

October 2011

# AVIATION SAFETY

## Enhanced Oversight and Improved Availability of Risk- Based Data Could Further Improve Safety

U.S. Government Accountability Office

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1921-2011

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## Why GAO Did This Study

Takeoffs, landings, and movement around the surface areas of airports (the terminal area) are critical to the safe and efficient movement of air traffic. The nation's aviation system is arguably the safest in the world, but close calls involving aircraft or other vehicles at or near airports are common, occurring almost daily. The Federal Aviation Administration (FAA) provides oversight of the terminal area and has taken action to improve safety, but has been called upon by the National Transportation Safety Board (NTSB) and others to take additional steps to improve its oversight.

As requested, this report addresses (1) recent actions FAA has taken to improve safety in the terminal area, (2) recent trends in terminal area safety and factors contributing to those trends, and (3) any additional actions FAA could take to improve safety in the terminal area. To address these issues, GAO analyzed data from FAA data; reviewed reports and FAA documents; and interviewed federal and industry officials.

## What GAO Recommends

GAO recommends that FAA (1) extend oversight of terminal area safety to include runway overruns and ramp areas, (2) develop risk-based measures for runway safety incidents, and (3) improve information sharing about incidents.

The Department of Transportation agreed to consider the recommendations and provided clarifying information about efforts made to improve runway safety, which GAO incorporated.

View [GAO-12-24](#) or key components. For more information, contact Gerald L. Dillingham, Ph.D. at (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov).

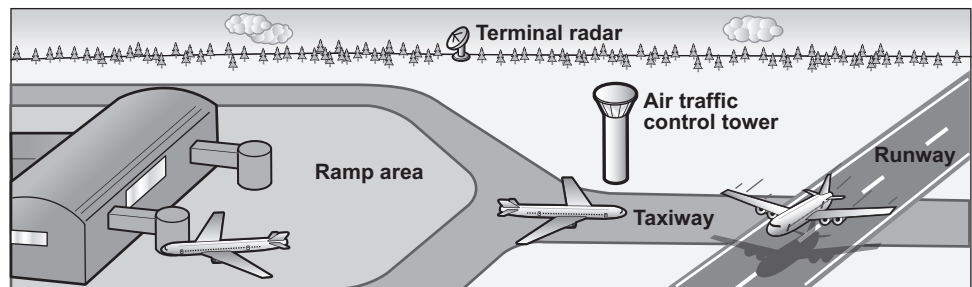
## AVIATION SAFETY

### Enhanced Oversight and Improved Availability of Risk-Based Data Could Further Improve Safety

## What GAO Found

Since 2007, FAA has taken several steps to further improve safety at and around airports (see fig.), including implementing procedural and technological changes to improve runway safety, proposing a rule that would require airports to establish risk-management plans that include the ramp areas where aircraft are serviced, collecting more data on safety incidents, and shifting toward risk-based analysis of airborne aviation safety information. Several of these initiatives are intended to better identify systemic issues in air traffic safety.

The Terminal Area



Source: GAO.

Rates of reported safety incidents in the terminal area continue to increase. FAA met its interim goals toward reducing the total number of runway incursions—the unauthorized presence of an airplane, vehicle, or person on the runway—in 2009 and 2010, but the overall rate of incursions at towered airports has trended steadily upward. In fiscal year 2004, there were 11 incursions per million operations at these airports; by fiscal year 2010, the rate increased to 18 incursions per million operations. The rate and number of airborne operational errors—errors made by air traffic controllers—have increased considerably in recent years, with the rate nearly doubling from the second quarter of fiscal 2008 to the same period of 2011. FAA has not met its related performance goals. Comprehensive data are not available for some safety incidents, including runway overruns or incidents in ramp areas. Recent increases in reported runway incursions and airborne operational errors can be somewhat attributed to several changes in reporting policies and procedures at FAA; however, trends may also indicate an increase in the actual occurrence of incidents.

Enhanced oversight and additional information about surface and airborne incidents could help improve safety in the terminal area. FAA oversight in the terminal area is currently limited to certain types of incidents, notably runway incursions and certain airborne incidents, and does not include runway overruns or incidents in ramp areas. In addition, the agency lacks data collection processes, risk-based metrics, and assessment frameworks for analyzing other safety incidents such as runway overruns, incidents in ramp areas, or a wider range of airborne errors. Further, changes to reporting processes and procedures make it difficult to assess safety trends, and existing data may not be readily available to decision makers, including those at the regional and local levels. As a result, FAA may have difficulty assessing recent trends in safety incidents, the risks posed to aircraft or passengers in the terminal area, and the impact of the agency's efforts to improve safety.

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## Abbreviations

ACRP	Airport Cooperative Research Program
ADS-B	Automatic Dependent Surveillance-Broadcast
AIP	Airport Improvement Program
AMASS	Airport Movement Area Safety System
ASDE-3	Airport Surface Detection Equipment, Model 3
ASDE-X	Airport Surface Detection Equipment, Model X
ASIAS	Aviation Safety Information Analysis and Sharing
ATO	Air Traffic Organization
ATQA	Air Traffic Quality Assurance database
ATSAP	Air Traffic Safety Action Program
CEDAR	Comprehensive Electronic Data Analysis and Reporting
Council	Runway Safety Council
EMAS	Engineered Materials Arresting System
Eurocontrol	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
FAROS	Final Approach Runway Occupancy Signal
Flight Standards	Flight Standards Service
ICAO	International Civil Aviation Organization
IG	Department of Transportation Inspector General
LoSS	Losses of Standard Separation
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
OSH Act	Occupational Safety and Health Act
RAP	Risk Analysis Process
Runway Safety	Office of Runway Safety
SRER	System Risk Event Rate
TARP	Traffic Analysis and Review Program
TCAS	Traffic Collision Avoidance System
TRACON	terminal radar approach control

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**United States Government Accountability Office**  
Washington, DC 20548

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October 5, 2011

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The Honorable Kay Bailey Hutchison  
Ranking Member  
Committee on Commerce, Science, and Transportation  
United States Senate

The Honorable John L. Mica  
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The Honorable Thomas E. Petri  
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The U.S. airspace system is one of the safest in the world, but mishaps and close calls involving aircraft or other vehicles at airports or in the airspace around airports are common, occurring almost daily. While few of these incidents result in accidents or the loss of life, the risk of catastrophic accidents in the terminal area remains, particularly during takeoff and landing, which are considered the most critical phases of flight given the higher level of risk associated with them. In a June 2011 incident at John F. Kennedy International Airport in New York, for example, a jumbo jet carrying 286 passengers and crew almost collided with another jumbo jet, which reportedly missed a turn and failed to stop where it should have to avoid the occupied runway. The Federal Aviation Administration (FAA) focuses its terminal area safety oversight on runways and taxiways<sup>1</sup> and on aircraft in the air near airports. By

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<sup>1</sup>Taxiways are routes that aircraft follow to and from runways.

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contrast, safety oversight of operations in ramp areas, which include areas of airports where aircraft are prepared for arrival and departure, has historically been handled primarily by airlines and airports.

You asked us to look at aviation safety and update our prior work, including our 2007 report on runway and ramp safety.<sup>2</sup> To do so, we addressed the following questions: (1) What actions has FAA taken to improve safety in the terminal area since 2007? (2) What are the trends in terminal area safety and the factors contributing to these trends? and (3) What additional actions could FAA take to improve terminal area safety?

To answer these questions we reviewed our prior work and other reports and literature on safety in the terminal area and analyzed FAA, National Transportation Safety Board (NTSB), and Occupational Safety and Health Administration (OSHA) data on surface and airborne incidents in the terminal area. In order to ensure that FAA data were sufficiently reliable for our purposes, we reviewed agency documentation and interviewed agency officials. We also obtained information about data from OSHA and NTSB to assure data reliability. We interviewed FAA officials, as well as industry experts and representatives from key industry associations. In addition, in order to obtain background information on safety in the terminal area, we interviewed facility managers and airport officials and observed facility operations and the application of key technologies at four air traffic control facilities and one airport, which were located near GAO offices. (See app. I for more information on our objectives, scope, and methodology.)

We conducted this performance audit from February 2011 to October 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

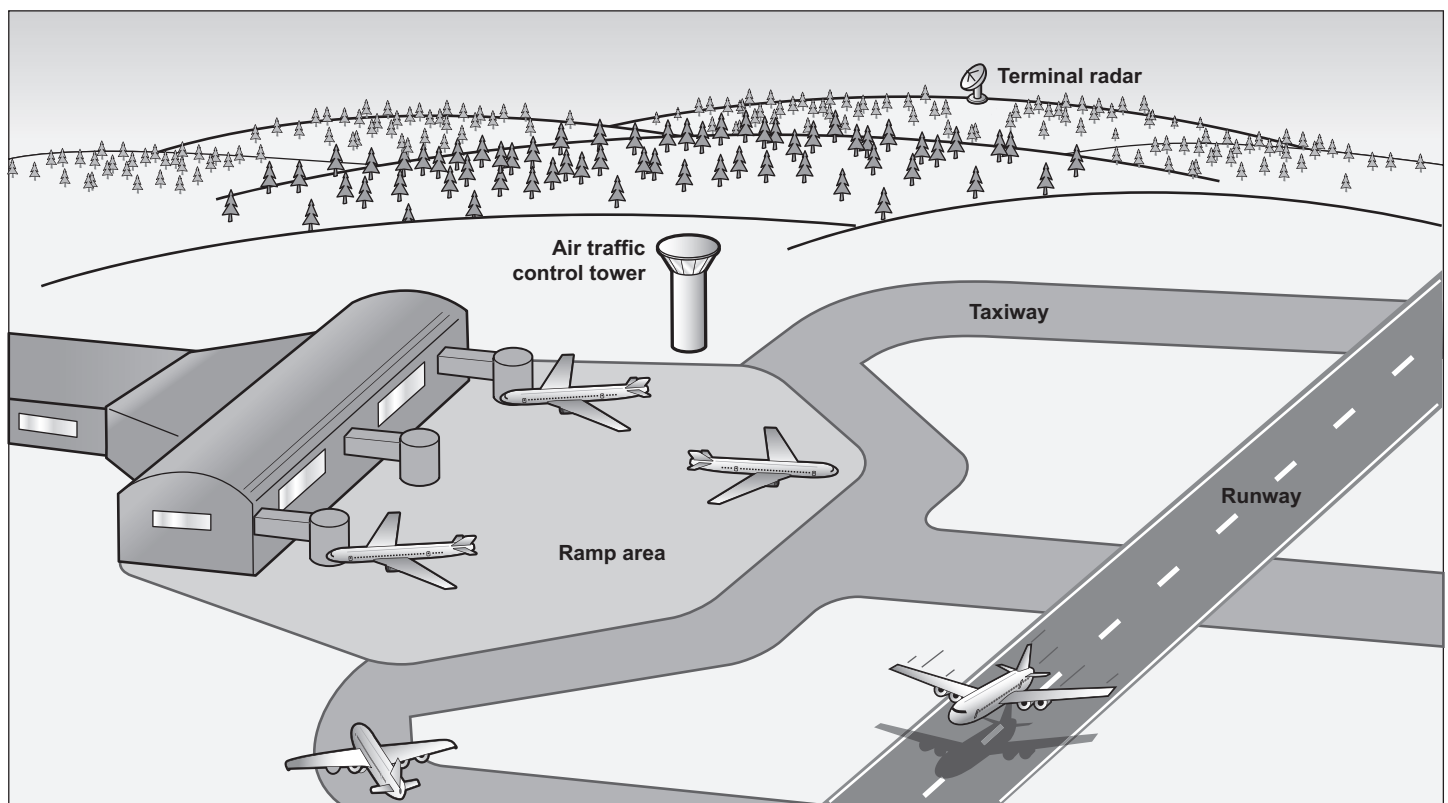
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<sup>2</sup>See GAO, *Aviation Runway and Ramp Safety: Sustained Efforts to Address Leadership, Technology, and Other Challenges Needed to Reduce Accidents and Incidents*, [GAO-08-29](#) (Washington, D.C.: Nov. 20, 2007).

## Background

The terminal area is the area around an airport extending from the airfield or surface to about 10,000 feet vertically and out to about 40 miles in any direction. The terminal area includes airport surface areas such as runways, taxiways, and ramps,<sup>3</sup> as well as the airspace covered by air traffic control towers—typically within 5 miles of a towered airport—and by terminal radar approach control (TRACON) facilities, which typically handle air traffic to within about 40 miles of an airport (see fig. 1).<sup>4</sup>

Figure 1: The Terminal Area



Source: GAO.

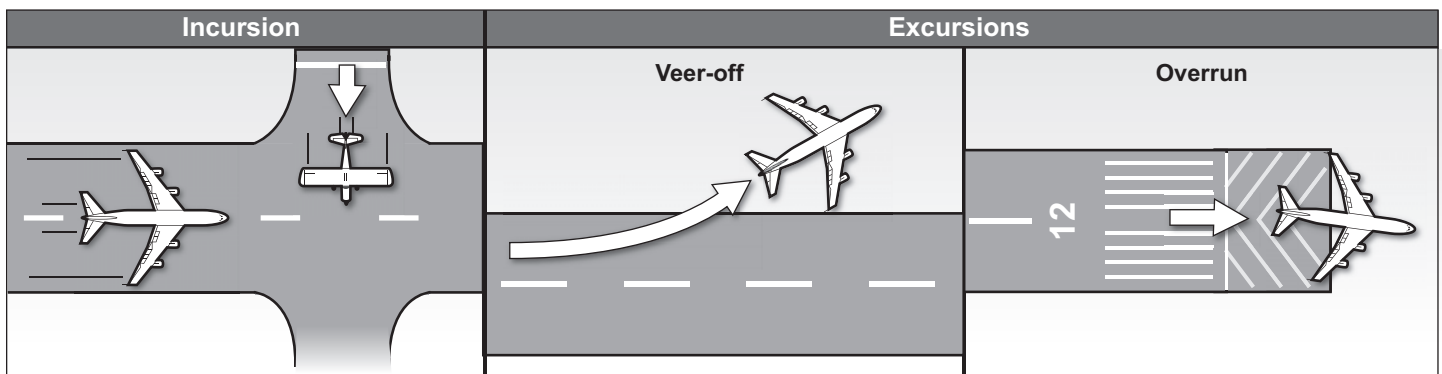
<sup>3</sup>Movement areas include taxiways and runways, while nonmovement areas include ramps, apron areas around these movement areas, and fueling areas. We are defining ramps to include all areas from the gate to runways or taxiways.

<sup>4</sup>Air traffic greater than 40 miles from the airport is referred to as en route air traffic and is controlled by air route traffic control centers. Not all airports have air traffic control towers.



Terminal area safety incidents can occur on the surface at airports or in the airspace around them. Surface incidents may threaten the safety of aircraft, passengers, and airport workers, among others. Terminal area safety incidents that happen on runways and taxiways include incursions and excursions. Runway incursions typically involve the incorrect presence of an aircraft, vehicle, or person on a runway,<sup>5</sup> and runway excursions generally occur when an aircraft veers off or overruns a runway (see fig. 2).<sup>6</sup> Ramp incidents can involve aircraft or airport vehicles, such as baggage carts or ground handling vehicles, as well as airline and airport employees and others.

**Figure 2: Runway Incidents: Incursions and Excursions**



Source: GAO.

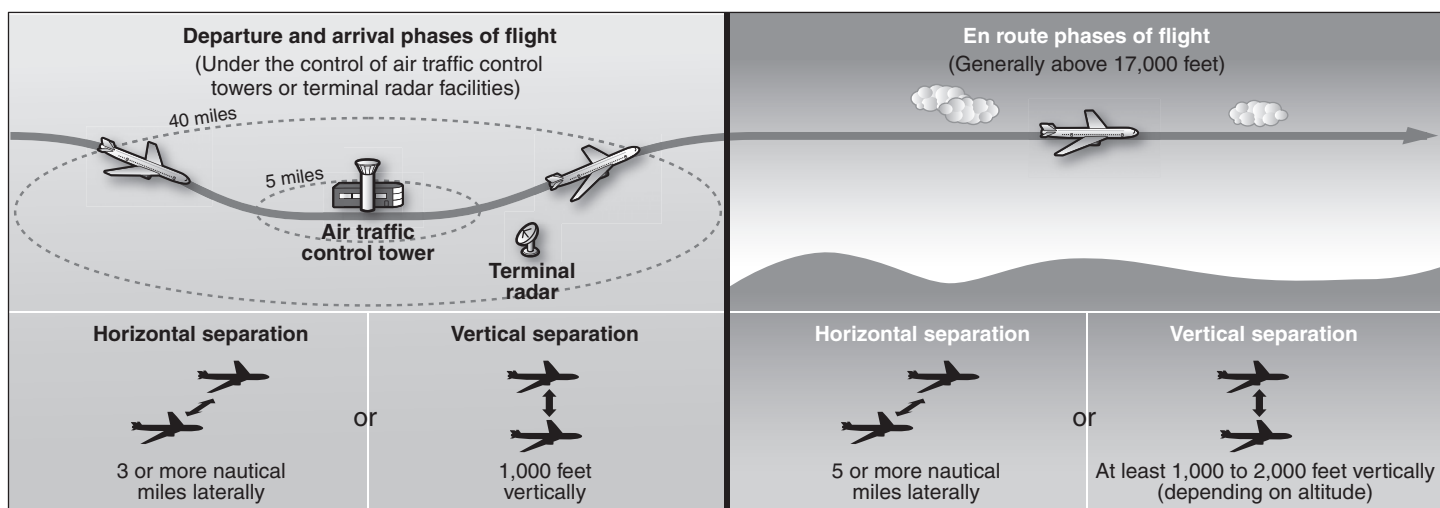
Airborne safety incidents in the terminal area often involve a loss of the minimum required distance between aircraft—as airplanes fly too close to each other—or as individual aircraft fly too close to terrain or obstructions.

<sup>5</sup>On October 1, 2007, FAA began using a broader definition of a runway incursion developed by the International Civil Aviation Organization (ICAO), a United Nations specialized agency, defining these incidents as the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft. Previously, FAA had 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.”

<sup>6</sup>According to FAA officials, neither FAA nor ICAO currently has a formal definition for runway excursions. The Flight Safety Foundation defines runway excursions as when an aircraft veers off or overruns a runway. See Flight Safety Foundation, *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative*, May 2009.

These incidents are called “losses of separation,” because there is a violation of FAA separation standards that ensure established distances are maintained between aircraft or other obstacles while under the control of air traffic controllers. Generally, air traffic controllers must maintain either vertical or horizontal separation between aircraft (see fig. 3), and losses of separation occur when *both* of these measures are violated, based on phase of flight and size of the aircraft.<sup>7</sup>

**Figure 3: FAA Standards for Airborne Separation**



Sources: GAO and FAA.

Safety in the terminal area is a shared responsibility among FAA, airlines, pilots, and airports. FAA air traffic controllers oversee activity on runways and taxiways, and airlines and airports provide primary safety oversight in ramp areas. Several FAA offices have a role in terminal area safety including:

- The Office of Runway Safety (Runway Safety) within the Air Traffic Organization (ATO) Safety Office was established in 1999 and leads and coordinates the agency’s runway safety efforts. Its primary mission is to improve runway safety by decreasing the number and severity of runway incursions. Runway Safety is responsible for

<sup>7</sup>One exception to these minimum standards involves air traffic controllers using visual separation rules for aircraft.

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developing a national runway safety plan and performance measures for runway safety and evaluating the effectiveness of runway safety activities. The office currently has an acting director.<sup>8</sup> Other FAA offices, including the Office of Aviation Safety, the Office of Airports, other components of ATO, and regional offices support Runway Safety's work to identify hazards and analyze risk.

- ATO manages air traffic control and develops and maintains runway safety technology.
- The Office of Aviation Safety and Flight Standards Service (Flight Standards) within it conduct safety inspections of airlines, audit air traffic safety issues, and administer a program to obtain information about safety incidents involving pilots.
- The Office of Airports oversees airport-related safety, including airport infrastructure. This includes issuing airport operating certificates to commercial service airports, establishing airport design and safety standards, and inspecting certificated airports. The Office of Airports also provides Airport Improvement Program (AIP) grants to airports to help support safety improvements.

Airlines and airports typically oversee the safety of operations in ramp areas.<sup>9</sup> Ramp areas are typically small, congested areas in which departing and arriving aircraft are serviced by ramp workers, who include baggage, catering, and fueling personnel. These areas can be dangerous for ground workers and passengers. As noted in our 2007 report on runway and ramp safety,<sup>10</sup> FAA's oversight of ramp areas is generally provided indirectly through its certification of airlines and airports.<sup>11</sup> Both NTSB and OSHA investigate accidents in the ramp area. Thus, NTSB investigates ramp accidents—and other accidents involving aircraft—that occur from the time any person boards an aircraft with the intention to fly until the time the last person disembarks the aircraft, if the accident

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<sup>8</sup>After 2 years without a permanent Director, FAA put in place a Director for Runway Safety in 2007, at the time of our prior report. This Director retired in April 2011, and the office has had two Acting Directors since then.

<sup>9</sup>Airports typically lease the ramp areas to air carriers.

<sup>10</sup>See [GAO-08-29](#).

<sup>11</sup>Primarily through 14 C.F.R. Parts 119, 121, 135, and 139.

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results in serious or fatal injury or substantial aircraft damage.<sup>12</sup> OSHA can conduct an inspection in response to a fatality, injuries, or a complaint, unless it is preempted by an exercise of statutory authority by FAA.<sup>13</sup>

FAA collects and analyzes information about various safety incidents in the terminal area in order to track incidents, identify their causes, and assign severity levels. Currently data are collected at towered airports for runway incursions, some other surface incidents, and for airborne incidents. By contrast, no complete data are collected for incidents in ramp areas. FAA categorizes incidents according to the actions or inactions of air traffic controllers, pilots, or others, such as pedestrians or vehicle operators. Table 1 provides hypothetical examples of each type of incident. Depending on the type of incident identified—air traffic control surface event, operational error or deviation, pilot deviation, or pedestrian/vehicle deviation—different offices within FAA are responsible for investigating individual incidents.<sup>14</sup>

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<sup>12</sup>NTSB officials said that they currently collect data on accidents in the ramp area that meet the definition of an aircraft accident as defined by 49 C.F.R. Part 830.2. That is, “an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.”

<sup>13</sup>Under the Occupational Safety and Health Act (OSH Act), OSHA has statutory authority to govern the occupational safety and health of employees. (29 U.S.C. §§651 et seq.) 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. (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.) 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.

<sup>14</sup>Pilot deviations are investigated by Flight Standards; operational errors or deviations are investigated by ATO; and vehicle or pedestrian deviations are investigated by the Office of Airports.

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**Table 1: Terminal Area Safety Incident Types**

Type of incident (surface or airborne)	Example
Air traffic control surface events (surface)	An aircraft enters an occupied runway after an air traffic controller fails to ensure the pilot repeats instructions correctly, resulting in a runway incursion.
Pilot deviation (surface)	A pilot taxis across a departure runway without clearance from air traffic control, resulting in a runway incursion.
Pilot deviation (airborne)	A pilot levels off at an incorrect altitude and flies too closely to another aircraft, resulting in a loss of separation.
Operational error (airborne)	An air traffic controller does not maintain separation standards when sequencing two aircraft on approach to an airport for landing, resulting in a loss of separation.
Operational deviation (airborne)	An air traffic controller at a TRACON fails to coordinate with the tower as an aircraft approaches the airport.
Vehicle/pedestrian deviation (surface)	An aircraft fueling truck crosses a runway without authorization from air traffic control, resulting in a runway incursion.
Other airport incidents (surface)	An aircraft slides from a taxiway onto a departure runway as the result of an accumulation of snow and ice on the ground, resulting in a runway incursion.

Source: GAO analysis of FAA information.

FAA is in the process of implementing a data-driven, risk-based approach to safety oversight that FAA expects will help it continuously improve safety by identifying hazards, assessing and mitigating risk, and measuring performance.<sup>15</sup> For decades, the aviation industry and FAA have used data reactively to identify the causes of aviation accidents and incidents and take actions to prevent their recurrence. Using a safety management system approach, the agency plans to use aviation safety data to identify conditions that could lead to incidents, allowing it to address risks proactively. FAA's current approach for analyzing

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<sup>15</sup>FAA is following the framework established by ICAO for a safety management system. ICAO's guidance for establishing such a system can be found at <http://www.icao.int/anb/safetymanagement/>.

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information about safety in the terminal area includes separate approaches for surface and airborne incidents.

- *Surface incidents.* For runway incursions, Runway Safety collects information from the Administrator’s Daily Bulletin and the Air Traffic Quality Assurance database (ATQA)—a mandatory reporting system with incident information recorded by FAA air traffic controller supervisors, support specialists, and managers—and other sources such as incident investigations.<sup>16</sup> Runway Safety determines how an event will be categorized (e.g., air traffic control, pilot, or vehicle/pedestrian deviation, etc.), and the runway incursion severity classification team, which consists of representatives from the Office of Airports, Flight Standards, and ATO Terminal Services, determines the severity of the incursion.
- *Airborne incidents.* For terminal area incidents that occur in the air, the primary source of information is ATQA.<sup>17</sup> FAA recently adopted a new process for analyzing these incident data and has taken steps to increase the amount and quality of information collected. FAA officials stated that, prior to this change, data were limited to the information collected in ATQA from FAA managers and supervisors, with limited input from individual controllers through controller statements gathered during incident investigations. We will discuss the new system in more detail in the following section.

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<sup>16</sup>FAA officials told us that after FAA adopted ICAO’s definition of runway incursions in 2007, the agency converted data for the most serious incidents from 2001 to 2008 to allow for trending analyses.

<sup>17</sup>FAA is in the process of bringing information from ATQA into a new system for terminal area data collection called Comprehensive Electronic Data Analysis and Reporting (CEDAR).

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## FAA Has Taken Actions to Reduce Risk in the Terminal Area

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### Procedural and Technological Changes to Improve Runway Safety

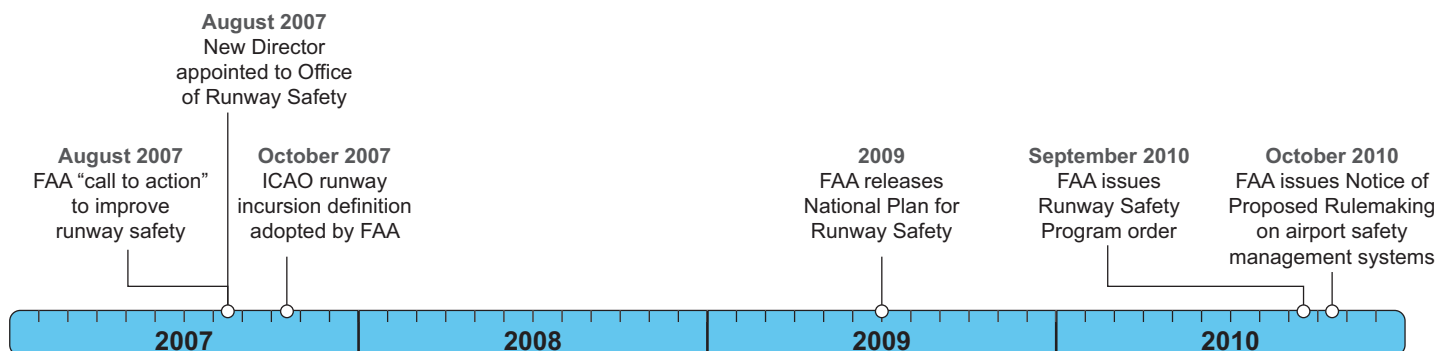
FAA has taken several steps since 2007 to further improve surface safety at airports, focusing most notably on efforts to reduce the number and severity of runway incursions—the agency’s key performance measures for this area.<sup>18</sup> (See fig. 4.) As part of its 2007 Call to Action Plan, the agency implemented new safety approaches and developed milestones for the implementation of various mid- and long-term initiatives, such as conducting safety reviews of 20 airports where incursions were of greatest concern, upgrading airport markings at airports, and reviewing cockpit and air traffic procedures. Additionally, FAA’s 2009–2011 National Runway Safety Plan establishes priorities for each FAA office involved in reducing incursion risks and identifies performance targets for reducing the risk of runway incursions, including an overall goal to reduce total runway incursions by 10 percent from 1,009 in fiscal year 2008 to 908 incursions by the end of fiscal year 2013. In 2010, FAA issued an order that further strengthened the role of Runway Safety as the agency’s focus for addressing incursions and improving runway safety.<sup>19</sup> FAA has also proposed new rules related to airport safety management systems that address ramp areas.

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<sup>18</sup>For information on improvements made by the agency before 2007, see [GAO-08-29](#).

<sup>19</sup>FAA National Policy, Order 7050.1A, Runway Safety Program, effective September 16, 2010. This order is currently being revised by FAA and was expected to be final in September 2011.

**Figure 4: Key FAA Policy Actions for Surface Safety at Airports Since 2007**



Source: GAO.

Additionally, FAA established local and regional runway safety action teams that assess runway safety issues at particular airports, formulate runway safety action plans to address these concerns, and execute their runway safety programs. FAA also established the Runway Safety Council (Council) with aviation industry stakeholders to develop a systemic approach to improving runway safety.<sup>20</sup> The Council's Root Cause Analysis Team—comprised of representatives from FAA and airlines—investigates severe runway incursions to determine root causes in order to identify systemic risks. The Root Cause Analysis Team presents recommendations to the Council, which in turn, assigns accepted recommendations to FAA or the aviation industry, based on which is best able to address root causes and prevent further incursions. The Council is responsible for tracking recommendations and ensuring that they get implemented.

FAA's layered approach to addressing runway safety includes a range of actions, such as encouraging airport improvements, including improving runway safety areas; changes to airport layout and runway markings, signage, and lighting; providing training for pilots and air traffic controllers; mitigating wildlife hazards; and researching, testing, and deploying new

<sup>20</sup>As a joint government-industry body, the Runway Safety Council consists of officials from FAA and various industry organizations, such as the National Air Traffic Controllers Association, the Air Line Pilots Association, the Air Transport Association, Airports Council International, the Aircraft Owners and Pilots Association, and the National Association of Flight Instructors.



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technology. According to its 2009–2011 National Runway Safety Plan and annual safety reports, FAA’s efforts to decrease the risk of surface incidents include:

- *Improving runway safety areas.* In order to reduce fatalities and injuries from runway excursions, the Office of Airports has provided between \$200 and \$300 million annually since 2000 through AIP grants to improve runway safety areas, which are unobstructed areas surrounding runways.
- *Outreach to general aviation pilots.*<sup>21</sup> Regional runway safety action team meetings, briefings, and clinics for general aviation pilots and flight instructors discuss the importance of runway safety and how to avoid incursions. FAA also provided training, printed materials, and electronic media such as DVDs explaining runway safety.
- *New terminology.* FAA adopted international air traffic controller-pilot terminology for taxi clearance instructions to help avoid miscommunication between pilots on the taxiway and runway and air traffic controllers. These included new mandatory detailed taxi instructions, including directional turns, for all aircraft and vehicles taxiing to and from ramps and runways.
- *Upgraded markings.* Markings—such as enhanced centerlines drawn on taxiways and runways—were installed at all 549 FAA-certificated commercial airports in 2010.<sup>22</sup>
- *Hot spot identification.* Hot spots—locations on runways or taxiways with a history of collisions or incursions or the heightened potential for such incidents—have been identified on airport diagrams to alert pilots of complex locations on runways and taxiways.
- *Airport layout.* Some airports have relocated taxiways, allowing pilots to avoid crossing active runways during the taxi phase. These “end

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<sup>21</sup>General aviation encompasses all civil aviation except scheduled passenger and cargo operations (i.e., commercial) and excludes military operations. It includes air medical-ambulance operations, flight schools, corporate aviation, and privately owned aircraft.

<sup>22</sup>Upgraded markings were installed at all Part 139 airports. (Part 139 airports are required to have FAA-issued operating certificates and include airports that serve unscheduled aircraft with more than 30 seats and scheduled aircraft with more than 9 seats. See 14 C.F.R. Part 139).

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around taxiways” facilitate ground movement and minimize conflicts with aircraft operating on runways. The Office of Airports has also released guidance on the design of taxiways and aprons to help prevent runway incursions.

- *Training.* FAA has developed video programs, training modules, and best practices for pilots, controllers, and airport personnel aimed at heightening awareness of situations that could lead to incursions. FAA now also requires that runway incursion prevention be included in refresher training for controllers, pilots, and all certificated airport employees.
- *Research and development of best practices and other useful information.* Runway Safety’s Web site has resources, best practices, and statistics on runway safety. Moreover, Runway Safety has produced DVDs and Pilot’s Guide brochures, as well as runway incursion safety alerts for airport operators.
- *Wildlife Hazard Mitigation.* In addition to an active research program for developing practical techniques for mitigating bird strikes, FAA has encouraged all certificated airports to conduct wildlife hazard assessments and is pursuing rulemaking to make it mandatory for certificated airports to do so.<sup>23</sup> FAA currently provides AIP funds to hire qualified wildlife biologists to develop assessments and mitigation plans, as needed.

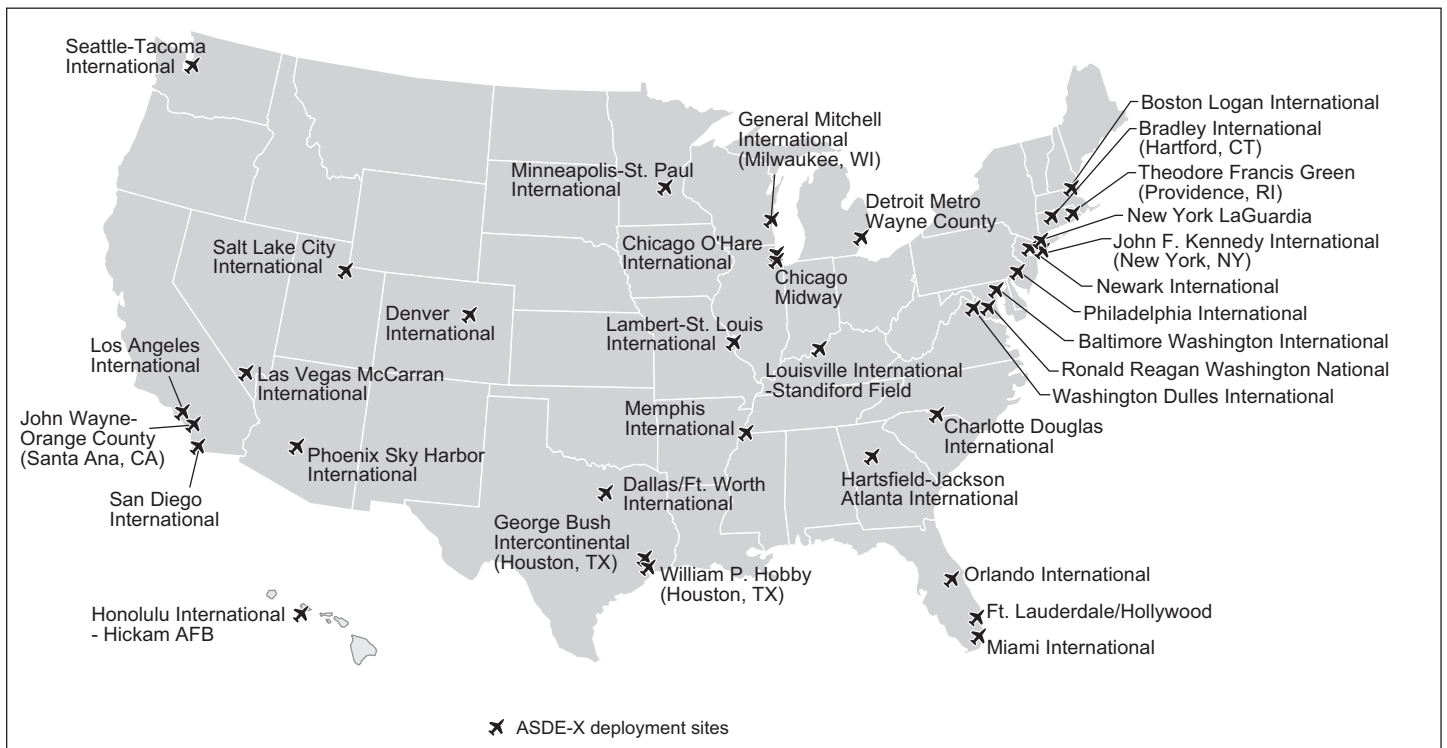
A number of available technological systems are intended to help reduce the number and severity of runway incursions, and FAA has made progress installing several of these systems since 2007. For example, in order to prevent collisions, FAA completed installation of the Airport Surface Detection Equipment, Model X (ASDE-X) system at 35 major airports, which provides air traffic controllers a visual representation of traffic on runways and taxiways (see fig. 5). Other systems that will provide safety information directly to pilots are being installed or tested. For example, runway status lights, an automatic series of lights that give pilots a visible warning when runways are not clear to enter, cross, or depart on, are planned to be installed at 23 airports by August 2016. See

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<sup>23</sup>FAA has also started an initiative to require all general aviation airports to do a wildlife hazard assessment or have a site visit from a qualified wildlife biologist.

appendix II for more information on technologies to improve runway safety.

**Figure 5: Deployment of the ASDE-X Surface Surveillance System at 35 Airports**



Sources: FAA and Map Resources (map).

To date, runway excursions have not received the same level of attention from FAA as incursions. However, excursions can be as dangerous as incursions; according to research by the Flight Safety Foundation, excursions have resulted in more fatalities than incursions globally. FAA is now planning efforts to track and assess excursions as well. According to FAA officials, in response to recommendations that we and others have made, Runway Safety will begin overseeing runway excursions on October 1, 2011. Specific responsibilities include collecting and analyzing data to develop steps to reduce the risk of such incidents. According to FAA officials, the office plans to develop an official definition of an excursion, develop a data collection instrument and performance metrics

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that would enable it to collect and evaluate excursion data, and develop training and steps to help mitigate excursions.<sup>24</sup> According to a timeline from Runway Safety, it will be several years before this program is totally implemented and FAA has detailed information about excursions.<sup>25</sup>

FAA recently issued two proposed rules for airports under the agency's authority to issue airport operating certificates. The first proposed rule, issued in October 2010,<sup>26</sup> would require airports to establish safety management systems for ramps areas, as well as other parts of the airfield, including runways and taxiways.<sup>27</sup> As previously noted, FAA historically has not primarily overseen safety in ramp areas, which are typically controlled by airlines or—to a lesser extent—airports using their own practices. FAA's proposal would require airports to establish safety management systems for the entire airfield environment in order to ensure that

- individuals are trained on the safety implications of working on the surface of the terminal area;
- hazards are identified proactively, and analysis systems are in place;
- data analysis, tracking, and reporting systems are available for trend analysis and to gain lessons learned; and
- there is timely communication of safety issues to all stakeholders.

A second proposed rule, issued in February 2011, would establish minimum training standards for all personnel who access ramp areas.<sup>28</sup>

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<sup>24</sup>Upon implementation of quality assurance and quality control directives later this year, FAA will begin collecting more information about excursions using an interim definition of "any instance in which an aircraft unintentionally maneuvers off the runway or taxiway."

<sup>25</sup>FAA's Office of Airports has issued guidance to track some excursions, obtaining information from their regional offices, in order to learn about airport surface issues (such as debris or friction problems in the runway area) that the Office of Airports would need to work on with individual airports.

<sup>26</sup>See 75 Fed. Reg. 62008, October 7, 2010.

<sup>27</sup>An airport safety management system would be required throughout the airport environment, including in movement areas, such as runways and taxiways, and in nonmovement areas, including ramps.

<sup>28</sup>See 76 Fed. Reg. 5510, February 1, 2011.

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Required training would occur at least yearly and include familiarization with airport markings, signs, and lighting, as well as procedures for operating in the nonmovement (ramp) area. The public comment period for these proposed rules closed during July 2011. FAA has not indicated when the rules would be finalized.

We reported in 2007 that FAA lacked ground handling standards for ramp areas.<sup>29</sup> In the absence of agency standards, other organizations have developed tools to improve ramp safety. For example, the Flight Safety Foundation has collected best practices and developed a template of standard operating procedures to assist ramp supervisors in developing their own procedures.<sup>30</sup> The guidelines are wide ranging and include the reporting of safety information, ramp safety rules, the positioning of equipment and safety cones, refueling, and caring for passengers, among other areas. In addition to the Flight Safety Foundation guidelines, the International Air Transport Association, an international airline association, has developed a safety audit program for ground handling companies aimed at improving safety and cutting airline costs by drastically reducing ground accidents and injuries.<sup>31</sup> The program is available to all ground service providers, who, after successfully completing the audit, are placed on a registry. As of August 2011, Seattle-Tacoma International Airport is the only domestic airport participating in the program.<sup>32</sup>

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<sup>29</sup>See [GAO-08-29](#).

<sup>30</sup>For more information about the Flight Safety Foundation's Ground Accident Prevention program, see <http://flightsafety.org/archives-and-resources/ground-accident-prevention-gap/gap-ramp-operational-safety-procedures>.

<sup>31</sup>For more information about the International Air Transport Association's Safety Audit for Ground Operations, see <http://www.iata.org/ps/certification/isago/pages/index.aspx>.

<sup>32</sup>The Port of Seattle, which manages Seattle-Tacoma International Airport, is requiring all airlines and ground handling companies at the airport to be certified with the International Air Transport Association's Safety Audit for Ground Operations by the end of 2011. According to the audit's registry, as of August 23, 2011, several individual companies have also been certified at individual airports, including LAN Airlines, S. A. in Miami, Florida, and Menzies Aviation in San Francisco and San Jose, California.

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## Data Collection and Risk-Based Analysis of Airborne Aviation Safety Information

As part of a planned shift to a risk-based safety management system throughout the agency, FAA has increased its data collection on safety incidents involving air traffic controllers by taking steps to encourage reporting of safety incidents (see fig. 6). In particular, between 2008 and 2010, ATO implemented a nonpunitive, voluntary safety reporting program for air traffic controllers—the Air Traffic Safety Action Program (ATSAP)—at 322 facilities. According to officials, the intent of ATSAP is to provide air traffic controllers with a method through which potential safety hazards can be identified, evaluated, and addressed. Modeled on a voluntary safety reporting program that various airlines operate for their pilots and other employees,<sup>33</sup> ATSAP enables air traffic controllers to report losses of separation and other safety issues that may help identify potential precursors to accidents without fear of punitive action. Voluntary, nonpunitive reporting is seen as a key part of safety management systems and is advocated by ICAO. According to FAA officials, 250–350 ATSAP reports are filed weekly, although not all of them are reporting safety incidents, such as losses of separation.<sup>34</sup> Reporting an incident into ATSAP fulfills most reporting requirements for air traffic controllers<sup>35</sup>—that controllers report any potential air traffic incidents that occur while the controller is working and are not otherwise reported to FAA<sup>36</sup>—and provides controllers with some protection from potential punitive action on the part of FAA in response to incidents, such as suspension or decertification. As of September 2011, the ATSAP program had issued more than 60 corrective action requests to address hazards identified as a result of its review of reports filed by controllers. Furthermore, officials stated that more than 100 additional safety

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<sup>33</sup>FAA's Aviation Safety Action Program encourages voluntary reporting of safety issues and events that come to the attention of employees of certain certificate holders by providing protection from legal or disciplinary action by FAA or others.

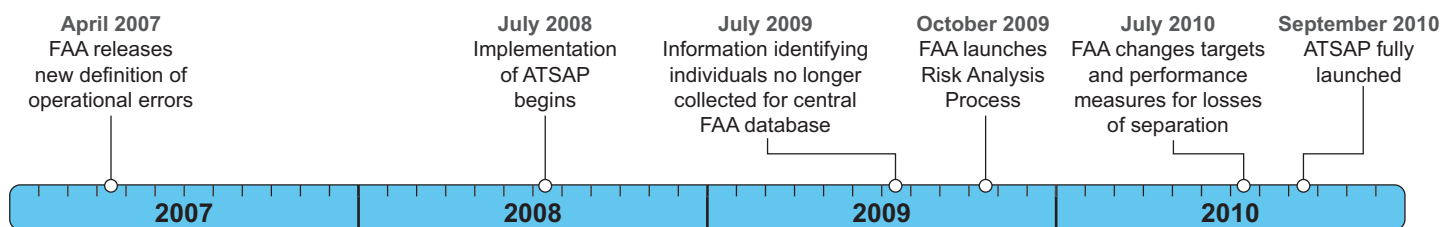
<sup>34</sup>According to ATSAP officials, reports into ATSAP can also include procedural or equipment issues with potential safety impacts, such as unclear guidance or malfunctioning radar.

<sup>35</sup>According to FAA officials, ATSAP does not fulfill reporting requirements for events that require immediate attention or events for which the controller involved is acting as a first level supervisor. For these situations, the event must also be reported directly to FAA.

<sup>36</sup>Controllers are required to report any occurrence that may be an operational deviation, operational error, proximity event, or air traffic incident if the reported issue is known only to the employee and occurs while the employee is directly providing air traffic services to aircraft or vehicles or first level watch supervision.

concerns have been addressed through informal discussions between AT SAP officials and FAA facilities.

**Figure 6: Key FAA Policy Actions to Increase Data Collection for Safety Incidents Involving Air Traffic Controllers**



Source: GAO.

In other efforts to obtain more safety data, FAA has taken other steps to make incident reporting less punitive. For example, in July 2009, FAA changed its incident reporting policy such that individually identifying information, such as air traffic controller names and performance records, is no longer associated with specific incidents in ATQA, the central FAA database used by air traffic control managers or supervisors to report incidents. In addition, in July 2010, FAA also stopped issuing incident “not to exceed” targets to individual air traffic control facilities (e.g., towers, TRACONS, or en route facilities).<sup>37</sup> According to officials, these targets created an incentive for underreporting of less serious incidents by supervisors at the facility level, and the targets were discontinued in order to encourage increased reporting at the agency.

FAA is also implementing new technologies, specifically, the Traffic Analysis and Review Program (TARP), an error detection system that can be used to automatically capture losses of separation that occur while aircraft are under the control of air traffic control towers and TRACONS. Historically, FAA relied on air traffic controllers and their supervisors to manually report on operational errors, something we have noted in the past may negatively impact data quality and completeness.<sup>38</sup> TARP automatically captures data on all airborne losses of separation, which, according to officials, will increase the volume of data FAA gathers on air

<sup>37</sup> Officials stated that, prior to 2010, FAA included facility-level targets for safety incidents in an effort to meet larger, agency-wide performance goals.

<sup>38</sup> See GAO, *Aviation Safety: Information on FAA’s Data on Operational Errors at Air Traffic Control Towers*, [GAO-03-1175R](#) (Washington, D.C.: Sept. 23, 2003).

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traffic safety incidents and enable FAA to obtain a more complete picture of potential safety hazards. According to the fiscal year 2010 FAA Performance and Accountability Report, FAA has deployed TARP at 150 air traffic control tower and TRACON facilities. According to FAA officials, TARP is currently being used as an audit tool for approximately 2 hours per month at some facilities—in lieu of full-time use at all facilities—but further implementation of the system has been delayed as the agency evaluates the impact of the system on controllers and determines how the system will be used and how to handle the additional workload that will be created as more incidents are captured and require investigation.<sup>39</sup> Following the completion of these steps, FAA will take 210 days to fully deploy TARP.<sup>40</sup> Currently, incidents identified through TARP are being included in official incident counts.

FAA is also shifting to a new, risk-based process for assessing a select category of airborne losses of separation. FAA began using the Risk Analysis Process (RAP)—which is adapted from a similar process used by the European Organization for the Safety of Air Navigation (Eurocontrol)<sup>41</sup>—in fiscal year 2010. While the new process is being established, RAP will be used in tandem with the existing system. RAP is currently limited to Losses of Standard Separation (LoSS).<sup>42</sup> This subset of airborne incidents includes those in which the separation maintained is less than 66 percent of the minimum separation standard for the planes involved. Under RAP, FAA determines both the severity and the repeatability of selected LoSS events (that is, how likely a certain LoSS event will occur again at any airport under similar circumstances based on a number of factors). These factors include proximity of planes to one another at the time of the event, rate of closure between planes, controller and pilot recovery, and whether or not Traffic Collision Avoidance System

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<sup>39</sup>Some incidents identified as losses of separation by the TARP system involve aircraft under visual separation rules, meaning that an operational error did not occur.

<sup>40</sup>According to FAA officials, FAA will fully implement TARP at selected facilities and phase in additional facilities every 30 days until full deployment is reached. During this period, FAA will evaluate workload and resources to determine whether adjustments to implementation are necessary.

<sup>41</sup>Eurocontrol is an international organization that coordinated and plans air traffic control for all of Europe.

<sup>42</sup>LoSS consists of radar-based operation under the control of air traffic operations that results in less than the required separation between two or more airborne aircraft.



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(TCAS) technology is triggered by the incident.<sup>43</sup> Prior to the development of RAP, FAA categorized losses of separation based on proximity alone: the greater the loss of separation between two planes, the greater the severity of the incident in question.<sup>44</sup> Operational errors were then rated on an A–C scale, with those that retained more than 90 percent of required minimum separation categorized as proximity events.<sup>45</sup> (Fig. 7 compares the threshold for review of incidents in each system.) Officials stated that RAP is more robust than the previous system because it is able to take numerous factors into account when determining event severity, as well as overall risk to air traffic safety. In addition, the RAP will assess risk for LoSS events that were not assigned a severity category under the old system. As a result, they said the agency will be better equipped to identify systemic issues in air traffic safety and to issue related corrective action requests. Based on analysis of systemic issues identified across incidents, RAP released its first five corrective action requests on July 19, 2011, which were developed to mitigate specific hazards that contribute to what RAP has identified as the highest risk events.

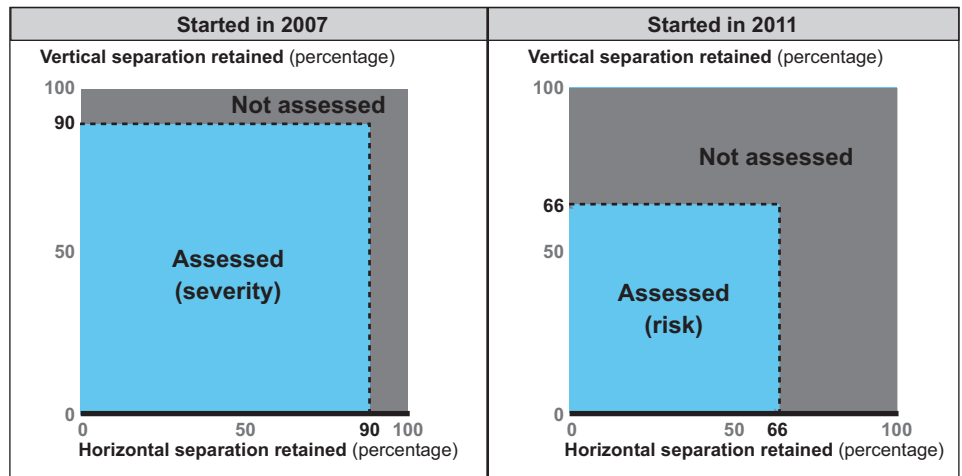
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<sup>43</sup>TCAS is an aircraft collision avoidance system required by the FAA to reduce the incidence of midair collisions between aircraft. TCAS operates independently from the ground-based air traffic control through transponders installed in aircraft and provides traffic alerts and directions to pilots to avoid conflicting aircraft.

<sup>44</sup>FAA officials stated that the agency will continue to categorize operational errors by severity as it transitions to the new, risk-based process.

<sup>45</sup>Proximity events are not considered operational errors and are therefore not assigned severity ratings nor included in ATQA.

**Figure 7: Changes in FAA’s Threshold for Incident Review**



Source: GAO.

**FAA Has Responded to Several Key Recommendations, but Some Areas Remain Unaddressed**

We, the Department of Transportation Inspector General (IG), and NTSB have raised concerns about terminal area safety. For example, we recommended, in 2007, that FAA take several steps to enhance runway and ramp safety, such as updating its national runway safety plan, collecting data on runway excursions, and working with OSHA and industry to collect and analyze better information on ramp accidents.<sup>46</sup> In 2007, FAA put in place a Director for Runway Safety and issued a Call to Action aimed at reducing the risk of incursions following several high-profile incidents (see table 2 for select recommendations to FAA). The IG also made recommendations to FAA about runway safety issues and recommended that FAA take several steps to reduce the risk of airborne incidents and improve oversight of this area. For example, the IG recommended that FAA clearly document the severity ratings used by FAA for runway incursions, revise the national plan for runway safety, and realign the Office of Runway Safety.<sup>47</sup> With regard to airborne incidents, the IG recommended establishing a process to rate the severity of pilot deviations and corresponding performance goals, developing milestones

<sup>46</sup>See [GAO-08-29](#).

<sup>47</sup>Department of Transportation IG, *Review of FAA’s Call to Action Plan for Runway Safety*, AV-2010-071 (Washington, D.C.: July 21, 2010).

for implementing TARP, and assuring that Flight Standards works with ATO Safety Services to determine whether losses of separation are pilot or controller errors, among other recommendations.<sup>48</sup> Further, NTSB continues to include runway safety, safety management systems, and pilot and air traffic controller professionalism issues on its list of most wanted safety improvements.

**Table 2: Key GAO and Department of Transportation IG Recommendations and FAA Actions, as of Sept. 30, 2011**

Agency	Selected recommendations	FAA response to recommendations	Status
GAO	Establish the Office of Runway Safety to lead the agency's runway safety efforts, including preparing a new national runway safety plan.	In 2007, FAA hired a permanent Director and in 2010, issued a new Order that enhanced the responsibilities of the Office of Runway Safety. FAA also issued the 2009–2011 National Runway Safety Plan.	Implemented.
	Develop and implement a plan to collect data on runway overruns (excursions) for analyses of trends and causes.	In January 2010, FAA's Office of Airports issued policy guidance to airport inspectors on how and what data to collect for every runway excursion, including overruns.	Implemented.
	Work with the aviation industry and OSHA to develop a mechanism to collect and analyze data on ramp accidents.	FAA's proposed rulemaking covers safety in airports.	Open.
IG	Revise FAA's National Plan for Runway Safety to include responsible FAA office, specific milestones, and metrics for each initiative.	FAA issued the 2009–2011 National Runway Safety Plan.	Implemented.
	Realign the Office of Runway Safety outside of FAA's operational lines of business, such as directly reporting to the Deputy Administrator.	FAA believes that the Office of Runway Safety has demonstrated effectiveness but will periodically review organizational structures and processes.	Closed.
	Develop milestones for implementing TARP as a full-time separation conformance tool.	FAA is in the process of testing TARP at selected locations.	Open.
	Establish a process to rate the severity of pilot deviations that cause a loss of separation and establish a corresponding goal to reduce the most severe incidents.	FAA believes that its Risk Analysis Process begins to address this recommendation, as some losses of separation caused by pilots are evaluated under the new system.	Open.

Sources: GAO and IG information.

<sup>48</sup>Department of Transportation IG, *FAA's Process for Reporting and Investigating Operational Errors*, AV-2009-045 (Washington, D.C.: Mar. 24, 2009).

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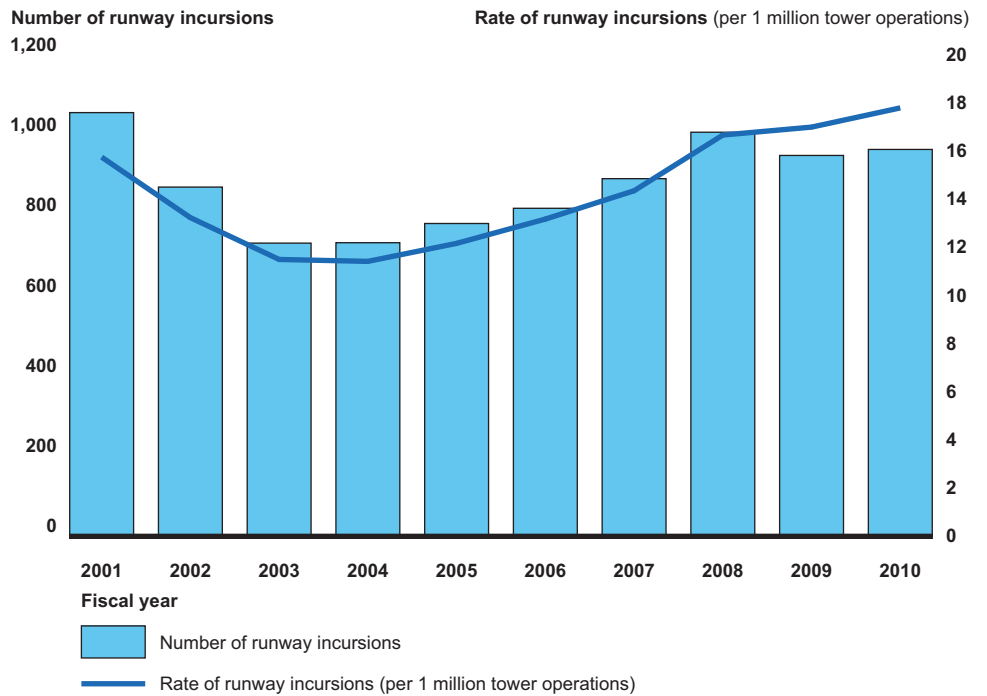
## Reported Surface and Airborne Incidents Have Increased, and Several Key Factors Likely Contribute to Trends

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### Rate of Reported Runway Incursions Has Increased since 2004, but Serious Incidents Have Significantly Declined

In fiscal years 2009 and 2010, the agency met its interim goals toward reducing the total number of runway incursions at towered airports, but the rate of incursions per million operations continued to increase (see fig. 8). As noted in our 2007 report, both the number and rate of incursions reached a peak in fiscal year 2001, prompting FAA to focus on runway safety. The number and rate of incursions at towered airports decreased dramatically for a few years thereafter, though the impact of FAA's efforts on these outcomes is uncertain. Beginning in 2004, however, both the number and rate of incursions began increasing again. For example, in fiscal year 2004, there were 733 incursions at a rate of 11.4 incursions per 1 million tower operations, compared with fiscal year 2010, when there were 966 incursions at a rate of 17.8 incursions per 1 million such operations. Although the rate of incursions at towered airports continues to increase, the number of incursions at these airports peaked in fiscal year 2008.

**Figure 8: Number and Rate of Runway Incursions at Towered Airports, Fiscal Years 2001–2010**



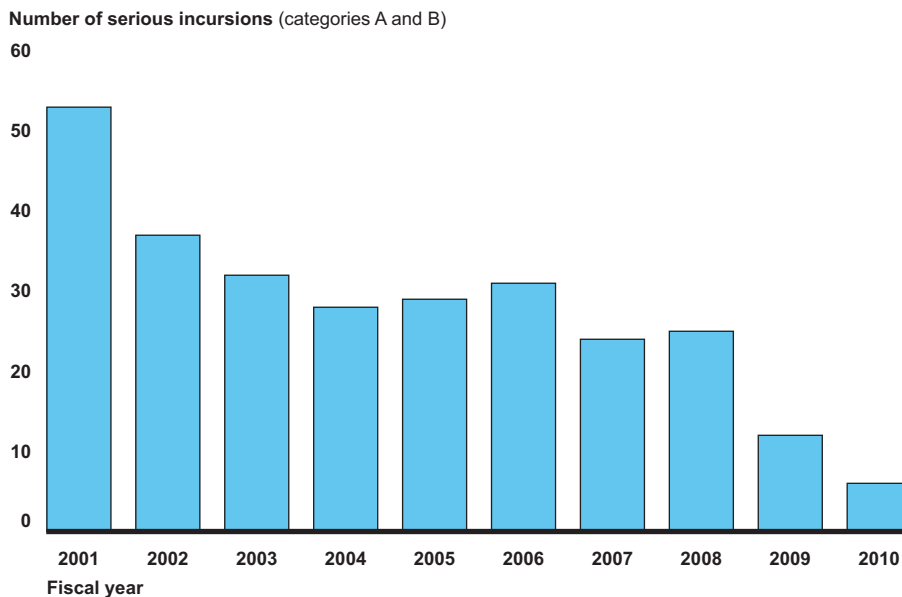
Source: GAO analysis of FAA data.

The most serious runway incursions at towered airports—where collisions are narrowly avoided—decreased by a large amount from fiscal year 2001 to 2010, and FAA met or exceeded its goals for reducing the rate of these incidents.<sup>49</sup> FAA classifies the severity of runway incursions into four categories—A through D—and its performance targets call for the reduction of the most severe incursions (category A and B) to a rate of no more than 0.45 per million air traffic control tower operations by fiscal year 2010 and for the rate to remain at or below that level through fiscal year 2013. The number of the most severe incidents at towered airports also dropped from fiscal year 2001 to 2010. Thus, category A and B

<sup>49</sup>FAA defines category A as a serious incident in which a collision was narrowly avoided; category B as an incident in which separation decreases and there is a significant potential for collision, which may result in a time critical corrective/evasive response to avoid a collision; category C as an incident characterized by ample time and/or distance to avoid a collision; and category D as an incident that meets the definition of runway incursions but with no immediate safety consequence.

incursions at these airports decreased from 53 to just 6 during that time, with category A incursions decreasing from 20 to 4, and category B incursions decreasing from 33 to 2 (see fig. 9).

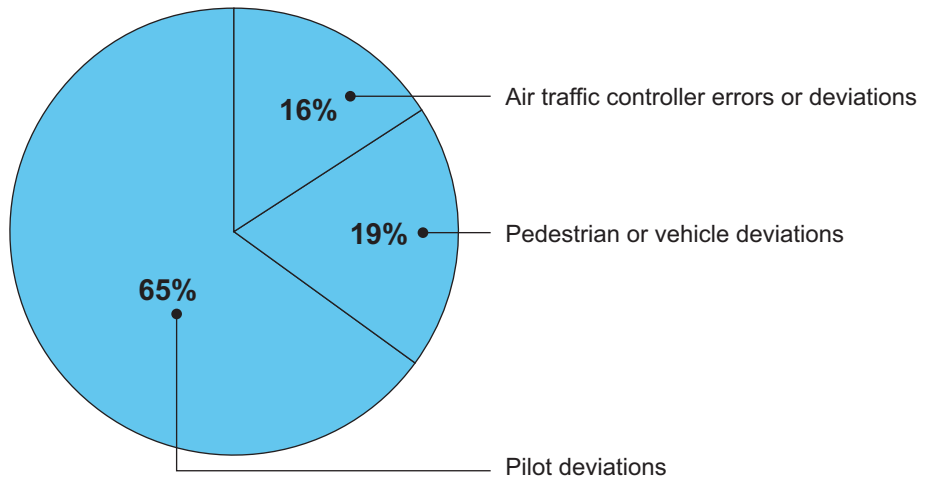
**Figure 9: Number of Serious (Category A or B) Runway Incursions at Towered Airports, Fiscal Years 2001–2010**



Source: GAO analysis of FAA data.

In fiscal year 2010, the majority of incursions at towered airports were classified as pilot deviations (65 percent), followed by vehicle/pedestrian deviations (19 percent), and operational errors and deviations by air traffic controllers (16 percent) (see fig. 10). Further, for every year since 2001, pilot deviations comprised the majority of runway incursions at these airports, and the proportion involving these errors steadily increased from about 55 percent of all incursions in fiscal year 2001 to 65 percent in fiscal year 2010.

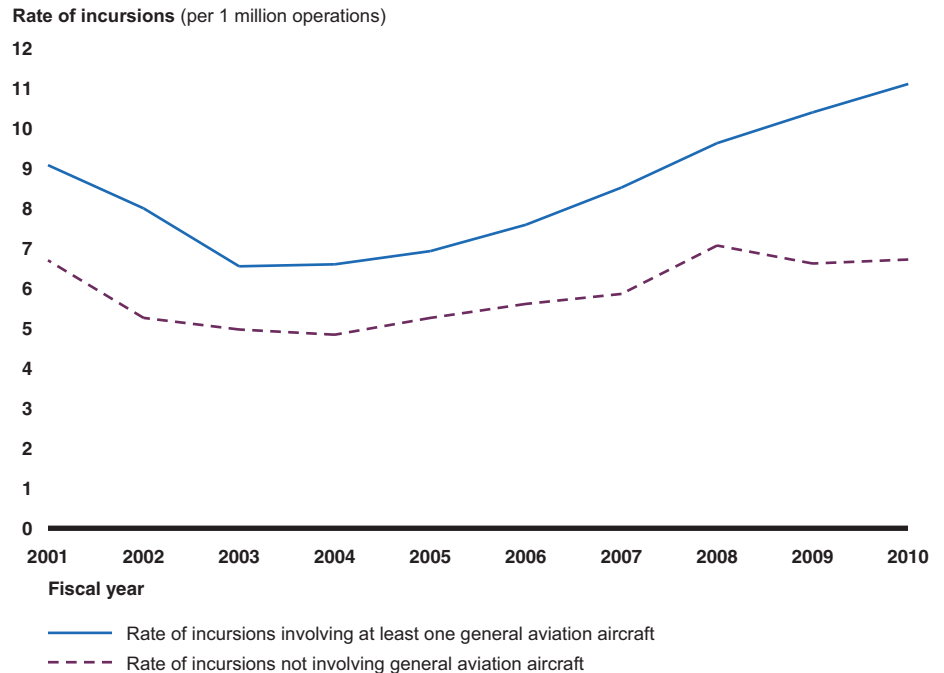
**Figure 10: Distribution of Runway Incursion Types, Fiscal Year 2010**



Source: GAO analysis of FAA data.

We previously reported that most runway incursions at towered airports involved general aviation aircraft and that trend continues. General aviation aircraft make up nearly a third of total operations at towered airports but have consistently accounted for about 60 percent of incidents each year since 2001. More specifically, the rate of incursions per million tower operations involving at least one general aviation aircraft is higher than the rate of incursions not involving general aviation aircraft, and the rate has increased every year since fiscal year 2004 (see fig. 11). Further, general aviation aircraft were involved in over 70 percent of the most serious—category A and B—incursions from fiscal year 2001 through the second quarter of fiscal year 2011. According to FAA officials, general aviation pilots may be more susceptible to incursions and other incidents because of their varying degrees of experience and frequency of flying. Furthermore, general aviation pilots do not generally undergo the same training as commercial airline pilots do.

**Figure 11: Rate of Runway Incursions Involving or Not Involving General Aviation per Million Air Traffic Control Tower Operations, Fiscal Years 2001–2010**



Source: GAO analysis of FAA data.

With regard to runway excursions, our review of NTSB data found that general aviation aircraft are also involved in most runway excursions. Although FAA does not yet formally collect information on runway excursions, NTSB provided us with accident investigation reports on 493 accidents that involved runway overruns or excursions since 2008. Seven of these accidents were fatal, resulting in 14 fatalities.<sup>50</sup> Our review of these reports found that 97 percent of the accidents involving excursions referred to the involvement of at least one general aviation aircraft.

In our 2007 report, we found that efforts to address the occurrence of safety incidents in ramp areas were hindered by the lack of data on the nature, extent, and cost of ramp incidents and accidents and by the absence of industrywide ground handling standards. As discussed above,

<sup>50</sup>NTSB investigates excursions that meet the definition of aircraft accident as specified in 49 C.F.R. Part 830.2.



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FAA collects no comprehensive data on incidents in the ramp area, and NTSB does not routinely collect data on ramp incidents that do not result in injury or aircraft damage.<sup>51</sup> Likewise, as mentioned above, OSHA, the primary source of ramp fatality data, does not collect data on incidents that do not result in at least three serious injuries or fatalities. In the ramp area, OSHA data on worker fatalities show the number of deaths in the ramp area to have varied between 3 and 11 from 2000 to 2010. The rate remained constant—between 4 and 6 deaths per year—from 2008 to 2010.

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### Rate and Number of Reported Airborne Operational Errors Increased since 2007, Including the Most Serious Incidents

The rate of reported airborne operational errors in the terminal area increased considerably in recent years. From the second quarter of fiscal year 2008 to the second quarter of fiscal year 2011, the rate and number of reported airborne operational errors increased significantly. During this time period, the rate of reported airborne operational errors in the terminal area nearly doubled, increasing 97 percent, and the number of reported airborne operational errors increased from 220 to 378.<sup>52</sup> The rate of incidents began a notable climb in the fourth quarter of fiscal year 2009, peaked in the second quarter of fiscal year 2010, and remained at rates higher than the historical average through the second quarter of 2011 (see fig. 12). FAA officials attributed at least some portion of the spike in reported incidents during the second quarter of fiscal year 2010 to approximately 150 events that occurred as the result of the misinterpretation of an arrival waiver at one TRACON facility.<sup>53</sup>

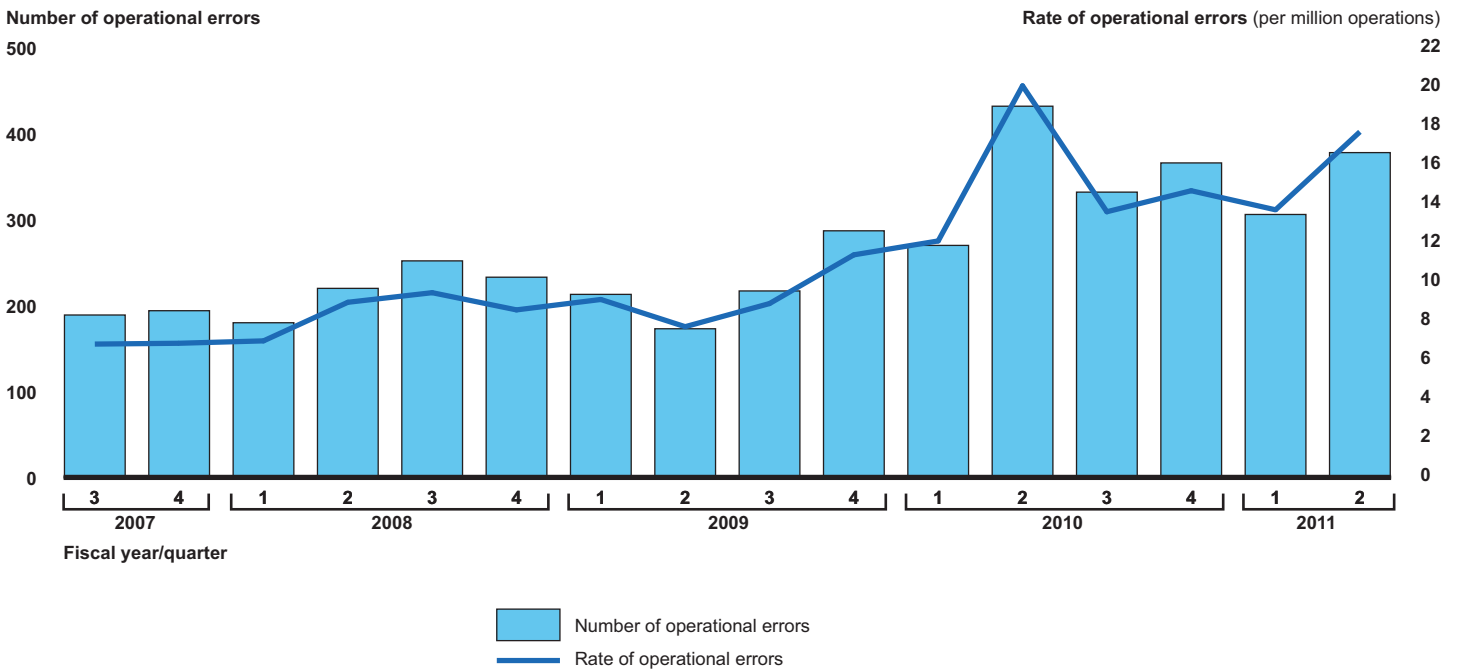
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<sup>51</sup>NTSB investigates ramp events that meet the definition of aircraft accident as specified in 49 C.F.R. Part 830.2.

<sup>52</sup>FAA revised the method of categorizing operational errors in the third quarter of fiscal year 2007 to use severity conformance ratings of A, B, or C. As a result, we used the enactment date of this definition change as the start date for our analyses of airborne operational errors.

<sup>53</sup>According to FAA officials, the waiver was intended to allow the South California TRACON facility to reduce standard separation requirements to less than 1,000 feet or 3 miles between aircraft on the final approach to Los Angeles International Airport and Hawthorne Municipal Airport for aircraft cleared for an Instrument Landing System approach. Officials at the TRACON erroneously also applied the waiver to aircraft on a visual approach for landing.

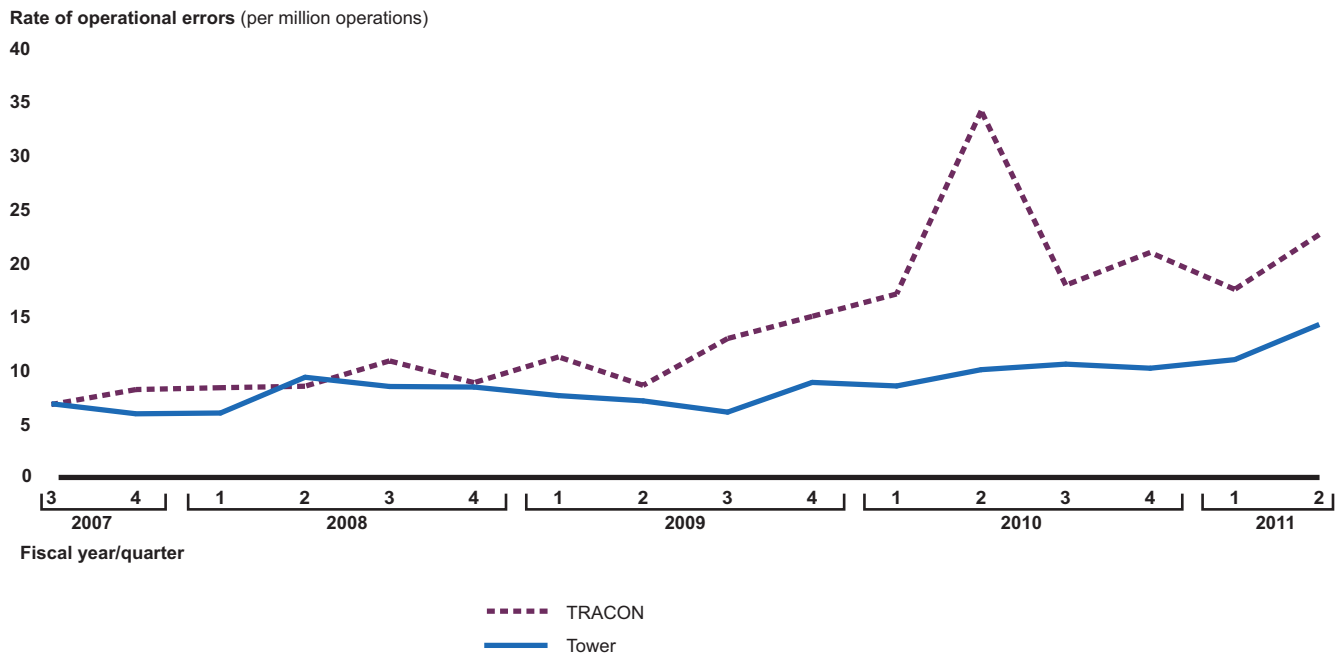
**Figure 12: Operational Errors in Towers and TRACONS, Third Quarter Fiscal Year 2007–Second Quarter Fiscal Year 2011**



Source: GAO analysis of FAA data.

While the rate of airborne operational errors has increased over time in both the TRACON and tower environments, the rate of errors in the TRACON environment has increased more. Between the second quarters of fiscal years 2008 and 2011, the rate of operational errors in the TRACON environment increased from 8.5 to 22.6 operational errors per million air traffic control operations—a 166 percent increase (see fig. 13). In comparison, operational errors increased by 53 percent in the tower environment.

**Figure 13: Rates of Operational Errors per 1 Million Operations, Third Quarter Fiscal Year 2007–Second Quarter Fiscal Year 2011**



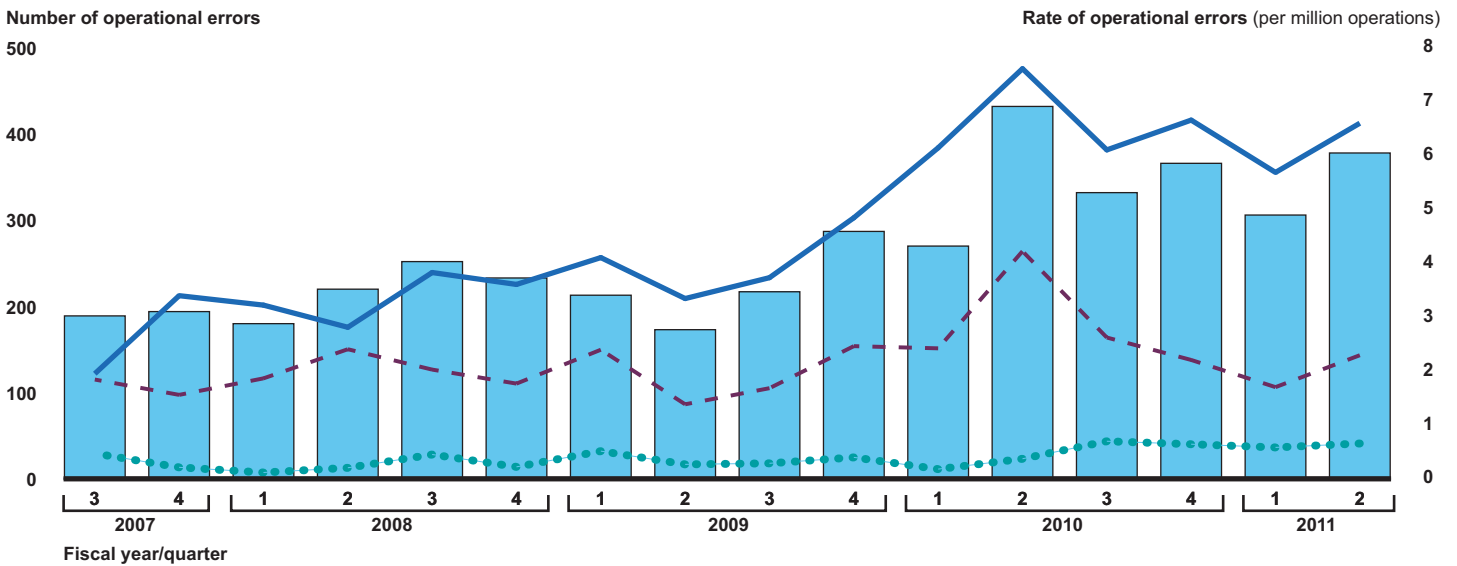
Source: GAO analysis of FAA data.

Note: TRACON rates of operational errors are per 1 million TRACON operations, and tower rates of operational errors are per 1 million tower operations.

Overall, the rate of the most severe airborne operational errors more than doubled between the second quarter of fiscal year 2008 and the second quarter of 2011.<sup>54</sup> While the least severe (category C) incidents are more numerous than the most severe, the most severe (category A) incidents increased from 5 in the second quarter of 2008 to 14 in the second quarter of 2011. In comparison, category C operational errors increased by 135 percent, and category B operational errors decreased by 5 percent.

<sup>54</sup>Incident severity as recorded in ATQA is based on proximity. Category A operational errors are those in which greater than 66 percent of required separation is lost, category B operational errors are those in which between 25 and 66 percent of required separation is lost, and category C operational errors are those in which between 10 and 25 percent of required separation is lost. Losses of separation in which 0 and 10 percent of required separation is lost are characterized as proximity events by FAA and are not considered operational errors.

**Figure 14: Operational Errors at Air Traffic Control Towers and at TRACONS, Third Quarter Fiscal Year 2007–Second Quarter Fiscal Year 2011**



■ Number of all operational errors  
— Rate of C errors  
- - - Rate of B errors  
●●●● Rate of A errors

Source: GAO analysis of FAA data.

These incident rates do not meet FAA goals under both the prior severity system and using new risk assessment measures. In fiscal year 2010, FAA reported 3.32 category A and B operational errors per million air traffic control operations, significantly exceeding its targeted rate for fiscal year 2010 of 2.05 per million operations.<sup>55</sup> In fiscal year 2011, FAA replaced its operational error measure with a new measure—the System Risk Event Rate (SRER)—a 12-month rolling rate of the most serious

<sup>55</sup>FAA performance targets for operational errors were established in its 2009 to 2013 *Flight Plan* and are target rates for all air traffic control activities. FAA’s target rates are not specific to the terminal area.

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LoSS events per thousand such events.<sup>56</sup> The rate of high-risk events also increased using this measure. According to data provided by FAA, the number of the most serious LoSS events—called high-risk events in the new risk assessment process<sup>57</sup>—spiked from 9 events in December 2010 to 16 events in January 2011 but has since decreased. However, the overall SRER increased significantly between December 2010 and February 2011 (from 21.9 to 29.9 high-risk LoSS events per 1000 LoSS events) and remains significantly elevated above FAA’s target of 20 serious LoSS events for every thousand such events. The SRER for the 12-month period ending in April 2011 was 28.97.<sup>58</sup> According to FAA officials, the agency’s target of 20 LoSS events per thousand LoSS incidents represents the system performance baseline<sup>59</sup> gathered using human reporting and may therefore be an unrealistic target as the agency moves to gathering data electronically. FAA plans to continue to collect data on and categorize events using both the old and new systems. Once FAA has completed a 2-year baseline period, it has committed to conduct an independent review of both metrics to determine whether any improvements are needed.

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### Several Key Factors Likely Contribute to Trends in Runway Incursions and Airborne Operational Errors

Several factors have likely contributed to recent trends in runway incursions and airborne operational errors. The agency has noted that recent increases in runway incursions and airborne operational errors are primarily attributable to changes in FAA’s reporting practices, which encourage increased reporting of incidents. We found evidence to

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<sup>56</sup>SRER represents the rate of radar-tracked losses of separation. The equation used to calculate the SRER is [the “number of serious LoSS events” divided by the “total number of LoSS events multiplied by 1000”]. The SRER is a cumulative function that is always presented as a rolling 12-month average. A 12-month rolling average prevents drastic shifts in the rate from month to month; however, large changes to either number used to calculate the rate can result in significant shifts that can be reflected in the rate for many months.

<sup>57</sup>High risk events are Losses of Standard Separation in which both the severity and the likelihood of the incident occurring again receive high scores within the Risk Analysis Process (RAP).

<sup>58</sup>The Department of Transportation IG is currently conducting an audit of FAA’s LoSS Index and the SRER.

<sup>59</sup>The SRER baseline target was developed using 6 months of LoSS data assessed through RAP. This baseline target is intended to be used as the process matures; allowing more data to be collected and to establish a more realistic target.

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suggest that changes to reporting policies and processes have likely contributed to the increased number of incidents reported—both into ATQA, the official database for incidents—and into ATSAP, the nonpunitive reporting system for air traffic controllers. In addition, the implementation of new technologies and procedures in the terminal area also likely contributed to an increase in the number of reported airborne incidents and runway incursions. FAA has carried out changes aimed at increasing reporting, and each of these factors may have contributed to an increase in the number of reported incidents. That said, it is possible that the increase in safety incidents in the terminal area may also reflect some real increase in the occurrence of safety incidents. As a comparison, we looked at the rate of en route operational errors, which are captured automatically by airplane tracking technology<sup>60</sup> and would therefore not be expected to substantially increase by a change in reporting practices or procedures at the agency. We found that the average rate of en route operational errors in fiscal year 2010 was 38 percent higher than the year before, and that the overall rate increased 13 percent from the second quarter of fiscal year 2008 to the same quarter in 2011. According to FAA officials, some of the increase in reported en route errors may be attributable to increased confidence in the nonpunitive nature of the system—reflected by a decrease in the number of requests for reclassification of incidents from en route facilities.

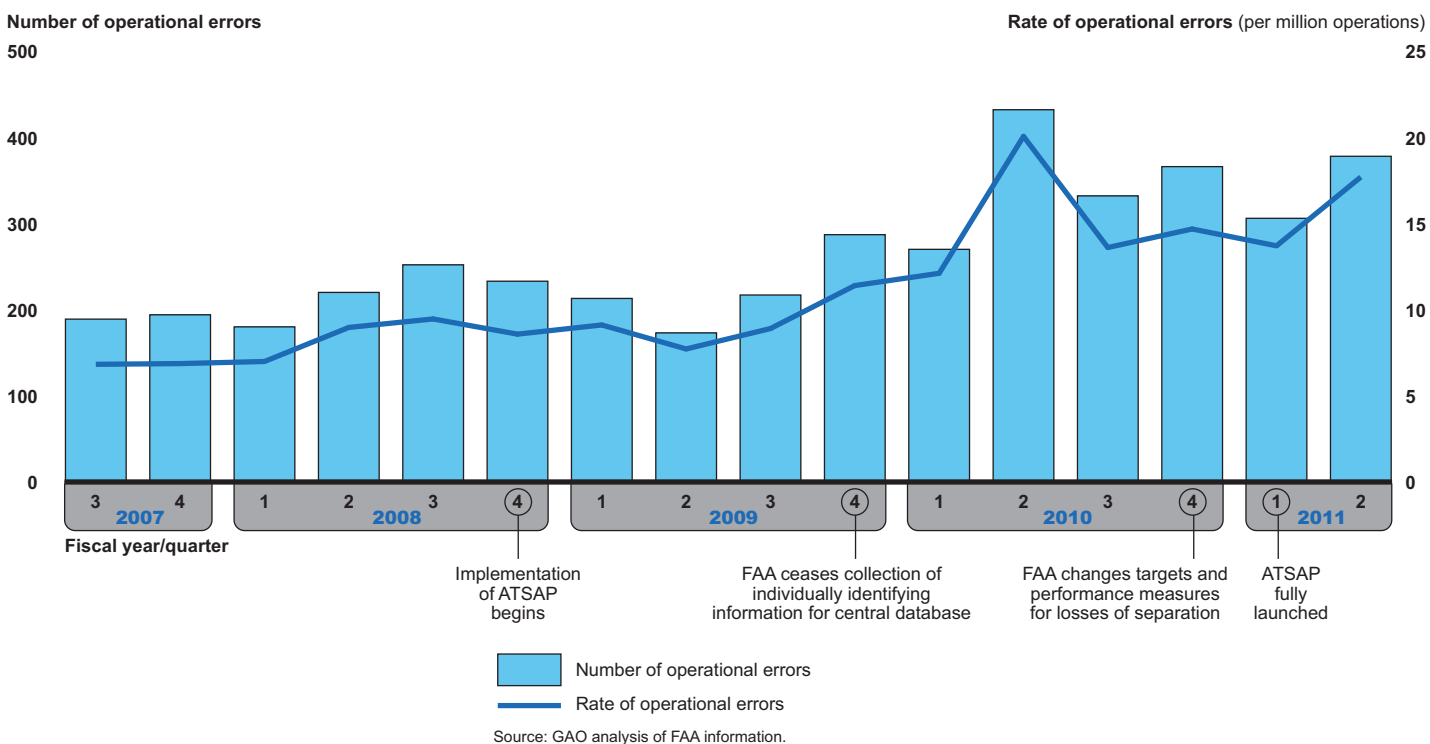
Changes to reporting processes and policies at FAA may explain in part the recent upward trend in reported runway incursions and airborne operational errors. Since operational errors and other losses of separation in both the tower and TRACON environments are currently reported manually by FAA supervisors and quality assurance staff into ATQA, changes in reported error rates may be partially attributable to changes made to encourage more comprehensive reporting of incidents. Most notably, as previously discussed, FAA changed its incident reporting policy in July 2009 such that individually identifying information, such as air traffic controller names and performance records, are no longer associated with specific events in the ATQA database. According to officials, this change may encourage controllers to share more information about incidents with supervisors and quality assurance officers. In addition, in fiscal year 2010, FAA stopped issuing incident “not

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<sup>60</sup>When the minimum separation standard is violated in en route airspace, the air route traffic control center’s computer system detects it. This technology has not significantly changed in recent years.

to exceed” targets to individual facilities. According to officials, these targets may have led supervisors in the past to underreport less serious incidents in order to meet these targets. These policy changes may have increased reporting to an extent that these effects are apparent in incident rates. (See fig. 15 for recent FAA changes to reporting practices overlaid on report operational errors.)

**Figure 15: FAA Changes to Reporting Practices and Recent Trends in Tower and TRACON Operational Errors**



Implementation of a nonpunitive, confidential, system of reporting for air traffic controllers may have also contributed to the real increase in the occurrence of operational errors, according to FAA officials. While the implementation of ATSAP may affect reporting rates—either by increasing reporting or by lowering the number of reports to supervisors given that the system satisfies reporting requirements—officials told us that it could also inadvertently lead to an actual increase in the occurrence of operational errors or deviations. According to these

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officials, the reduced personal accountability ATSAP provides may make some air traffic controllers less risk averse in certain situations.<sup>61</sup> In addition, officials also noted that ATSAP may present a barrier to managerial efforts to directly manage controller performance. For example, if a report is filed into ATSAP, a supervisor may have limited options to assign training or take other corrective actions in response to an incident, even if he or she is aware that an error was made by an individual air traffic controller, presuming the incident did not involve alcohol or drug use or other such violations.<sup>62</sup>

The implementation of ATSAP may have resulted in increased reporting of incidents, although reporting into this system does not directly affect official trends in operational errors. According to FAA officials, the confidential, nonpunitive nature of ATSAP has contributed to a positive change in the reporting at FAA. As a result, errors that previously may have gone unreported by air traffic controllers are now being reported to ATSAP. However, data entered into ATSAP are not directly available to FAA and do not feed into ATQA (see fig. 16). In addition, it is possible that some incidents that would have previously been reported to FAA are now being reported only to ATSAP, thus decreasing the number of incidents reported to FAA.<sup>63</sup> According to ATSAP data, approximately 35 percent of all incidents reported to ATSAP in 2010 were “known” to FAA—meaning that the incident was reported into ATQA by a supervisor or manager, as well as into ATSAP by an air traffic controller—while the other 65 percent were not official reported to FAA.<sup>64</sup>

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<sup>61</sup>Before the implementation of ATSAP, air traffic controllers were required to report operational errors through ATQA and controllers could face punitive consequences including decertification if they were found to have committed errors.

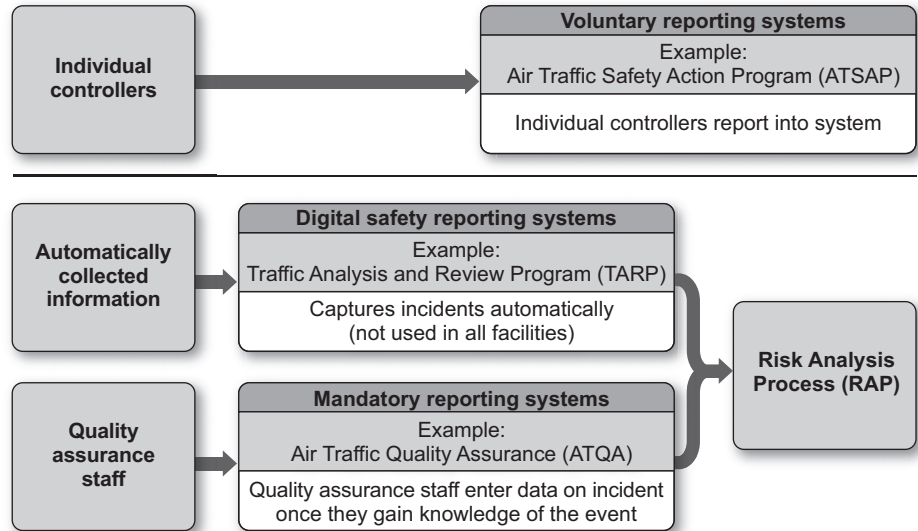
<sup>62</sup>Reports filed into ATSAP are reviewed by a committee comprised of representatives from the union representing air traffic controllers, FAA management, and FAA aviation oversight. Controllers whose reports are accepted into the program are granted protection from punitive action on the part of FAA. Reports of events involving apparent non compliance with applicable air traffic control directives that are not inadvertent or that involve gross negligence, substance abuse, controlled substances, alcohol, intentional falsification, or criminal activity are excluded from the program.

<sup>63</sup>As mentioned previously, air traffic controllers can satisfy reporting requirements by filing an ATSAP report, in lieu of informing their supervisors about incidents for inclusion in ATQA.

<sup>64</sup>The rate of errors that are unknown to FAA has decreased since the launch of ATSAP.



**Figure 16: Flow of Information into ATSAP is Separate from Other Systems FAA Uses to Track Air Traffic Safety Incidents**



Source: GAO.

Implementation of new technologies in the terminal area may also impact recent trends in surface incidents and airborne losses of separation. For example, since FAA’s ongoing implementation of TARP will allow FAA to automatically capture losses of separation in the tower and TRACON environments, it will also likely increase the number of reported losses of separation. According to officials, during its limited testing at facilities, TARP has already captured errors that were not being reported by air traffic controllers. For surface incidents, the ASDE-X system alerts controllers when aircraft or vehicles are at risk of colliding on runways, resulting in the identification of incidents that controllers might otherwise not be aware of. Designed as a surface surveillance system, ASDE-X helps to prevent collisions by raising alarms when aircraft appear to be at risk of colliding. As these alerts draw attention to near misses or potential collisions, they also serve to notify personnel of possible incursions and thus may have contributed to an increase in reported events, even as they may have prevented accidents. We analyzed the number of reported incursions at airports with ASDE-X and found that, at many of these airports, the number of reported incursions actually increased after their ASDE-X systems became operational. (For more information about our analysis of how the number of runway incursions changed after the installation of ASDE-X, see app. III.) Officials with the Sensis Corporation,

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the developer of ASDE-X, acknowledged to us that this may be a side effect of the deployment of the system.

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## Enhanced Oversight and Additional Information about Incidents Could Help Improve Safety in the Terminal Area

FAA has taken steps to improve safety in the terminal area since 2007 and has both reduced the number of serious incursions and undertaken successful efforts to increase reporting of incidents, but we identified two areas in which FAA could further improve management of data and technology in order to take a more proactive, systemic approach to improving terminal area safety. These areas include: (1) enhanced oversight of terminal area safety, including the management of runway excursions and ramp areas, and (2) assurance that data for risk assessments are complete, meaningful, and available to decision makers.

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## Federal Oversight of Terminal Areas Could Be Enhanced

### Runway Safety Oversight Remains Limited

Stakeholders we spoke with generally lauded Runway Safety's efforts on incursions, but FAA could do more to expand to other aspects of runway safety—notably runway excursions—as well as playing a more active oversight role in ramp areas. As we noted earlier, FAA is rolling out a new program to gather and analyze data on excursions, which should allow the agency to better understand why excursions happen and develop programs to mitigate risk. FAA is exercising some additional authority over ramps by proposing rules to address airport safety management systems and training for personnel accessing ramp areas, but these efforts are limited and involve requiring airports to develop and implement their own safety guidelines. In 2007, we reported that the lack of standards for ramp operations hindered safety, and an upcoming report by the Airport Cooperative Research Program (ACRP) continues to find that no comprehensive standards exist with regard to ramp area markings, ground operations, or safety training.<sup>65</sup> The two proposed rules by FAA on airport safety management systems and training establish some standards for the ramp area, but proposed federal oversight would still be limited. The proposed rule implementing safety management

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<sup>65</sup>Joanne Landry, *ACRP Synthesis 29: Ramp Safety Practices* (Washington, D.C.: Transportation Research Board of the National Academies, forthcoming).

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systems for airports would require airports to develop plans to identify and address hazards in the ramp area and on the airfield, in addition to ensuring that all employees with access to runways, taxiways, and ramps receive training on operational safety and on the airport's safety management system. Other aspects of ground handling, such as surface marking and ground operations, would continue to largely be overseen by airlines and the ground handling companies that are contracted by them.

### Organizational Placement of Runway Safety May Limit Efforts

The placement of the Runway Safety within the ATO Safety Office may limit its ability to serve as an effective focal point for runway and terminal area safety, given that aspects of runway and terminal area safety fall under the purview of several parts of FAA, including ATO, the Office of Airports, and the Office of Aviation Safety. In 2010, the IG recommended that the placement of Runway Safety within ATO be reconsidered, because the office may be limited in its ability to carry out cross-agency risk management efforts. Subsequently, the IG determined that Runway Safety had demonstrated effectiveness within ATO, but pointed to a need to periodically review organizational structures and processes to ensure that it continues to be effective. Runway Safety oversees data, assessments, and performance measures across a number of safety areas—air traffic control, pilot actions and training, outreach to general aviation, airport infrastructure, and technologies, among others—which are under the purview of different offices within FAA. As a result, Runway Safety has the potential to serve as the focal point for risk management in the terminal area.

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### FAA Data for Risk Assessment May Not Be Complete, Meaningful, or Available to Decision Makers

#### Impact of Changes in Reporting Policies and Processes on Measures of Incidents and Risk Is Unclear

Multiple changes to reporting policies and processes in recent years make it difficult to know the extent to which the recent increases in some terminal area incidents are due to more accurate reporting or an increase in the occurrence of safety incidents or both. For example, FAA officials have specifically attributed the increase in airborne operational errors to changes in reporting practices following the implementation of ATSAP, but, as previously mentioned, the relationship between the implementation of ATSAP and an increase in errors is uncertain. Likewise, other changes to performance measures and internal reporting policies, such as removal of individually identifying information from ATQA, further obscure the source

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FAA Risk-Assessment  
Processes Are Not  
Comprehensive

of recent trends. Without accurate and consistent measures of safety outcomes, FAA cannot assess the risks posed to aircraft or passengers over time or the impacts of its efforts to improve safety.

As we noted in a 2010 report, FAA has embarked on a data-driven, risk-based safety oversight approach.<sup>66</sup> As part of this effort, FAA has established a new, risk-based measure to track losses of separation, but measures for runway incursions are not risk based, reflecting instead a simple count of incidents. Thus, FAA currently rates the severity of incursions based on proximity and the response time to avoid a collision and does not differentiate between types of aircraft—or the number of lives put at risk—as part of its severity calculation. While any loss of life is catastrophic, the impact of an accident involving a commercial aircraft carrying hundreds of passengers can have different implications than an accident involving smaller aircraft. According to industry stakeholders, the use of proximity as the main criterion for severity of incursions is overly simplistic. As a result, FAA may be unable to use incursion data to identify the most serious systemic safety issues. Similarly, the application of risk assessment to measures of runway safety could allow FAA to focus individually on the risk posed by incursions by large commercial aircraft, as well as the risk posed by an ever-increasing incursion rate among general aviation operations. Additional attention to the root causes of incidents involving general aviation could potentially identify strategies addressing this ongoing challenge, which may include the installation of low-cost ground surveillance systems.<sup>67</sup> While FAA officials did not detail immediate plans to alter the measure for incursions, officials did state that the agency plans to introduce surface incidents into RAP at the beginning of fiscal year 2012. The joint FAA-aviation industry Runway Safety Council is a first step toward the effort to reduce incursion risks. By identifying causes and making recommendations that could help determine what changes would be needed to make measures more risk-based, the Council's Root Cause Analysis Team can help reduce incursion risks. Further, according to FAA officials, the new measure

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<sup>66</sup>GAO, *Aviation Safety: Improved Data Quality and Analysis Capabilities Are Needed as FAA Plans a Risk-Based Approach to Safety Oversight*, [GAO-10-414](#) (Washington, D.C.: May 6, 2010).

<sup>67</sup>As we noted earlier, FAA is currently assessing a low-cost ground surveillance system but has not made any decisions as to whether it will install this system and at which airports.

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being developed for excursions will be risk-based; however, this measure will not be fully in use until 2014.

By contrast, FAA has taken steps to improve its ability to assess the risk of airborne operational errors and to collect more information. However, under the new risk assessment system, far fewer incidents are subject to analysis than were included in previous, nonrisk-based iterations, and the measure may therefore not account for all potential risk. For instance, RAP does not yet have procedures to assess losses of separation with terrain and with airspace boundaries. Currently, LoSS events in which at least 66 percent of minimum separation is maintained between aircraft are not assessed through FAA's recently launched RAP.<sup>68</sup> According to FAA officials, the 66 percent threshold for inclusion in RAP was adopted in recognition of the resources required for the enhanced risk-analysis process. This initial threshold is not based on specific risk-based criteria. Furthermore, losses of separation eligible for inclusion in RAP are currently limited to those that occur between two or more radar-tracked aircraft. As a result, many incidents—such as those that occur between aircraft and terrain or aircraft and protected airspace—are currently excluded from FAA's process for assessing systemic risk. According to FAA officials, this exclusion is in part because there is no system in place through which the current RAP proximity inclusion threshold could be applied to these types of incidents, although FAA officials stated that an effort is under way to expand RAP to include these areas. In addition, FAA's new measure for assessing air traffic risk levels—the SRER—does not include many losses of separation that were tracked under the old measure, although it does expand the assessment process to include some errors caused by pilots. Further, while the technology has been developed to collect data automatically for potential operational errors involving losses of separation, FAA has delayed the full implementation of TARP in air traffic control towers and TRACONS. According to FAA officials, the implementation of TARP may create workload challenges for quality assurance staff, as the technology is likely to capture hundreds of potential losses of separation that were not previously being reported

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<sup>68</sup>FAA officials noted that data on LoSS events that are not currently assessed through RAP will continue to be collected electronically and used for trending and analysis purposes.

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through existing channels.<sup>69</sup> In 2009, the IG recommended that FAA establish firm timelines for the full implementation of TARP.

Data collected through ATSAP, the nonpunitive reporting system, have limitations.<sup>70</sup> There is the potential for serious events to be reported only to ATSAP and to therefore not be included in the official ATQA database or in RAP. Such events are referred to as “unknown” events. In 2010, 65 percent of incidents reported to ATSAP were unknown to FAA. (See fig. 17.) FAA officials acknowledged that there are a large proportion of unknown incidents but stated that these incidents are likely to be minor. In addition, some information about incidents reported to ATSAP is available for analysis by FAA and the aviation industry via the Aviation Safety Information Analysis and Sharing (ASIAS) program, as de-identified ATSAP data are shared with ASIAS.<sup>71</sup> Further, they noted, ATSAP reports may be procedural, rather than reports of incidents or operational errors. Available data from the ATSAP program office indicates, however, that some of the “unknown” reports in the system were potentially serious events. For example, between the program’s launch in July 2008 and June 2011, 74 out of 253 ATSAP reports that were classified as potentially hazardous did not appear in ATQA, accounting for 29 percent of these reports.<sup>72</sup> In June 2011—the most recent month for which data are available—approximately one third of all ATSAP reports classified as potentially major events, and 42 percent of those classified as hazardous, did not appear in ATQA. According to officials, ATSAP allows controllers to report incidents that may have otherwise gone unreported, and the program facilitates early detection and improved awareness of operational deficiencies and adverse trends. These unknown events, FAA

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<sup>69</sup>According to officials, FAA may have difficulty assessing all incidents captured by TARP. Such assessment will be necessary as some of the losses of separation identified by TARP may not be operational errors. For example, if an air traffic controller is using visual separation between aircraft, the proximity of aircraft captured by TARP may actually be appropriate, despite appearing to be a loss of separation.

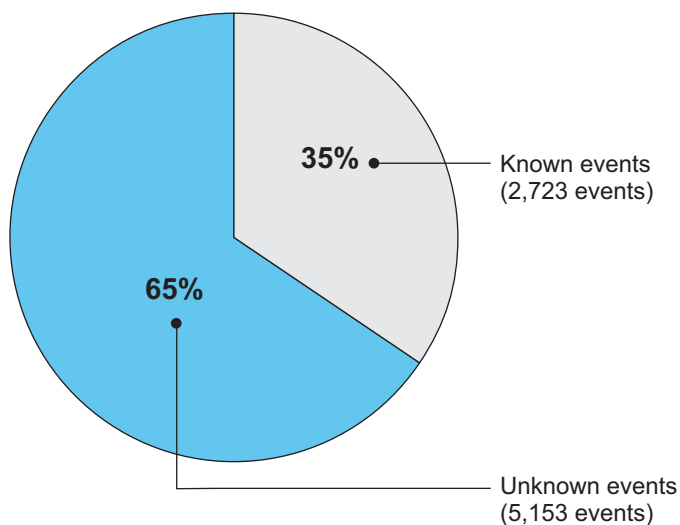
<sup>70</sup>The Department of Transportation IG is currently conducting an audit of FAA’s implementation of ATSAP.

<sup>71</sup>ATSAP information is shared with ASIAS, but incident reports do not include information that would identify controllers.

<sup>72</sup>ATSAP Event Review Committees review controller reports to ATSAP and assign a severity rating to each report. Possible severity ratings, in order from least to most potential risk are: (1) none, (2) minimal, (3) minor, (4) major, (5) hazardous, and (6) catastrophic.

officials point out, would not likely have been reported into ATQA before the implementation of ATSAP.

**Figure 17: Incidents Reported to ATSAP in 2010 That Are Known to FAA versus Those That Are Unknown**



Source: GAO presentation of ATSAP data.

### Key Safety Data May Not be Available to Decision Makers

Information sharing challenges may impact the ability of FAA to analyze safety data and understand safety trends. Multiple FAA programs and data systems assign contributing factors to incidents, but factors are not coordinated across programs. For instance, both ATSAP and RAP have developed sets of factors that are identified as contributing to incidents during the incident investigation process. However, despite the fact that these two programs look at some of the same type of incidents (airborne losses of separation), program officials have not coordinated their development of the categories used to describe incidents. As a result, officials we interviewed stated that it is difficult to compare data across systems. For example, both ATSAP and RAP issued internal reports identifying top factors contributing to reported incidents, but there is no apparent overlap between the two lists. In addition, while the ATQA database contains more than 50 contributing factors for operational errors, FAA and the ATSAP program office do not use these data to identify systemic safety issues (see table 3). According to FAA officials, FAA is currently developing a common set of contributing factors for ATSAP and RAP, as well as a translation capability that will allow for the inclusion of historical data on contributing factors in future analyses. The

IG raised concerns about the quality of ATQA data on contributing factors in a 2009 report, noting that FAA does not consistently include fatigue issues in contributing factor data it collects on operational errors.<sup>73</sup> FAA has added contributing factors related to fatigue to ATSAP and is exploring ways to gather objective shift, schedule, and related resource management data to support enhanced fatigue analysis.

**Table 3: Comparison of Top Factors Identified as Contributing to Controller Safety Incidents across Programs**

ATQA	RAP	ATSAP
1. Inappropriate use of displayed data	1. Perception	1. Clearance problem
2. Readback	2. Memory	2. Airspace violation
3. Improper use of visual data	3. Pilot actions	3. Expectation bias
4. Area of occurrence		4. Organization factor
5. Aircraft observation		5. Pilot noncompliance

Source: GAO analysis of FAA data.

Regional and local access to and awareness of data related to both individual incidents and incident trends may be limited. According to FAA officials we interviewed at the regional level, it is difficult for supervisors at the regional and facility levels to obtain information on incident trends specific to their area of supervision in part because key databases, such as ATQA, do not have the capability to allow regional supervisors to run region- or facility-specific data queries. In addition, while multiple data resources may be available, officials stated that information on incidents is scattered, and no central source exists where employees can identify available data resources. While FAA has made advances in the quantity and comprehensiveness of the data it collects on incidents in the terminal area, officials stated that the agency faces difficulty in developing sophisticated databases with which to perform queries and modeling of the data. According to FAA officials, the full implementation of CEDAR will address many of the deficiencies identified by regional and local offices.

The nature and scope of ramp accidents are still unknown, just as they were when we reported in 2007, and we were told by officials with Airports Council International that it can be difficult for airports to get data on

<sup>73</sup>Department of Transportation IG, *Air Traffic Control: Potential Fatigue Factors*, AV-2009-065 (Washington, D.C.: June 29, 2009).



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incidents in the ramp area—areas typically overseen by airlines. This will pose a challenge as airports move to implement safety management systems and seek to identify and mitigate hazards. As one aviation expert explained, even if data are available locally—which they may not be—the number of incidents at individual airports can be too few to allow for the identification of root causes or the proactive identification of risk.

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## Conclusions

The Office of Runway Safety focuses on improving safety by reducing the number and severity of runway incursions. However, risk management in terminal areas involves more than just incursions—notably runway excursions and incidents in ramp areas. Runway Safety plans to start tracking runway excursions in October 2011, but it will take several years to develop processes for identifying and tracking incidents, identifying and mitigating risks, and measuring outcomes. Likewise, FAA does not track incidents in ramp areas, although we previously recommended that FAA work with the aviation industry and OSHA to develop a mechanism to collect and analyze data on ramp accidents. Airports implementing plans for safety management systems under FAA’s proposed rule will need data that are useful, complete, and meaningful in order to accurately assess risk and plan for safety, but FAA cannot yet provide meaningful data for the assessment and management of risks posed by runway excursions or ramp areas. Without information on incidents in these areas, FAA and its safety partners are hampered in their ability to identify risk, develop mitigation strategies, and track outcomes.

FAA addresses runway incursions as a specific type of incident and does not distinguish between commercial and general aviation in its performance measures. However, risks posed by runway safety incidents to passengers and aircraft in the national airspace system are different for commercial aircraft and general aviation. FAA performance measures for runway incursions—including the number, rate, and severity—do not reflect differences between commercial and general aviation and are not risk-based. The agency has installed risk-reduction technologies at larger commercial service airports, for example, but in the absence of risk-based performance measures, it lacks the ability to prioritize projects or measure effectiveness. With regard to general aviation, this traffic currently accounts for about a third of total tower operations, but 60 percent of runway incursions involve these aircraft. While Runway Safety has acknowledged that general aviation has caused more runway incursions, without performance measures that reflect risk, FAA may not be able to identify appropriate mitigation strategies to address the large—and growing—proportion of runway incidents—including both incursions and

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excursions—involving general aviation aircraft. Strategies to decrease the risk posed by safety incidents involving general aviation could include additional outreach to these pilots, increased remediation following pilot errors, or the installation of technologies such as low-cost ground surveillance at airports serving general aviation traffic.

Safety in the terminal area is a shared responsibility among FAA, airlines, pilots, and airports, and there are a number of FAA offices that either collect or analyze terminal area incident data, but useful access to complete and meaningful data is limited. The agency currently does not have comprehensive risk-based data, sophisticated databases to perform queries and model data, methods of reporting that capture all incidents, or a level of coordination that would facilitate the comparison of incidents across systems. Technologies aimed at improving reporting have not been fully implemented. As a result, aviation officials managing risk using safety management systems, including local and regional decision makers, have limited—if any—access to FAA incident data. For example, FAA’s official database for air traffic safety does not allow local or regional FAA safety officials to run region- or facility-specific data queries. Further, under the new risk assessment process used for losses of separation, fewer incidents are assessed and accounted for in performance measures—such as losses of separation between aircraft and terrain or aircraft and protected airspace—which may distort risk assessment processes. Finally, according to FAA officials, one reason the agency has not fully implemented TARP is that implementation of TARP may create workload challenges for FAA quality assurance staff, as the technology is likely to capture hundreds of potential losses of separation that were not previously being reported through existing channels. FAA offices and others using a safety management system approach to manage risk should have access to complete and meaningful data to allow for hazard identification and risk management. The ability of FAA and airport officials—and the local Runway Safety Action Teams that they serve on—to identify safety risks, develop mitigation strategies, and measure outcomes is hindered by limited access to complete and meaningful data.

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## Recommendations for Executive Action

To enhance oversight of terminal area safety to include the range of incidents that pose risks to aircraft and passengers, we recommend that the Secretary of Transportation direct the FAA Administrator to take the following three actions:

- develop and implement plans to track and assess runway excursions and extend oversight to ramp safety;

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- develop separate risk-based assessment processes, measures, and performance goals for runway safety incidents (including both incursions and excursions) involving commercial aircraft and general aviation and expand the existing risk-based process for assessing airborne losses of separation to include incidents beyond those that occur between two or more radar-tracked aircraft; and
  - develop plans to ensure that information about terminal area safety incidents, causes, and risk assessment is meaningful, complete, and available to appropriate decision makers.

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## Agency Comments

We provided the Departments of Transportation and Labor, NTSB, and the National Aeronautics and Space Administration (NASA) with a draft of this report for review and comment. The Department of Transportation agreed to consider our recommendations and provided clarifying information about efforts made to improve runway safety, which we incorporated. The Department of Labor, NTSB, and NASA provided technical corrections, which we also incorporated.

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As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 7 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretaries of Transportation and Labor, NTSB, the Administrator of NASA, and interested parties. In addition, this report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me on (202) 512-2834 or at [dillinghamg@gao.gov](mailto: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 IV.



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

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# Appendix I: Objectives, Scope, and Methodology

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Our objective was to review aviation safety and update our 2007 report on runway and ramp safety.<sup>1</sup> To do so, we addressed the following questions: (1) What actions has the Federal Aviation Administration (FAA) taken to improve safety in the terminal area since 2007? (2) What are the trends in terminal area safety and the factors contributing to these trends? and (3) What additional actions could FAA take to improve terminal area safety?

To identify actions FAA has taken since 2007 to improve safety in the terminal area and to identify additional actions FAA could take to improve safety, we reviewed our prior reports, as well as documents and reports from FAA, the Department of Transportation Inspector General (IG), the National Transportation Safety Board (NTSB), the International Civil Aviation Organization (ICAO), and others; FAA orders, advisory circulars, and regulations; and applicable laws. We also determined the roles and responsibilities of FAA, NTSB, the Occupational Safety and Health Administration (OSHA), the National Aeronautics and Space Administration (NASA), airports, and airlines involving runway, terminal airborne, and ramp safety. In addition to interviewing officials from FAA, IG, and NTSB, we interviewed aviation experts affiliated with the Air Line Pilots Association, Airports Council International, Air Transportation Association, the Flight Safety Foundation, and the National Air Traffic Controllers Association about terminal area safety practices and technologies. We also interviewed researchers from the Air Cooperative Research Program (ACRP) of the Transportation Research Board and experts affiliated with various aviation technology companies. To obtain information about air traffic control operations, observe the application of key technologies, and interview facility managers, we visited four FAA facilities that were near our GAO offices: the Potomac Consolidated Terminal Radar Approach Control facility, the Washington Air Route Traffic Control Center, and the air traffic control towers at Ronald Reagan Washington National Airport and the Seattle-Tacoma International Airport. We also interviewed airport officials with the Port of Seattle at Seattle-Tacoma International Airport. To obtain information about the Air Traffic Safety Action Program (ATSAP), we interviewed officials with the ATSAP program office and attended an Event Review Committee meeting in Renton, Washington. We also reviewed FAA's progress in addressing recommendations that we, IG, and NTSB have made in previous years

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<sup>1</sup>See [GAO-08-29](#).

and reviewed the processes that FAA uses to collect and assess runway and air traffic safety data.

To identify and describe recent trends in terminal area safety and the factors contributing to these trends, we obtained and analyzed data from FAA, NTSB, and OSHA on safety incidents in the terminal area. We analyzed FAA runway incursion data collected from fiscal year 2001 through the second quarter of fiscal year 2011, as well as FAA data on airborne operational errors from the Air Traffic Quality Assurance database (ATQA) from the third quarter of fiscal year 2007 through the second quarter of fiscal year 2011. We limited our analysis to airborne operational errors in order to avoid double counting of surface operational errors that are included in our counts of runway incursions. We used Operations Network data from FAA to determine rates of incursions and airborne operational errors per million operations. Rates of incursions were calculated per million tower operations, and rates of airborne operational errors were calculated per million operations performed by air traffic control towers, terminal radar approach control (TRACON) facilities, and en route facilities on a quarterly basis.<sup>2</sup> We also reviewed NTSB data involving runway incursions and excursions from 2008 through June 2011 and summarized OSHA data on fatalities in the ramp area from 2001 through 2010. We used statistical models to assess the association between safety incidents and the concentration of general aviation operations and the implementation of the Airport Surface Detection Equipment, Model X (ASDE-X) surface surveillance system from fiscal year 2001 through April 2011. These models estimated how the number of incursions changed after airports installed ASDE-X or increased the proportion of operations involving general aviation. The models account for other factors that may contribute to incursions, such as long-term weather patterns, runway layouts, as well as controller and pilot experience. See appendix III for more information about the methods and results of these analyses. To assess the reliability of FAA data, we (1) reviewed internal FAA documents about its collection, entry, and maintenance of the data and (2) interviewed FAA officials who were knowledgeable about the content and limitations of these data. Both NTSB and OSHA provided information about the reliability of their excursion and fatality data, respectively. We determined that these data

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<sup>2</sup>Tower operations include all takeoffs and landings, including flights that take off and land at the same airport, and all flights that fly through the airspace and are tracked by the tower without landing.

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were sufficiently reliable for the descriptive and comparative analyses used in this report.

We conducted this performance audit from February 2011 to October 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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# Appendix II: Technologies to Improve Runway Safety

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Researching, testing, and deploying new technology is a major part of FAA's risk-reduction strategy. A number of available technological systems are intended to help reduce the number and severity of runway incursions. For example, to give air traffic controllers better visibility of activity on the airfield and help prevent collisions, FAA has installed the ASDE-X system at 35 major airports, while the Airport Surface Detection Equipment, Model 3 (ASDE-3) radar and the Airport Movement Area Safety System (AMASS) provide surface surveillance at 9 additional airports.<sup>1</sup> Runway status lights, which will be installed at 23 airports, are a fully automatic series of lights that give pilots a visible warning when runways are not clear to enter, cross, or depart on. To mitigate the risks posed by runway excursions, FAA conducted research that led to the development of the Engineered Materials Arresting System (EMAS), a bed of crushable concrete designed to stop aircraft from overrunning runway areas. As of July 2011, EMAS has been installed at 52 runways at 36 airports, and there are plans to install 11 EMAS systems at 7 others. According to FAA officials, EMAS has successfully arrested seven overrunning aircraft with no fatalities or serious injuries and little damage to the aircraft to date. (See table 4 for a brief description of technologies designed to improve runway safety.)

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<sup>1</sup>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 and was originally implemented at 34 airports. All but 9 of these locations now have ASDE-X.

**Table 4: Technologies Intended to Reduce the Number and Severity of Runway Incursions or Excursions**

Technology	Description
ASDE-3/AMASS	ASDE-3/AMASS is a radar-based system that tracks ground movements and provides an automatic visual and audio alert to controllers when it detects potential collisions on airport runways and taxiways.
ASDE-X	ASDE-X integrates data from a variety of sources, including radars, transponder multilateration systems, and Automatic Dependent Surveillance-Broadcast (ADS-B) to provide accurate target position and identification information and thus give controllers a more reliable view of airport operations. ASDE-X provides tower controllers a surface traffic situation display with visual and audible alerting of potential collisions.
ADS-B	ADS-B uses Global Positioning System signals along with aircraft avionics to transmit an aircraft's location to ground receivers. The ground receivers then transmit that information to controller screens and cockpit displays on aircraft equipped with ADS-B avionics. Both pilots and controllers will be able to see other aircraft in the sky around them. Pilots will also be able to see bad weather and terrain and receive flight information such as temporary flight restrictions. All commercial and most general aviation aircraft will be required to be equipped with ADS-B by 2020 as part of FAA's implementation of the Next Generation Air Transportation System.
Electronic Flight Bag with Moving Map Displays	The FAA reached agreements with several U.S. airlines to fund in-cockpit runway safety systems in exchange for critical operational data. With Moving Map Displays and Own-Ship Position, pilots will see exactly where their aircraft is on the airfield, thus reducing the chances of losing situational awareness and being in the wrong place.
Final Approach Runway Occupancy Signal (FAROS)	FAROS is designed to provide a visual alert of runway status to pilots intending to use a runway. Arriving aircraft approaching a runway for landing are alerted if the runway is occupied by flashing Indicator lights.
Low-cost ground surveillance systems	Low-cost systems designed to further reduce the risk of ground incidents or accidents, especially during periods of low visibility by providing ASDE-X-like capabilities at certain small and medium-sized airports.
Runway safety area improvements	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.
Runway status lights	Runway status lights provide warnings on runways and taxiways, illuminating when it is unsafe to enter, cross, or take off on a runway. Airport surveillance sensor inputs are processed through light control logic that commands in-pavement lights to illuminate red when traffic is on or approaching the runway.
EMAS	A lightweight, crushable concrete that is placed at the end of a runway to stop or greatly slow an aircraft that overruns the runway. A standard EMAS installation extends 600 feet from the end of the runway. However, EMAS is still effective even when less than 600 feet of land is available for its installation. EMAS has been installed at airports that do not have enough land for a standard runway safety area.

Source: GAO analysis of FAA information.



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# Appendix III: Technical Appendix

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This appendix summarizes our statistical analysis of the relationship between the ASDE-X airfield surface surveillance system and runway incursions. We focused on ASDE-X, among many other runway safety programs, because of its potential for persuasive impact evaluation. We describe how the process FAA used to install ASDE-X created a “quasi-experiment,” which allows us to compare how incursions changed at airports that received the technology relative to airports that kept the status quo.

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## Evaluating the Impact of ASDE-X on Runway Incursions

A key goal of ASDE-X is to make air traffic controllers more aware of activities on taxiways and runways in order to avoid collisions. The system consists of airfield radar and sensors that collect data on the location of aircraft and vehicles. Computers transform these data into continuously updated maps of the airfield, which are displayed on color monitors in air traffic control towers. The system warns controllers of potential collisions—which may draw attention to possible incursions—through visual and audible alarms.

FAA used a selective and staggered process to install ASDE-X at 34 airports from 2003 through 2011 (of 35 airports slated to receive this system). The variation among airports receiving the technology, as well as the times when they received it, allows for a quasi-experimental evaluation. This type of analysis compares the change in incursions over time at airports that installed ASDE-X with the change at airports that did not receive the technology, also known as a “difference-in-difference.”

FAA selected 35 airports to receive ASDE-X after assessing 59 top-tier airports, and those airports that were not selected can serve as a valid comparison group. Although FAA originally estimated the financial benefits of ASDE-X at each of 59 candidate airports, 24 of them ultimately did not receive the technology.<sup>1</sup> At a minimum, the 24 unsuccessful airports were similar enough to the treated airports to be part of the same funding process. In some cases, airports that did and did not receive ASDE-X had similar estimated benefits. For these reasons, the runner-up

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<sup>1</sup>According to FAA officials, the agency selected airports for ASDE-X deployment after an analysis of site-specific safety and efficiency benefits as compared to site-specific costs. The analysis determined that maximum benefit was achieved by deploying ASDE-X capability to airports with larger traffic counts or more complex operations (e.g., airports using the same runways for arrivals and departures).

airports provide a plausible comparison group for analysis, but we use a variety of other comparison groups to ensure that our findings are robust.

Many factors that may contribute to incursions are controlled in our analysis here. We control for variation among airports in runway and taxiway layouts, markings, and lighting, in addition to long-term variations in weather, air traffic, and pilot and controller skills. The staggered installation of ASDE-X makes bias due to short-term weather conditions or pilot and controller experience unlikely, because these factors would need to be correlated with 34 installation times throughout the country. In addition, the staggered installation lets us control for factors that affect all airports equally, such as changes in training and procedures made throughout the country at the same time.

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## Data Sources

The time period of our analysis spans fiscal years 2001 through April 2011. We assembled data on the number of incursions that occurred per month at each FAA-towered airport in this period, along with data on air traffic control tower operations. The latter data included the number of monthly tower operations at each airport, as well as the mixture of commercial and general aviation operations.<sup>2</sup> The operations data identify the population of interest, including the many smaller airports with no incursions that do not appear in the incursion data.

FAA provided the installation dates and locations for the ASDE-X, runway status lights, FAROS, and low-cost ground surveillance systems. We used these data to identify whether each technology was installed for each airport and month between fiscal year 2001 and April 2011.

The complete dataset is a panel, with the variables above measured for a maximum of 485 airports and 127 months between fiscal year 2001 and April 2011, producing a maximum sample size of 58,917 airport-months.

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<sup>2</sup>We obtained the incursion data from the FAA Office of Runway Safety and the operations data from the FAA Operations Network database.

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## Statistical Modeling

We used a statistical model to estimate the association between ASDE-X and the number of incursions for airport  $i$  and month  $t$ . The model took the form of

$$E(Y_{it} | a_i, p_t, t_{it}, x_{it}) = a_i \exp(\delta p_t + \alpha t_{it} + x_{it} \beta),$$

where  $Y_{it}$  randomly varies according to the Poisson distribution,  $a_i$  is a vector of airport fixed effects,  $p_t$  is a vector of year-month fixed effects,  $t_{it}$  indicates whether ASDE-X was operational at airport  $i$  in month  $t$ ,  $x_{it}$  are other time-varying covariates, and  $\delta$ ,  $\alpha$ , and  $\beta$  are vectors of parameters. We estimated the change in incursions after the installation of ASDE-X using one contemporaneous, before-and-after parameter,  $\alpha$ , because ASDE-X likely has an immediate effect on incursions once it has been installed that does not change over time.<sup>3,4</sup>

The covariates  $x_{it}$  included the number of air traffic control tower operations (to measure exposure and variation in the nature of activity across airports), indicators for having 25 to 60 percent and greater than 60 percent of operations involving general aviation (excluding 0 to 25 percent), and indicators for having the runway status lights, FAROS, or low-cost ground surveillance systems installed at airport  $i$  and time  $t$ .

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<sup>3</sup>We estimated the model by maximizing the Poisson likelihood function conditioned on the sum of the incursions for each airport over time. Although the conditional ML estimator makes the airport fixed effects possible, the method requires variation over time in the number of incursions, and thus we exclude 39 airports that had zero incursions in each period when using all FAA-towered airports as the comparison group.

<sup>4</sup>The variances of the model parameters are robust, “sandwich” estimates, clustered by airport. The 485 airports in the panel ensure that these estimates will be accurate approximations, even if incursions are not Poisson-distributed. As Wooldridge 2003 (674-675) notes, conditional ML estimators consistently estimate the parameters of a fixed effects model, even with arbitrary forms of over- and under-dispersion, heteroskedasticity, and serial correlation. As a result, we can safely use the Poisson conditional likelihood to estimate the parameters while using cluster-robust standard errors.

The models used several groups to compare the change in incursions before and after ASDE-X was installed, in order to assess the sensitivity of our results to plausible alternatives. The groups included

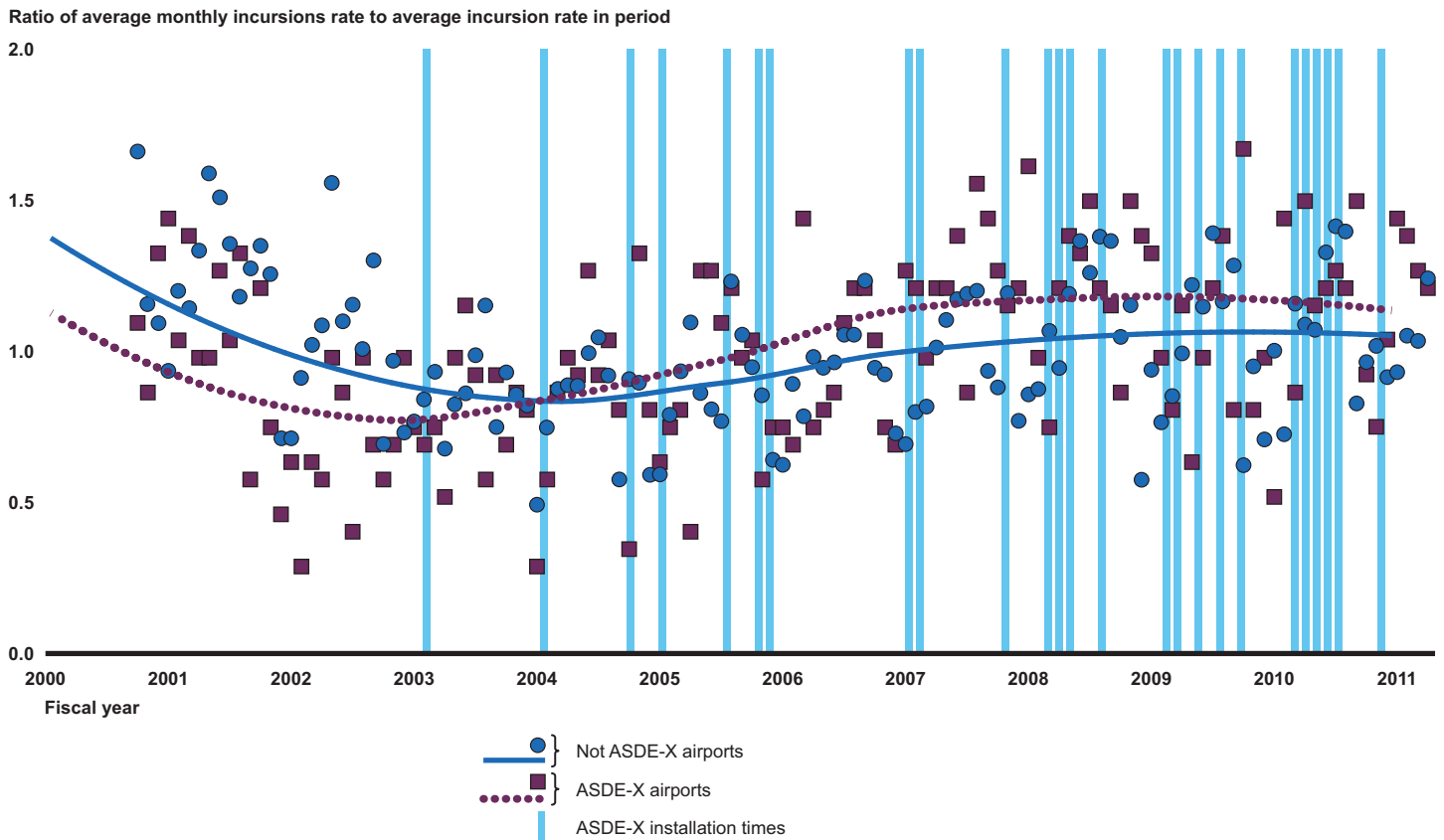
1. all FAA-towered airports;
2. airports that were included in the FAA benefit-cost analysis above but did not receive ASDE-X;
3. the top 100 airports in tower operations from fiscal year 2001 through April 2011;
4. airports that had a similar ground surveillance system, ASDE-3/AMASS, installed prior to the first installation of ASDE-X (baseline);
5. airports that did not have ASDE-3/AMASS installed at baseline; and
6. airports that did not have ASDE-3/AMASS installed at baseline and that were among the top 100 airports in tower operations from fiscal year 2001 through April 2011.

Groups 2, 3, 4, and 6 control for differences among the generally large airports that received ASDE-X and the small airports that did not. Groups 4, 5, and 6 distinguish between airports that did and did not already have a form of ground surveillance radar and safety warnings. FAA considered the preexisting technology when choosing ASDE-X sites, and the effect of ASDE-X may vary according to the system that was already in place.

Runway Incursions Rise after the Installation of ASDE-X, but Better Reporting May Explain the Change

Figure 18 plots the average monthly incursion rate for airports that did and did not receive ASDE-X, rescaled to a ratio of the over-time mean to better express the trends. The smooth lines summarize the average incursion rate for each group and month using nonparametric locally weighted regression models. The vertical lines show the ASDE-X installation times for each airport.

Figure 18: Change in Reported Runway Incursion Rates by Installation of ASDE-X, Fiscal Year 2001–April 2011



Source: GAO analysis of FAA data.

Prior to the first installation of ASDE-X, the incursion rate changed in roughly the same ways for the ASDE-X and comparison airports. As FAA began to install the system in late 2003, and the incursion rate began to increase for the ASDE-X airports, but it decreased and then increased at a slower rate for the comparison airports. Substituting the other comparison groups in these plots produces similar patterns. Consequently, the raw data suggest that reported incursions increased at

airports that received ASDE-X, as compared to the change at airports that did not receive the system.

Our statistical model supports similar conclusions (see table 5). Airports that received ASDE-X saw their reported incursions increase by 25.6 percent more than all other FAA-towered airports; by 18.3 percent more than other airports that were among the 100 busiest; and by 15.4 percent more than airports that were unsuccessful candidates to receive ASDE-X in the FAA benefit-cost analysis. The confidence intervals of these estimates broadly overlap, suggesting that the differences in the changes between the airports that received ASDE-X and the comparison airports are not distinguishable from each other and therefore do not depend on the choice of comparison airports. All estimates hold constant fixed differences across airports, as well as FAA policy changes, programs, and other national trends that affect airports in similar ways over time.<sup>5</sup>

**Table 5: Estimated Change in Runway Incursions after the Installation of ASDE-X Airfield Surveillance Technology**

Comparison group	Difference in estimated change	95 percent confidence interval
All FAA-towered airports	25.6 percent	[5.0 percent, 50.2 percent]
ASDE-X finalist airports, not selected	18.3	[-2.8, 44.0]
100 busiest airports	15.4	[-5.3, 40.6]
Airports without ASDE-3/AMASS	37.0	[4.0, 80.3]
Airports without ASDE-3/AMASS and among 100 busiest	28.0	[-3.5, 69.9]
Airports with ASDE-3/AMASS	12.3	[-10.7, 41.3]

Source: GAO analysis of FAA data.

The change in incursions depends on whether the ASDE-3/AMASS surface surveillance system was previously installed. Among airports that did not already have ASDE-3/AMASS, incursions increased by 37.0 percent after the facility installed ASDE-X, as compared with such airports that did not install ASDE-X. In contrast, incursions increased by only 12.3 percent at airports that already had ASDE-3/AMASS or by about one third

<sup>5</sup>Negative binomial models produced similar estimates to those in table 5. The estimates varied by no more than 2.6 percentage points, except that the estimate for the 100 busiest airports without AMASS was 7.2 percentage points smaller.

of the change at airports that did not have ASDE-3/AMASS. This is an intuitive pattern, because the addition of a new surveillance system should likely have a larger effect than the replacement of a similar system.

The positive association between ASDE-X and runway incursions may reflect better reporting rather than less safe runways. ASDE-X is designed to make air traffic controllers more aware of airfield activity and to warn about possible collisions. In principle, this should reduce the risk of serious incursions, because controllers can prevent them before they occur. At the same time, more precise information from ASDE-X may allow controllers to more reliably report less serious, class C and D incursions, which made up 97 percent of the incursions in our period of analysis. These incursions previously might have been less visible from air traffic control towers and, therefore, underreported prior to the installation of ASDE-X.<sup>6</sup>

Our statistical analysis of ASDE-X has several limitations that prevent us from conclusively estimating the system's impact on reported incursions. We were unable to obtain timely data to control for a number of important variables, such as short-term weather patterns, changes to runway lighting and markings, and implemented recommendations of the local and regional runway safety action teams. Accounting for these factors may produce different results. In this sense, we view our results as preliminary, pending further evaluation with additional covariates and years of incursion data.

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<sup>6</sup>Several stakeholders we interviewed agreed with this interpretation. Officials from the Sensis Corporation, which developed ASDE-X, agreed that the system may produce better reporting of incursions by air traffic controllers. Similarly, officials at Seattle-Tacoma International Airport said pilots and ground crews at that airport have become more likely to report their own incursions, because they expect controllers to identify them using ASDE-X.

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# Appendix IV: GAO Contact and Staff Acknowledgments

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## GAO Contact

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