉ No, the questionnaire is not yet complete

14. **Would you like to print all of your answers?**

(Check one.)

1. ○ Yes (**Click here to go to** Get a Copy of Your Responses)
2. ○ No (Click on the "Save responses and close" button below to send your answers to GAO)

Get a Copy of Your Responses

Click here to get a copy of your responses. Once you open the copy of your responses, scroll to the end of the document and click on "Print".

Click on "Save responses and close" below to send your answers to GAO.

Thank you for your participation in GAO's Survey on Runway and Ramp Safety.

Print this page

Save Responses and Close

Close this page

Questionnaire Programming Language - Version 5.0
U.S. Government Accountability Office

Appendix III: Serious Incursions Involving Commercial Aircraft

Table 8: Serious Incursions Involving At Least One Commercial Aircraft during Fiscal Year 2006 and Fiscal Year 2007

Date	Airport	Airline(s) and aircraft involved	Number of air passengers
October 13, 2005	Gulfport-Biloxi International, MS	Northwest Airlines DC9 and Cessna C172	N/A
March 21, 2006	Chicago O'Hare International	Lufthansa Airbus A319 and Chautauqua Embraer E145	78
April 29, 2006	Phoenix Sky Harbor International	US Airways Airbus A320 and pedestrian	N/A
May 25, 2006	Miami International	Boeing 747 and American Eagle Aerospatiale AT43	N/A
July 18, 2006	Chicago O'Hare International	American Eagle Canadair CRJ7 and US Airways Boeing 737	N/A
July 23, 2006	Chicago O'Hare International	ATLAS Boeing 747 and United Airlines Boeing 737	131
July 26, 2006	Los Angeles International	Mesa Canadair CRJ2 and Skywest Embraer E120	N/A
August 8, 2006	Southwest Florida International, Ft. Myers, FL	Southwest Boeing 737 and vehicle	N/A
September 30, 2006	Los Angeles International	Gulfstream GLF5 and Skywest Canadair CRJ7	N/A
January 5, 2007	Denver International	Key Lime Air Swearingen SW4 and Frontier Airbus A319	50
February 2, 2007	Denver International	United Boeing 737 and snowplow	101
May 4, 2007	Cyril E. King Airport, Charlotte Amalie, VI	American Airlines Boeing 757 and Cessna C208	N/A
May 6, 2007	Los Angeles International	Skywest Embraer 120 and Virgin Air A346	N/A
May 26, 2007	San Francisco International	Republic Airlines Embraer 170, Skywest Airlines Embraer 120	27
July 11, 2007	Fort Lauderdale-Hollywood International, FL	Delta Air Lines Boeing 757 and United Airlines Airbus A320	172
July 19, 2007	Chicago O'Hare International	United Airlines Boeing 737 and US Airways Boeing 737	N/A
August 16, 2007	Lost Angeles International	WestJet Boeing 737 and Northwest Airlines Airbus A320	296

Source: GAO analysis of Federal Aviation Administration and NTSB data.

Note: N/A indicates that the information was not contained in the National Transportation Safety Board (NTSB) incident reports.

Appendix IV: Status of the National Runway Safety Plan Objectives

Table 9: Implementation Status of the Objectives Contained in Federal Aviation Administration's (FAA) National Runway Safety Plan for 2002-2004

Runway Safety Objective	Status
1. Develop new training courses or informational briefings for controllers to reduce operational errors.	Complete
2. Facilitate use of surface operations training for air carriers and general aviation.	Complete
3. Distribute mechanic runway safety taxi training to major airlines.	Complete
4. Complete over 1,000 safety seminars per year, including runway safety topics.	Ongoing
5. Publish airport vehicle surface operations advisory circular with best practices and standard operating procedures.	Complete
6. Conduct research on improving controller training related to memory limitations. Review existing course materials.	Complete
7. Require all tower controllers to complete training emphasizing team effectiveness and situational awareness.	Ongoing
8. Develop course material and conduct training for aviation safety inspectors and enhance awareness of certified flight instructors and pilot examiners on pilot surface operations.	Complete
9. Develop and implement enhanced training for tower controllers.	Complete
10. Implement a foreign air carrier pilot training program.	Cancelled
11. Expand role of flight service station specialists to provide runway safety information for general aviation at towered and nontowered airports.	Complete
12. Publish series of letters to all pilots discussing runway safety.	Cancelled
13. Provide airport diagrams for towered airports to pilots via a link or other means.	Complete
14. Conduct at least one annual media emphasis project with trade or association periodicals.	Complete
15. Assess selected air traffic control procedures to enhance runway safety.	Ongoing
16. Implement national standardized requirements for tower positions.	Complete
17. Implement standardization of national equipment and procedures for runway incursion devices.	Cancelled
18. Publish and disseminate best practices and standard operating procedures as appendixes to pilot surface movement advisory circulars.	Complete
19. During inspectors, ensure that pilots have current surface movements charts available and are being used.	Complete
20. Develop advisory circulars addressing procedures, best practices, and standard operating procedures for airline maintenance taxi operators and tug and tow vehicles on airport surface.	Complete
21. Disseminate and provide training to all safety inspectors for the Runway Incursion Information Evaluation Program.	Ongoing
22. Improve runway safety data collection, storage retrieval, and distribution.	Ongoing
23. Improve collection and analysis of operational error data with human factors tool, using technique to identify root causes.	Cancelled
24. Complete and publish results from phraseology workgroup.	Complete
25. Evaluate and, if appropriate, implement national procedures requiring pilot read-backs to controllers for certain clearances or instructions.	Complete
26. Publish guidance on standard surface operations phraseology for pilots and mechanics moving aircraft.	Complete
27. Issue guidance on vehicle operations near active runways.	Complete
28. Complete airport paint marking study and revise advisory circular standards, if appropriate.	Complete
29. Complete airport design and operations study. Enhance design standards and improve procedures as appropriate.	Complete

Runway Safety Objective	Status
30. Ensure towered airports have current airport diagrams. Clarify process, roles, and responsibilities for development and maintenance of airport diagrams.	Complete
31. Maintain the published ASDE-3/AMASS deployment waterfall schedule.	Complete
32. Develop high-level requirements for runway status lights and validate implementation methods through field demonstrations.	Ongoing
33. Conduct evaluations of existing low-cost technologies.	Complete
34. Meet published ASDE-X milestones.	Not met
35. Evaluate moving map technologies in an operational environment, using either aircraft or surface vehicles.	Complete
36. Develop and evaluate visual signal for direct warning to aircraft on final approach when the runway is occupied.	Ongoing
37. Develop a surface “road map” for low-cost technology architecture and issue Broad Agency Announcements to solicit industry ideas.	Complete
38. Create and accomplish periodic regional runway safety plans for each FAA region, including Runway Safety Action Team site visits to airports in each region.	Ongoing
39. Implement an aggressive runway safety “special emphasis” program at selected airports that results in reducing runway incursions.	Ongoing

Source: GAO analysis of FAA data.

Appendix V: Airports with Surface Surveillance Technology

Table 10: Airports with Airport Surface Detection Equipment, Model 3 (ASDE-3)/Airport Movement Area Safety Systems (AMASS) or the Airport Surface Detection Equipment, Model X (ASDE-X) or Scheduled to Receive ASDE-X

Airport	ASDE-3/ AMASS	ASDE-X Commissioned	Scheduled ASDE-X Deployment[a]
Baltimore Washington International	✓		June 2010
Boston Logan International	✓		July 2009
Bradley International, Hartford, CT		✓	
Camp Springs Andrews Air Force Base	✓		
Charlotte Douglas International		✓	
Chicago Midway			July 2010
Chicago O'Hare International		✓	
Cleveland Hopkins International	✓		
Covington/Cincinnati Northern Kentucky International	✓		
Dallas-Ft. Worth International	✓		April 2010
Denver International	✓		November 2009
Detroit Metro Wayne County	✓		June 2008
Ft. Lauderdale/Hollywood			April 2009
General Mitchell International, Milwaukee, WI		✓	
George Bush Intercontinental	✓		November 2009
Hartsfield-Jackson Atlanta International		✓	
Honolulu International - Hickam Air Force Base			August 2010
John F. Kennedy International, New York, NY	✓		July 2009
John Wayne-Orange County, Santa Ana, CA			February 2010
Kansas City International	✓		
Lambert-St. Louis International		✓	
Las Vegas McCarran International	✓		December 2009
Los Angeles International	✓		June 2009
Louis Armstrong New Orleans International	✓		
Louisville International-Standiford Field		✓	
Memphis International	✓		January 2011
Miami International	✓		August 2010
Minneapolis-St. Paul International	✓		February 2010
New York LaGuardia	✓		December 2010
Newark International	✓		July 2009
Orlando International		✓	
Philadelphia International	✓		December 2009
Phoenix Sky Harbor International			December 2008
Pittsburgh International	✓		

Airport	ASDE-3/ AMASS	ASDE-X Commissioned	Scheduled ASDE-X Deployment[a]
Portland International	✓		
Ronald Reagan Washington National	✓		December 2010
Salt Lake City International	✓		May 2010
San Diego International	✓		January 2011
San Francisco International	✓		
Seattle-Tacoma International		✓	
Ted Stevens Anchorage International	✓		
Theodore Francis Green State, Providence, RI		✓	
Washington Dulles International	✓		July 2008
William P. Hobby, Houston, TX		✓	

Source: FAA.

[a]Represents when the facility first declares the system ready for conditional use. Once the system is formally accepted by the facility, the system is commissioned.

Note: As indicated above, 28 airports currently have ASDE-3/AMASS. Six additional airports (Seattle-Tacoma International, Lambert-St. Louis International, Hartsfield-Jackson Atlanta International, Louisville International-Standiford Field, Chicago O'Hare International, and Charlotte Douglas International) originally had ASDE-3/AMASS, but the equipment has since been upgraded to ASDE-X.

Appendix VI: Airports Where Ramp Accident Fatalities Occurred

Table 11: U.S. Airports at which Ramp Fatalities Occurred from 2001 through 2006

Airport	Location	Type[a]	Number of fatalities
Addison	Dallas, TX	Reliever	1
Burke Lakefront	Cleveland, OH	Reliever	1
Logan International	Boston, MA	Large hub	1
Baltimore/Washington International	Baltimore, MD	Large hub	1
Casa Grande Municipal	Casa Grande, AZ	General aviation	1
Cincinnati/Northern Kentucky International	Covington, KY	Large hub	1
Ronald Reagan Washington National	Arlington, VA	Large hub	2
Denver International	Denver, CO	Large hub	1
Detroit Metropolitan Wayne County	Detroit, MI	Large hub	1
El Paso International	El Paso, TX	Small hub	1
Newark Liberty International	Newark, NJ	Large hub	2
Forrest City Municipal	Forrest City, AR	General aviation	1
Hayward Executive	Hayward, CA	Reliever	1
Chicago O'Hare International	Chicago, IL	Large hub	2
Norfolk International	Norfolk, VA	Medium hub	1
Philadelphia International	Philadelphia, PA	Large hub	2
Richmond International	Richmond, VA	Small hub	1
Louisville International-Standiford Field	Louisville, KY	Small hub	1
Scappoose Industrial Airpark	Scappoose, OR	General aviation	1
Nut Tree	Vacaville, CA	General aviation	1
Total			**24**[b]

Source: GAO analysis of Federal Aviation Administration, National Transportation Safety Board, and Occupational Safety and Health Administration data.

[a]Primary commercial service airports are categorized based on the percentage of total annual passenger boardings (enplanements) for all operations of U.S. carriers within the United States. General aviation airports are small airports that do not receive scheduled commercial service.

[b]Five additional fatalities occurred from 2001 through 2006, but the data sources did not specify the airports.

Appendix VII: GAO Contact and Staff Acknowledgments

GAO Contact

Gerald Dillingham, Ph.D., (202) 512-2834 or dillinghamg@gao.gov

Staff Acknowledgments

In addition to the individual named above, Teresa Spisak (Assistant Director), Ashley Alley, Nancy Boardman, Colin Fallon, Evan Gilman, Bob Homan, Dave Hooper, Richard Hung, Rosa Leung, Sara Ann Moessbauer, Josh Ormond, and Pamela Vines made key contributions to this report.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "E-mail Updates."

Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, DC 20548

To order by phone: Voice: (202) 512-6000
TDD: (202) 512-2537
Fax: (202) 512-6061

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Gloria Jarmon, Managing Director, jarmonG@gao.gov, (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngcl@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548