Runway Incursions 2000–2010: Is Safety Improving?

Robert Chapin

Eastern Michigan University

Abstract

Runway incursion severity factors were examined. In particular, incidents involving high speed near-collisions where the paths of aircraft actually intersected on the runway were considered in terms of severity. Pilots were surveyed to determine if they agreed with the severity categorization for an incident of this type. The survey group consisted of 174 pilots, including 75 airline transport pilots. Only 5% of pilots agreed with the severity assigned by the FAA. Using the FAA definitions, 90% of pilots decided the incident was "serious." The majority of airline transport pilots considered the incident to be category A, the highest level of severity. All category C (non-serious) incident records from fiscal year 2010 were reviewed, and 22 of them were found to involve near-collisions where the paths of aircraft intersected. Four of those records were compared to similar incidents in 2002 and 2003, showing that the 2010 incidents had received a lower severity categorization. These findings suggest the seriousness of some recent incidents may have been understated compared to previous years. Safety may be improved by focusing on circumstances that lead to high-speed convergence of traffic in the runway environment rather than focusing on the horizontal separation of traffic.

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On October 8, 2010, the Federal Aviation Administration (FAA, 2010b) announced the number of "serious" runway incursions in the U.S. had dropped by half since the previous year. The fiscal year ended on September 30, and only six incidents had been recorded. How did the FAA determine that such a small number of near-collisions occurred? Is the FAA meeting its own goals for runway safety?

Much of the topic of runway safety revolves around the vocabulary and statistics used to describe and measure activity at airports. Several hundred runway incursions are reported by the FAA Office of Runway Safety each year, but only certain reports are deemed serious. The definitions used for terms such as "severe" or "serious" appear to be vague and open to interpretation. Therefore, the measurement of safety may be highly subjective.

Following some definitions and explanations of the vocabulary, specific concerns are raised about those definitions. Examples of accidents and incidents that were not deemed serious by the FAA are presented. Results of a survey are presented, in which pilots overwhelmingly disagreed with the determination of severity in a runway incursion incident. Those examples and concerns are discussed, and solutions are proposed. The conclusion is that safety may be improved by focusing on the circumstances that lead to high-speed convergence of traffic in the runway environment rather than focusing on horizontal separation of traffic.

A runway incursion is defined differently between agencies, and has changed significantly within the FAA since 2007. From 2000 through 2007, the FAA definition was:

> Any occurrence in the airport 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 with an aircraft taking off, intending to take off, landing, or intending to land. (FAA, 2004, p. 9)

Four categories of severity were based on that definition. Category A was the most severe, meaning a collision resulted or was avoided by extreme action. Category B meant there was great risk caused by loss of separation. Category C incidents allowed time or distance necessary to avoid a collision. Category D incidents were those where the risk of collision was little to none (FAA, 2004). The four categories are illustrated in Figure 1. A typical category B incident involved one airplane overflying another at an altitude of 200 ft (61 m) (FAA, 2010a, Event 771900). By comparison, if separation decreased to one mile (1.6 km) or one-eighth mile (0.2 km) on final approach with instructions to go around, it was a common category C incident (FAA, 2010a, Event 773002). Crossing a runway hold line by a few feet (1 m) was typical for category D. Serious runway incursions were those that fell under Categories A and B only (FAA, 2004).

Since 2008, the FAA uses internationally standardized definitions of a runway incursion and severity. As a result, the FAA category D incidents from before 2008 are now considered to be category C incidents (FAA, 2008). Also, the category A description is re-worded slightly so that its criteria do not include actions to avoid a collision. There is no indication that the FAA enforced that criterion previous to the change. A new type of category D incident now signifies only one aircraft, vehicle, person, or object is involved in an incident.

The FAA makes an important exception in tabulating runway incursion statistics. Incidents at non-towered airports are not considered runway incursions. At least, they are not included in the Runway Safety Reports or the Aviation Safety Information Analysis and Sharing (ASIAS) database. This exception applies to all severities. On March 1, 2008, three people died when an airplane landed on a runway already occupied by a formation of four other airplanes at Arthur Dunn Air Park (National Transportation Safety Board [NTSB], 2010). No mention of that collision can be found in FAA publications. A cursory search of 2000 through 2010 records in non-FAA databases finds six more runway collisions (National Aeronautics and Space Administration [NASA], 2010; NTSB, 2010). Those seven collisions at non-towered airports represent at least the same rate of collisions that occurred at towered airports between 2000 and 2010, according to ASIAS. It is unknown if the rates of less-severe incidents are also similar at towered and non-towered airports, and it may be impractical to maintain such statistics.

There were two goals for improving runway safety since 2000: Reducing serious incursions by 48% and reducing total incursions by 10% (FAA, 2003, 2008). The former goal was an apparent success, with 67 serious incursions in 2000, 31 in 2006, and only six recently. Equally apparent was the increase in other incursions from 338 in 2000 to 391 in 2008. Incursion rates by category and year are charted in Figure 2. The incursion totals for each year are charted in Figure 3.

It is surprising that an increase in runway incursions would occur while a program is in place to improve runway safety through the reduction of rate and severity of incidents. This raises questions about the categorization of incident severity because at first glance it appears serious incursions are being offset by a rash of non-serious

incursions. Are the additional incursions characterized by ample time or distance to avoid a collision, as defined by category C? Are serious incursions being treated the same since 2008 as they were before?

On July 2, 2010, a vehicle drove through a runway intersection in front of a CRJ7 during its landing rollout at Hartsfield-Jackson Atlanta International Airport (FAA, 2010a, Event 775135). The vehicle cleared the runway approximately 2,900 ft (884 m) in front of the airplane, and there was no collision. This incident was designated category C, not a serious runway incursion. Why? This example seems to illustrate a situation where the path of an airplane actually intersected the path of a vehicle at a high rate of speed. The analysis section of the runway incursion record does not consider the speed or capability of the airplane, the reaction time available to the pilots, whether the airplane rolled past the vehicle, or the closest proximity of the two as the airplane continued its rollout. Only the horizontal separation when the vehicle entered and cleared the runway is reported. If that is the extent of the analysis, is that how the FAA determines ample time or distance to avoid a collision? Are the circumstances contributing to a dangerous situation being ignored here? More to the point, if a matter of seconds is considered ample criterion for a non-serious event, then the pilots in this event are simply lucky that they did not land a few seconds sooner.

Upon seeing example incidents that seemed serious, but were not among the six serious incidents of 2010, I developed three hypotheses for further research. Hypothesis #1: The decreasing rate of serious runway incursions is caused by a corresponding negative trend in the determination of severity of similar incursions over time. In other words, circumstances that once defined category B incidents are now seen in category C.

Hypothesis #2: Most pilots, when shown recent category C incident records, would agree with the FAA severity determinations based on horizontal separation. Hypothesis #3: A large number of pilots would recognize circumstances such as high speeds and intersecting paths as allowing little or no time for collision avoidance. A significant minority of pilots would identify those situations as meeting the definition of a serious runway incursion regardless of horizontal separation.

Method

Participants

On November 2, 2010, I posted a hyperlink in public forums on the World Wide Web to solicit survey responses. Due to varying forum policies and limited time to negotiate with forum staff members, the link appeared on only two websites: www.airliners.net and www.airlinepilotforums.com. These websites were the top Google search results for "aviation forums" and "pilot forums" respectively. All visitors to these websites could use the hyperlink to submit anonymous survey responses until November 8, 2010. Participants were neither required to register with these websites nor required to be referred by these websites directly.

All participants were required to answer the first four survey questions before their answers were saved. The first two questions were age range and type of pilot certificate held. The intent of these questions was to establish the overall experience and qualifications of the survey group, and to discourage non-pilots from responding to the survey. Participants tended to be young, mostly less than 30 years old, which was an expected characteristic of the online forums. Ages are summarized in Table 1.

Of the 186 surveys collected, 12 did not contain an answer to the question about runway incursions. The survey group for this paper consisted of the remaining 174 respondents. Two of the participants used the "Other" certificate option incorrectly to indicate they held a private, commercial, or airline certificate. Those two answers were corrected in the results. The remaining four "Other" answers correctly indicated the participants held a different type of certificate. Certificates held by the participants are summarized in Table 2.

Procedures

After the two demographic questions, the survey contained two more required questions and two optional questions. Question five was a multiple choice question about runway incursions, the results of which are reported in this paper. The other questions were on the topic of "challenges faced by airline pilots," which will be reported in a separate paper. Combining the topics into one survey made the research more efficient and helped conceal the context of the questions in a single-blind manner. One forum member commented that they could not figure out the purpose of the survey questions.

HTTP Cookie technology was used to allow participants to return to the survey and change their answers while the survey was open. It also prevented multiple surveys from being submitted in a single web browser. This technology could have been easily bypassed and did not totally mitigate the anonymous nature of the survey.

In question five, participants were given the description of a runway incursion scenario, as well as a list of the definitions of severity. The question asked participants to determine the severity of the incursion. Category letters A through D were not mentioned in the question. Options were listed in order from most severe to least. The

runway incursion scenario was based on a real incident report from February 10, 2009 at Charlotte/Douglas International Airport (FAA, 2010a, Event 773527). Participants were not told that this was a real incident, and were not given a time or place for the scenario.

The survey and participants tested hypotheses #2 and #3 only. To test hypothesis #1, I developed a new definition of category B severity: "An incident in which there is a significant potential for collision, which includes any incident where the paths of aircraft actually intersected during takeoff or landing." All 371 of the category C runway incursion records from fiscal year 2010 were reviewed and tested against this experimental definition. This definition was not intended to be all-encompassing or to remove all ambiguity. For example, in any incident where an airplane rotated with a separation of several thousand feet (2 km) from a hazard on the runway and flew over it by several hundred feet (200 m) in altitude, the paths did not actually intersect even though both the airplane and hazard were on the same runway and the incident could be considered serious for other reasons. If one airplane was taking off while another airplane was crossing the threshold of the same runway, same direction, with reduced separation, their paths were considered not to have intersected for the purpose of this experiment.

Results

Only 5% of the pilots surveyed agreed with the determination of category C severity for the incident where a C182 crossed in front of a departing DH8. An additional 2% answered category D, 3% unsure, and one person thought this incident was not a runway incursion. 41% of the pilots surveyed chose the category B definition of a serious incident for this scenario. Unexpectedly, the most common answer was category

A, the highest level of severity by definition, chosen by 48% of the pilots surveyed. 90% of the pilots surveyed decided this was a serious runway incursion. Answers are summarized in Table 3.

Hypotheses #2 and #3 were not generally affected by age. Participants aged 18-49 answered category A 50% of the time. Ages 50-69 diverged from the averages and answered category B 56% of the time. Answers by age range are summarized in Table 4.

Hypotheses #2 and #3 were not generally affected by pilot certification. However, it appears category A was favored only by airline transport pilots, having a 53% majority of them in agreement. Answers given by all other pilots were evenly split between categories A and B. Answers by pilot certification are summarized in Table 5.

In the review of all category C incident records from fiscal year 2010, there were 22 incidents that fit the experimental definition for category B severity (see the Appendix for a complete list). Of the 371 total incidents, 31% involved an airplane taxiing across the hold line of an active runway, 30% involved improperly entering a runway, and 25% seemed to involve errors committed by tower or ground controllers.

I could not review the entire database of incidents for all eleven years within the scope of this study. Instead, I located a very limited set of examples to highlight discrepancies in the determination of incident severity. Two direct comparisons are presented here:

On January 5, 2002, a C172 made an unauthorized departure from Santa Barbara Municipal Airport, nearly colliding with an SF34 that was landing on an intersecting runway. “EGF231 was instructed to go around and passed the intersection of 15L/25 at 300 feet [91 m] vertical and climbing when N44DP rolled through the intersection”

(FAA, 2010a, Event 772814). On February 3, 2010, a BE23 and a P3 landed on intersecting runways at Grant County International Airport. "The BE23 passed above the intersection of runway 4 and runway 32R at approximately 300 feet [91 m] AGL when the P3 stayed on the ground. . . . Closest proximity reported was 350 feet [107 m] lateral and 300 feet [91 m] vertical" (FAA, 2010a, Event 774598). The 2002 event was designated category B, the 2010 event category C.

On May 2, 2003, a DH8 and an A319 landed on intersecting runways at Philadelphia International Airport. "ALO 3792 landed runway 35 and was crossing the intersection of runway 35/27R as NW 624 was passing the landing threshold of runway 27R. Horizontal separation reported was between 650 and 1,000 feet [198 and 305 m]" (FAA, 2010a, Event 771392). On April 19, 2010, a C172 and a B737 landed on intersecting runways at Bob Hope Airport. "Closest proximity is estimated as 200 feet [61 m] vertical, lateral was . . . an estimate of 500 feet [152 m]" (FAA, 2010a, Event 774849). The 2003 event was designated category B, and the 2010 event category C.

For further reading, event 772743 can be compared to 774939, and 771998 to 774580.

Discussion

Examples are available to support the hypothesis that runway incursions in 2002 and 2003 are considered more severe than runway incursions in 2010, even when their descriptions are nearly identical. The particular examples given above also suggest that the interpretation of an older incident is more likely in line with the experimental definition of category B than the interpretation of an incident in 2010.

Deeper insight can be gained simply by looking at which numbers are available in each incident record. In retrospect of reviewing 371 of those records, not one of them contains the elements that the FAA claims to consider in severity. There is a list of ten items, which includes at the very top, “speed and performance of the aircraft” (FAA, 2004, p. B-2). This would seem to be a necessary factor in severity, and it is almost never mentioned in high speed incidents. With this information missing, perhaps it is expected that incident severity will fluctuate and will be open to varying interpretations. That possibility is further illuminated by the most prominent information in the records, which tends to be horizontal separation. The examples above show, even with separation being the same or less in 2010, the severity of a near-collision scenario dropped from category B to category C over the course of seven to eight years.

An overwhelming majority of pilots disagreed with the FAA on the severity of an incident that occurred in 2009, showing hypothesis #2 to be false. This could mean pilots think there is rarely ample time or distance available to avoid a collision when aircraft cross paths on the runway. It is also somewhat disconcerting to observe such a wide gap between pilot opinion and investigative records.

The biggest surprise and possibly the most important finding in this paper is that 48% of pilots consider an improper runway crossing during takeoff to be one of the most severe runway incursions possible, even when the aircraft are separated by a third of a mile (579 m). This suggests pilots perceive the extreme danger created by high speed convergence more so than a lack of horizontal separation. It is unlikely that air traffic controllers understand that distinction, and they are the ones submitting the incident reports. Controllers look at airplanes in plan view, and for them more horizontal

separation means more time and more safety. Pilots look at airplanes like deer about to jump across the road that cannot be avoided unless it is possible to stop in the remaining distance. 200 ft (61 m) or 2,000 ft (610 m) makes no difference if the airplane is moving too fast to stop and too slow to become airborne.

The solution may involve changing runway control procedures to guarantee aircraft separation in time. Controllers and taxiing pilots need time to anticipate and recognize mistakes at the hold line before an airplane crosses a runway edge. Pilots preparing to takeoff or land could be informed of traffic taxiing toward the runway hold lines so they can anticipate and recognize mistakes before they run out of options. Most importantly, traffic taxiing toward hold lines near the approach half of arrival runways and the middle half of departure runways could be separated in time from arrivals and departures. High speed areas could be considered high risk areas, and controllers could be instructed on the increased severity of high speed convergence and intersecting paths. In other words, a controller should think more like a pilot and become more risk averse to an airplane taxiing near the middle of a departure runway, where high speed rotations occur, than the departure end, where traffic is likely airborne. A controller who considers all runway incursions to be created equal may be ignoring the potential severity of different types of pilot mistakes, and ignoring the opportunities to anticipate those mistakes.

As in the example scenario in the survey, there are elements that many runway incursions have in common:

- Controller instructs a pilot to taxi toward the middle of a runway while an airplane is already in position for departure on that runway.

- Pilot preparing for departure is unaware of an airplane that will approach the runway from an intersecting taxiway.
- Pilot and controller run out of options shortly after a takeoff clearance is issued.
- Pilot taxiing mistakenly crosses a hold line.
- Controller fails to stop the converging traffic because there is inadequate time or communication.

Each of these events raises the risk of collision. Reducing risk in this scenario requires increased timing control. Taxi instructions could include a parallel turn or a hold at a point well before the hold line when separation is not guaranteed by an optimistic hold short instruction. Since the taxiing airplane is already delayed by waiting for the departing airplane, there is no loss of efficiency by issuing an instruction to hold short of an enhanced centerline if the controller then anticipates separation during the departure roll and issues the next hold short or crossing instruction. In other words, high risk scenarios may necessitate an earlier taxi hold and an earlier crossing approval. This would be more practical than increasing the distance between the runway and the hold lines, or diverting traffic to the ends of the runway to increase safety. If a taxiing pilot fails to hold at the enhanced centerline, there is still adequate time to stop one or both airplanes. Anticipating this eventual error at an earlier point in time could prevent some serious runway incursions.

Changes in runway traffic control may be needed to decrease the potential for serious runway incursions. Despite a significant decline in the number of near-collisions on runways since 2008, it is not clear that runway safety has improved overall. The average rate of all runway incursions has been around one per day, trending level for the

past eleven years. The seriousness of some incidents seems to be understated by the FAA, raising doubts about the categorization of near-collisions. Awareness should be raised about the varying degree of danger in different types of incursions so that air traffic controllers and pilots can anticipate errors in critical situations.

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Table 1

Age of Participants

Age	Count
18-29	95
30-39	42
40-49	21
50-59	12
60-69	4
70+	

Table 2

Qualification of Participants

Certificate Type	Count
Private Pilot	41
Commercial Pilot	54
Airline Transport Pilot	75
Other	4

Table 3

Severity Perceived by Participants in Example Where Aircraft Paths Intersected During Takeoff

Choice	Count
A serious incident in which a collision was narrowly avoided.	84
An incident in which separation decreases and there is a significant potential for collision.	72
An incident characterized by ample time or distance to avoid a collision.	8
An incident such as incorrect presence of a single aircraft with no immediate safety consequences.	4
An incident that does not meet the definition of a runway incursion.	1
Unsure.	5

Note. The full text of the survey question was as follows: "5. Given the following scenario, determine the severity of the runway incursion: At a towered airport, a Cessna 182 pilot is instructed to hold short of an active runway on a crossing taxiway. During its taxi, the Cessna proceeds across that runway while a de Havilland Dash 8 is on takeoff roll on the same runway. The Dash 8 continues its takeoff, and there is no collision. Analysis shows the Cessna cleared the runway approximately 1900 ft in front of the departing airplane. Proximity of the Dash 8 as it crossed the taxiway was not reported."

Table 4

Severity Perceived in Example by Age of Participants

Severity	18-29	30-39	40-49	50-59	60-69
Category A	45	22	12	5	
Category B	39	17	7	6	3
Category C	5	2			1
Category D	3	1			
None			1		
Unsure	3		1	1	

Table 5

Severity Perceived in Example by Qualification of Participants

Severity	Private	Commercial	Airline	Other
Category A	18	24	40	2
Category B	18	25	28	1
Category C	1	4	3	
Category D	1	1	2	
None			1	
Unsure	3		1	1

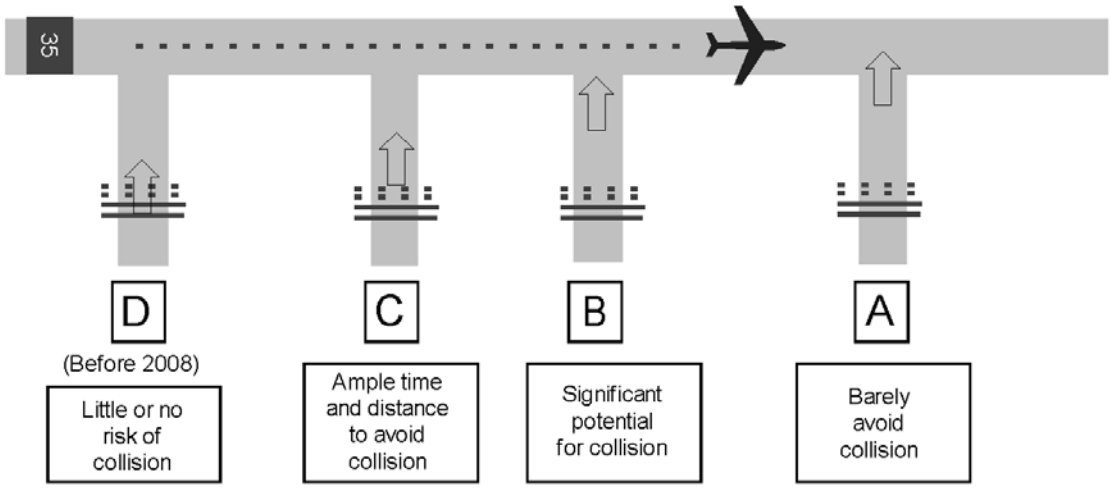

Figure 1. Illustration of runway incursion severities. Adapted from "Reducing Runway Incursions, Focus: Pilot Deviations" by Federal Aviation Administration, June 2003.

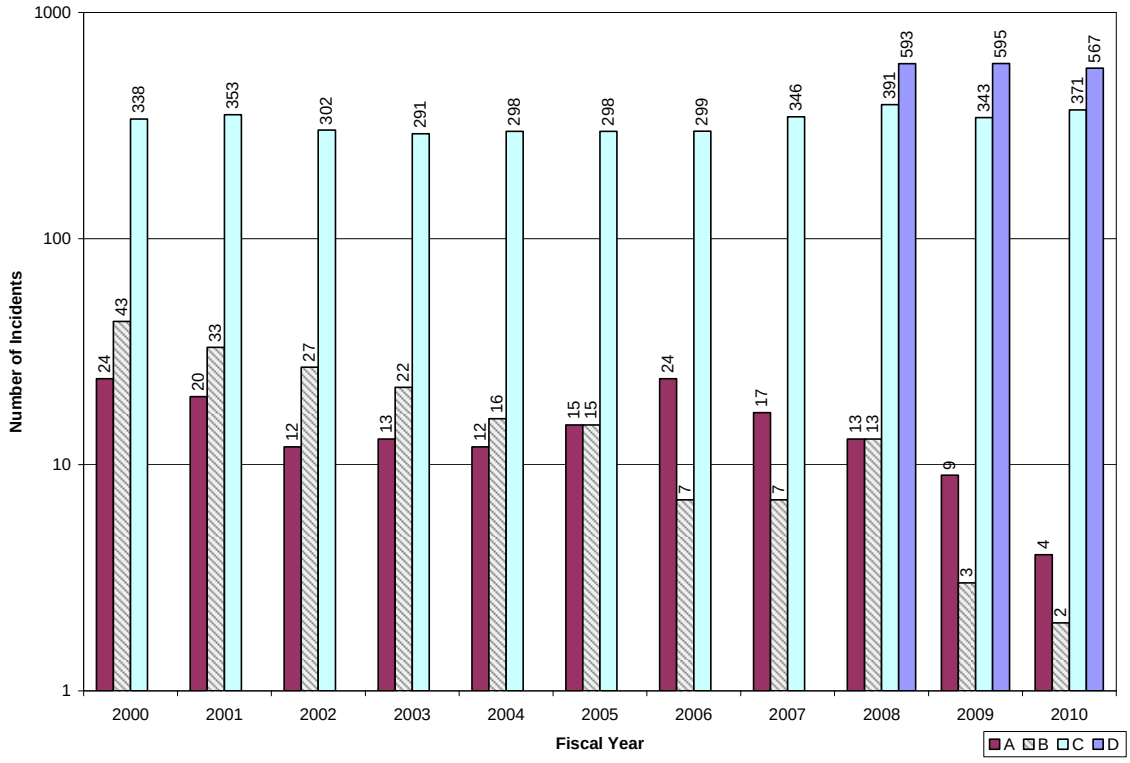

Figure 2. Runway incursions by category. Data from the ASIAS database, and the 2004 Runway Safety Report. Fiscal year 2010 is incomplete. Categories C & D were merged into category C prior to 2008 to reflect new definitions.

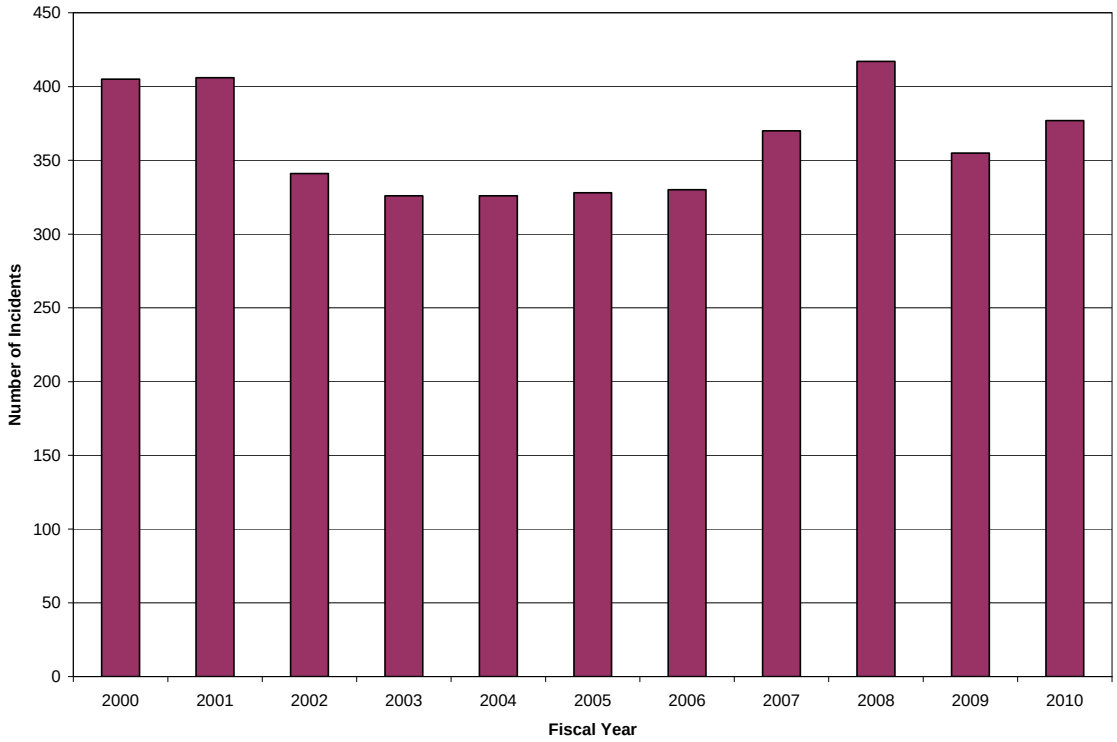

Figure 3. Total runway incursions per year. Category D incidents excluded from 2008 through 2010 for consistency. Data from the ASIAS database, and the 2004 Runway Safety Report. Fiscal year 2010 is incomplete.

Appendix

Incidents Where Aircraft Paths Intersected During Takeoff or Landing, FY 2010

Event ID	Date	Summary
774296	10/5/2009	DH8D crossed in front of a departing B737.
774300	10/6/2009	Vehicle crossed in front of a departing A306.
774382	11/8/2009	DH8D crossed in front of a departing E145.
774423	11/22/2009	E145 crossed in front of a landing B737.
774546	1/15/2010	C172 overflew a departing SR22, opposite directions.
774580	1/26/2010	C182 landed behind and overtook traffic on the runway.
774598	2/3/2010	BE23 and P3 landed on intersecting runways.
774599	2/4/2010	MD88 crossed in front of a departing CRJ1.
774635	2/15/2010	BE9L crossed in front of a landing B737.
774675	3/1/2010	C182 crossed in front of a landing XL2.
774849	4/19/2010	B737 and a C172 landed on intersecting runways.
774868	4/24/2010	VO10 crossed in front of a landing Cruz Sport Cruiser.
774939	5/17/2010	Vehicle crossed in front of a landing GLF2.
775030	6/10/2010	A320 crossed in front of a departing A330.
775109	6/30/2010	C172 performed a touch and go on an occupied runway.
775135	7/6/2010	Vehicle crossed in front of a landing CRJ7.
775174	7/15/2010	Unauthorized departure intersected a landing B190.
775292	8/13/2010	C560 and a PA28 departed intersecting runways.
775341	8/26/2010	C172 crossed in front of a landing C172.
775373	9/7/2010	CRJ1 landed on an occupied runway.
775386	9/13/2010	C182 departed an occupied runway.
775428	9/23/2010	B712 landed on an occupied runway.

Note. Information retrieved from the ASIAS database of runway incursions. Incident descriptions were summarized for brevity.