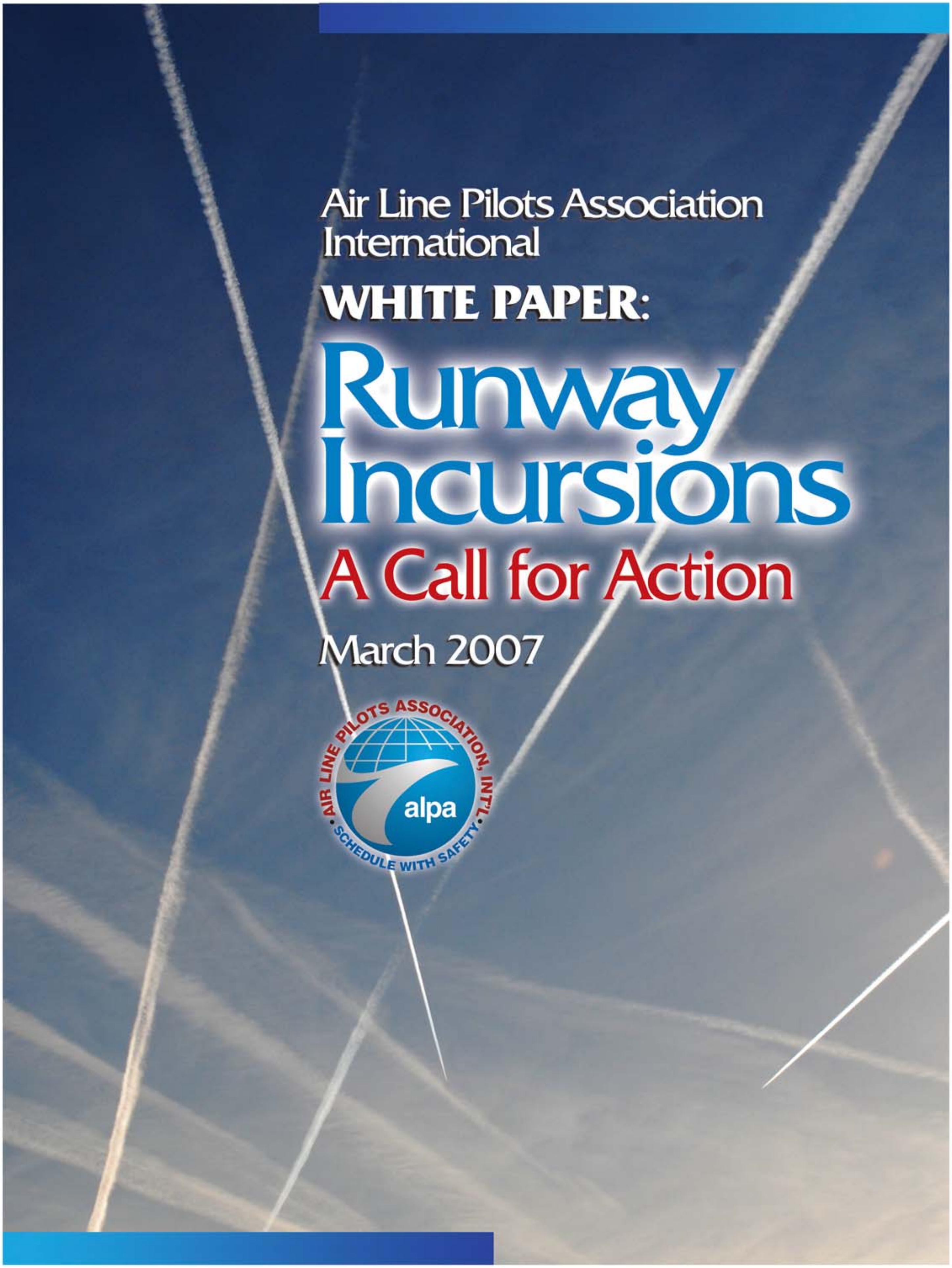


Air Line Pilots Association International

WHITE PAPER:

Runway Incursions

A Call for Action

March 2007

ALPA WHITE PAPER
AIR LINE PILOTS ASSOCIATION, INTERNATIONAL
1625 Massachusetts Avenue, N.W., Washington, D.C. 20036
703-481-4440 ▪ MEDIA@ALPA.ORG ▪ WWW.ALPA.ORG

Runway Incursions

Executive Summary

This paper provides an analysis of the risk and severity of the runway incursion problem facing the U.S. air transportation system. FAA defines a runway incursion as "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."

Approximately one runway incursion occurs each day in the United States, and the potential for a catastrophic accident is "unacceptable," according to the FAA's risk/severity matrix. The likelihood for runway incursions grows exponentially as a function of air traffic growth, which is on the increase in the United States.

Numerous studies have been performed on the runway incursion problem, both in and outside of the United States. The studies share a great deal of commonality with respect to causal factors and solutions.

The most exhaustive and data-centric study performed to date is one completed in 2002 by the U.S. Commercial Aviation Safety Team (CAST), a group made up of dozens of government and industry aviation safety experts. The study found that the runway incursion problem can be reduced by as much as 95 percent with a combination of technologies that greatly enhance pilot situational awareness and provide conflict alerting to air traffic controllers and pilots. Numerous other enhancements can provide further margins of safety.

CAST described dozens of runway incursion risk mitigations, and the U.S. government and industry made commitments five years ago to institute them, but few have been completed.

The paper concludes with a call for action by government and industry to comprehensively address the risk of runway incursions through prompt implementation of all CAST-recommended mitigations.

Contents

I. Introduction

The risk of a runway incursion event that could kill hundreds of people in a single accident is real and growing larger as a result of current, and forecast, increases of traffic within the U.S. National Airspace System (NAS). Fortunately, the incursion problem has been exhaustively studied by dozens of experts, and mitigations have been devised that can greatly lessen the risk inherent with ground operations today. Unfortunately, implementation of most mitigations has been very slow. The question that must be answered is whether the government and industry are willing to spend the resources that are required to achieve the potential high level of safety.

We have traveled this road before. Ingenious technology, combined with political will and monetary resources, have virtually thwarted two of the deadliest types of accidents: midair collisions and controlled flight into terrain (CFIT). Numerous midair collisions, resulting in hundreds of deaths over several decades, occurred when air traffic controllers and pilots relied solely on basic ground-based radar and see-and-avoid techniques to maintain required separation between aircraft. The development of the traffic alert and collision avoidance system (TCAS) equipped pilots with an invaluable tool that warns them of an impending collision and gives instructions on how to avoid it. Since the introduction of TCAS, many midair collisions have been averted, and many lives have been saved.

CFIT accidents have been similarly catastrophic and caused perhaps thousands of casualties during the era when controllers and pilots relied solely on radar coverage, charts, and ground visual references to maintain adequate clearance from the ground in low visibility conditions and periods of darkness. The invention, development, and implementation of the ground proximity warning system (GPWS), and its newer supplement, the enhanced GPWS, or EGPWS/TAWS, has had the same powerful effect on reducing the number of CFIT accidents that TCAS has had on reducing the number of midair collisions. In both instances, existing technologies, training, and procedures were insufficient to satisfactorily meet the challenge of preventing incidents and accidents. In both instances, enhanced situational awareness and conflict alerting capability were combined for a powerful one-two punch to the heart of the problem. In both instances, recommendations for great risk mitigations were ignored until several high-profile accidents occurred.

So it is with runway incursions. The risk posed by runway incursions can be significantly reduced—by as much as 95 percent according to the U.S. Commercial Aviation Safety Team (CAST)—with a combination of technologies which greatly improve the flight crew's situational awareness and provide conflict-alerting capability during ground operations. For decades, ALPA has led the airline industry in developing and promoting airport-related measures to reduce the potential for incursions. In the early 1990s, the International Civil Aviation Organization (ICAO) adopted new standards for airport signs that bore ALPA's influence, and new signs have been installed at nearly all airline airports in North America, and many other airports around the world. New paint markings, vehicle driver training programs, pilot training programs, localized runway incursion action teams, and numerous other initiatives have been undertaken with the goal of reducing incursions. While all of these programs have had a positive effect and are valuable, the simple truth is that, according to government statistics, the number of runway incursions at U.S. airports remained nearly constant from 2002 to 2004 while total traffic volume decreased by three (3) percent. That is, in spite of clear risk mitigations put in place, the rate of runway incursions has continued to increase.

We conclude that the runway incursion problem—and its commensurate potential for causing death and injury to hundreds of travelers and crewmembers in a single accident—can be addressed to high degree of satisfaction by implementing recommendations that CAST made five years ago.

ALPA, which represents the interests of 60,000 airline pilots who fly for 40 airlines in the United States and Canada, has prepared this paper to educate and inform government, industry, and the traveling public about the runway incursion risk and the steps which should be taken to properly and promptly address it.

II. Definitions

According to the FAA, a runway incursion is "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's definition applies only to airports with operating air traffic control towers.

Increasing Severity

Category D	Category C	Category B	Category A
Little or no chance of collision but meets the definition of a runway incursion.	Separation decreases but there is ample time and distance to avoid a potential collision.	Separation decreases and there is a significant potential for collision.	Separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision.

The FAA further categorizes runway incursion events by severity, as shown on left[1]:

A surface incident (SI) is defined as "an event during which unauthorized or unapproved movement occurs within the movement area or an occurrence in the movement area associated with the operation of an aircraft that affects or could affect the safety of flight."

The FAA categorizes runway incursions on the basis of who was determined to be most at fault:

- A pilot deviation (PD) is any action of a pilot that results in violation of a Federal Aviation Regulation.
- An operational error (OE) is an occurrence, attributable to an element of the ATC system, that results in

  —less than the applicable separation minimum between two or more aircraft and obstacles (obstacles include vehicles, equipment, and personnel on runways), or

  —an aircraft landing or departing on a runway closed to aircraft after receiving authorization from air traffic control.
- A vehicle or pedestrian deviation (VPD) results from a vehicle operator, nonpilot operator of an aircraft, or pedestrian who deviates onto the movement area, including the runway, without ATC authorization.

III. Risk and Severity

The Effect of Increased Traffic on the Potential for an Incursion

There is strong evidence that a minor increase in traffic congestion leads to an exponential increase in the potential for runway incursions. Former air traffic controller Lincoln Lounsbury says, "Even if pilot, controller, and vehicle operator performance improve simultaneously, we can still expect the runway incursion problem to worsen simply as a function of the slightest increase in traffic volume. Conversely, if traffic volume decreases even slightly, we should expect an exponential drop in the runway incursion rate. This is precisely what has happened since the FAA began keeping runway incursion statistics in 1988. From 1988 to 1990, traffic volume at towered airports in the United States increased 4.76 percent, but the runway incursion rate at these airports increased more than 43 percent. From 1990 to 1993, traffic volume suddenly decreased 5.34 percent, and the runway incursion rate quickly dropped by 30 percent. Then, reversing the trend once again, from 1993 to 1998, traffic volume grew only 2.41 percent, but the runway incursion rate climbed an incredible 67 percent."[2]

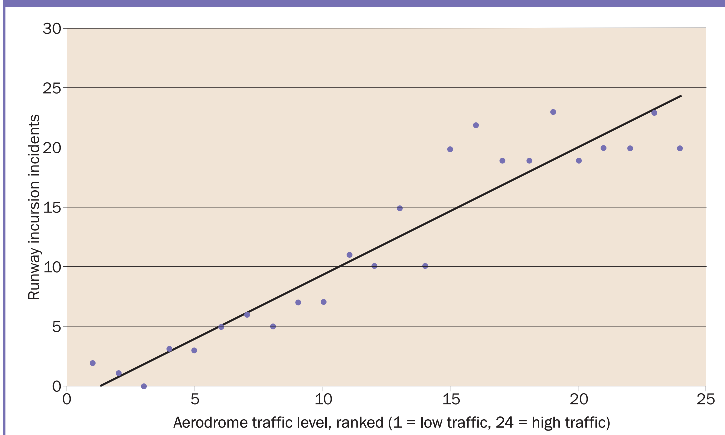
A September 2000 study by Transport Canada[3] elaborated on the relationship between traffic volume and the potential for incursions. Following is an excerpt from that report: "Using a single-runway model, the number of runway incursion scenarios can be calculated for a given number of aircraft on the manoeuvring surface, as shown in Table 1.

Table 1: Runway Incursion Potential, Single-Runway Operation

Number of Aircraft	Number of Incursion Scenarios
1	0
2	1
3	4
4	10
5	24

"Referring to Table 1, it becomes immediately apparent that the potential for a runway incursion increases more rapidly than traffic volume. For example, a 20 percent increase in volume (4 aircraft to 5 aircraft), which is typical of the traffic volume increase since 1996 at some Canadian aerodromes, represents a 140 percent increase in runway incursion potential. It is similarly apparent that smaller average rates of growth, such as those recently witnessed in Canada and forecast for the future, will result in a disproportionately large increase in runway incursion potential. In keeping with the laws of probability, and in the absence of significantly improved safeguards, an increase in the potential for runway incursions can be expected to be associated with an increase in actual runway incursion events. This expectation is consistent with the runway incursion trend observed in Canada since 1996."

Chart 1: Number of runway incursions at eight Class C aerodromes by relative traffic level—Australia 1997 to 2003



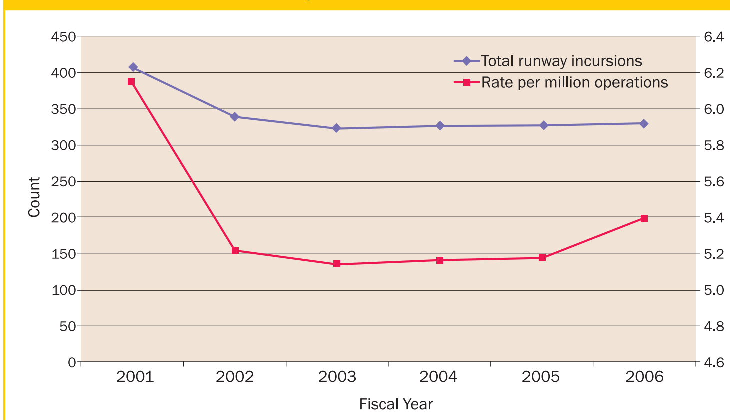
The Australian Transportation Safety Board also made a direct correlation between the number of incursions and traffic levels[4] as is seen in Chart 1.

The FAA has forecast that IFR aircraft operations will increase 3.0 percent annually, from 47.5 million aircraft handled in 2005 to 67.7 million in 2017.[5] Based on the information presented above, it is reasonable to expect that the number of incursions will increase exponentially over that time, unless highly effective mitigations are put in place.

Runway Incursion Likelihood

Runway incursions occur frequently within the NAS. Chart 2 is an FAA chart of incursions, which demonstrates that approximately 325 incursions have occurred in each of the past five years, which equates to roughly one incursion per day. Air traffic control towers in the United States handle approximately 63 million takeoffs and landings each year; thus, the current rate of runway incursions in the United States is about five incursions per million operations.

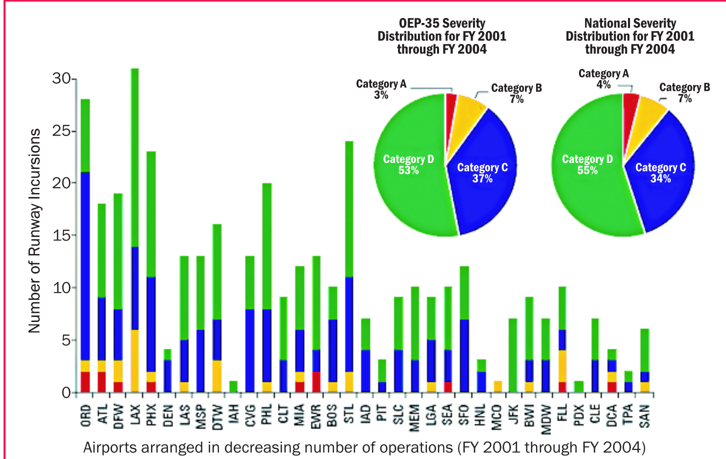
Chart 2: Review of Runway Incursions



According to FAA figures, 327 runway incursions were reported in the United States during fiscal year 2005; in FY 2006, the number rose to 330.[6] Perhaps even more importantly, the number of incursions in the highest-risk categories increased to 31 in FY 2006.

The FAA tabulates data on runway incursions across the NAS.[7] Table 2 depicts incursions at the 35 so-called FAA Operational Evolution Plan (OEP-35) airports, which are those that handle mostly airline operations and drive NAS capacity. Although some significant exceptions to the trend (e.g., IAH and STL) exist, the table demonstrates a general relationship between the amount of traffic and the number of incursions. Numerous factors, which include the mix of traffic, airport layout, traffic procedures, and in-place mitigations, can increase or decrease the incursion rate. See also Table 3, which shows the U.S. airports with the highest number of runway incursions.

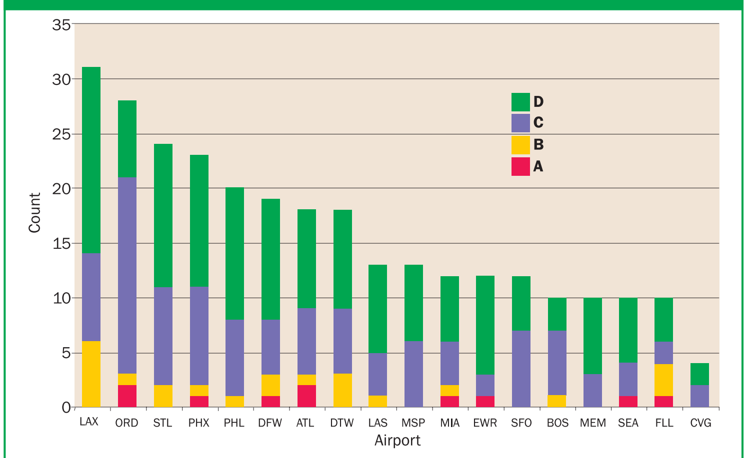
Table 2: From the FAA's August 2005 *Runway Safety Report*, tabulates incursions at the 35 busiest U.S. airline airports during FY 2001–2004



Runway Incursion Severity

Runway incursion events can be catastrophic. The worst aviation accident on record occurred as a result of a runway incursion in 1977 at Tenerife, Canary Islands, Spain, when two B-747s collided, causing the loss of 583 lives. Since 1990, five fatal runway-incursion–caused accidents involving airliners have occurred in the United States; each of these events received extensive news media coverage and caused extensive public debate about the safety of U.S. aviation. The most deadly incursion involving an airliner in the United States occurred February 1991 at Los Angeles International Airport when a B-737 collided with a turboprop airliner sitting on a runway; 34 people were killed in that accident.

Table 3: From the FAA's August 2005 *Runway Safety Report*, shows the U.S. airports with the highest number of runway incursions for FY 2001–2004



We have had some recent reminders that the runway incursion problem is literally an accident waiting to happen. On July 23, 2006, a B-747 freighter landing at about 10 p.m. local time on Runway 14R at Chicago O'Hare International Airport rolled through the intersection with Runway 27L just as a B-737 with 120 passengers and five crewmembers aboard was taking off on the latter runway. The National Transportation Safety Board (NTSB) later estimated the miss distance at 35 feet.

Three days later, a small jet airliner taxied onto Runway 25R at Los Angeles International Airport—and into the path of a turboprop airliner making an intersection takeoff. The turboprop missed the jet by an estimated 150 feet vertically and 50 feet horizontally.

These widely publicized events are sobering reminders that the potential for a catastrophe is undeniable when aircraft-to-aircraft separation is reduced at high speed. We cannot wait for yet another high-profile accident to serve as a catalyst for the changes clearly demanded by our current operating environment.

Runway Incursion Risk: Acceptable or Unacceptable?

A great deal of work has been accomplished in the past several years on the development of international standards for safety management systems (SMS) in air traffic service providers, civil aviation authorities, airports, and airlines. SMS provides a powerful, risk-based approach to managing safety that allows us to effectively manage the risk of the air transportation system and concentrate our resources in the appropriate areas. The FAA recognizes the importance of SMS and is moving toward regulation in this area.

The following excerpts from FAA Advisory Circular (AC) 120-92, Introduction to Safety Management Systems for Air Operators, address hazards, risk, and risk mitigations:

> **Risk Analysis and Assessment.** The standard's risk analysis and risk assessment clauses use a conventional breakdown of risk by its two components: likelihood of occurrence of an injurious mishap and severity of the mishap related to an identified hazard, if it were to occur. A common tool for risk decision-making and acceptance is a risk matrix similar to those in the U.S. Military Standard (MIL STD 882) and the ICAO Safety Management Manual.
>
> **Severity and Likelihood Criteria.** The definitions and final construction of the matrix are left to the aviation service provider's organization to design. The definitions of each level of severity and likelihood will be defined in terms that are realistic for the operational environment. This ensures each organization's decision-making tools are relevant to their operations and operational environment, recognizing the extensive diversity in this area. An example of severity and likelihood definitions is shown in Table 4 below. Each operator's specific definitions for severity and likelihood may be qualitative but quantitative measures are preferable, where possible.
>
> **Risk Acceptance.** Aviation service providers, in developing their risk assessment criteria, are expected to develop risk acceptance procedures, including acceptance criteria and designation of authority and responsibility for risk management decision making. The acceptability of risk can be evaluated by using a risk matrix such as the one

TABLE 4: SAMPLE SEVERITY AND LIKELIHOOD CRITERIA

Severity of Consequences			Likelihood of Occurrence		
Severity Level	**Definition**	**Value**	**Likelihood Level**	**Definition**	**Value**
Catastrophic	Equipment destroyed, multiple deaths	5	Frequent	Likely to occur many times	5
Hazardous	Large reduction in safety margins, physical distress, or a workload such that operators cannot be relied upon to perform their tasks accurately or completely. Serious injury or death to a number of people. Major equipment damage.	4	Occasional	Likely to occur sometimes	4
Major	Significant reduction in safety margins, reduction in the ability of operators to cope with adverse operating conditions as a result of an increase in workload, or as result of conditions impairing their efficiency. Serious incident. Injury to persons.	3	Remote	Unlikely, but possible to occur	3
Minor	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.	2	Improbable	Very unlikely to occur	2
Negligible	Little consequence	1	Extremely improbable	Almost inconceivable that the event will occur	1

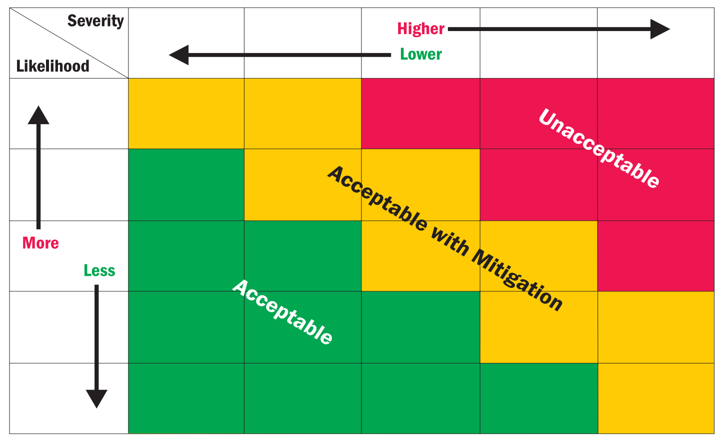
illustrated in Figure 1. The example matrix shows three areas of acceptability. Risk matrices may be color coded—unacceptable (red), acceptable (green), and acceptable with mitigation (yellow).

(a) Unacceptable (red): Where combinations of severity and likelihood cause risk to fall into the red area, the risk would be assessed as unacceptable and further work would be required to design an intervention to eliminate that associated hazard or to control the factors that lead to higher risk likelihood or severity.

(b) Acceptable (green): Where the assessed risk falls into the green area, it may be accepted without further action. The objective in risk management should always be to reduce risk to as low as practicable regardless of whether or not the assessment shows that it can be accepted as is. This is a fundamental principle of continuous improvement.

(c) Acceptable with Mitigation (yellow): Where the risk assessment falls into the yellow area, the risk may be accepted under defined conditions of mitigation.

Figure 1: Risk Mix



Using the FAA guidance materials above, and facts about the likelihood and severity of runway incursion accidents, ALPA has come to the following conclusions:

1. The most severe types of runway incursions may result in catastrophic accidents that lead to the loss of aircraft and hundreds of passengers and crewmembers.

2. Although the number of serious runway incursions has declined since 67 were recorded in 2000, runway incursions still happen too frequently; 31 combined Category A and B incursions occurred in FY 2006.[8] A consistent, historical record demonstrates that this pattern will continue absent powerful intervention(s).

3. *Given the potential severity and likelihood of a Category A or B event, ALPA's believes that the U.S. air transportation system is currently operating in the "unacceptable risk" category.*

In addition, we need to move beyond the current FAA classification of runway incursions based only on who is at fault. Although individual errors need to be recorded and corrected, we must look past assigning blame and start to look at systemic deficiencies that are contributing to these problems as opposed to taking airport- or runway-specific approaches. Examining and correcting systemic deficiencies is the most effective way to reduce safety risk.

AC 120-92 discusses actions that should be taken to deal with various risks; following is an excerpt from that document:

Hierarchy of Controls. The process of selecting or designing controls should be approached in a structured manner. System safety technology and practice have provided a hierarchy or preferred order of control actions that range from most to least effective. Depending on the hazard under scrutiny and its complexity, more than one action or strategy may be applied. Further, the controls may be applied at different times depending on the immediacy of the required action and the complexity of developing more effective controls. For example, it may be appropriate to post warnings while a more effective elimination of the hazard is developed. The hierarchy of controls is as follows:

(a) Design the hazard out—modify the system (this includes hardware/software systems involving physical hazards as well as organizational systems).

(b) Install physical guards or barriers—reduce exposure to the hazard or reduce the severity of consequences.

(c) Issue warnings, advisories, or signals of the hazard.

(d) Institute procedural changes to avoid the hazard or reduce likelihood or severity of associated risk

(e) Train pilots and controllers to avoid the hazard or reduce the likelihood of an associated risk.

To date, aviation authorities have undertaken to develop and implement mitigations which can be generally categorized as either (c), (d) or (e) controls. Examples, respectively, are: enhanced signs, markings, and lighting at runway entrances; better operating procedures for so-called "hot spots" at runway incursion-prone airports; and improved pilot and controller training.

Controls of the (a) or (b) type are more difficult and expensive to implement and less likely to be used as a result, but they are also the most effective. An example of a (b) control would be a perimeter fence and access control system to keep unauthorized vehicles outside of the air operations area (AOA). An example of an (a) control would be modifying an airport pavement configuration to eliminate a taxiway/runway intersection where incursions frequently occur.

A description of recommended incursion mitigations is contained in Section VIII of this document.

IV. Studies

Following is a description of some of the more prominent runway incursion studies made in several countries. The studies' conclusions and recommended mitigations share a significant degree of commonality.

United States of America

Since the publication of the FAA's first Runway Incursion Plan in 1991, the agency has devoted considerable resources to reducing the potential for incursions. That plan, and amendments to it, published in 1993, 1995, and 1998, detailed numerous projects and programs designed to reduce the potential for runway incursions. CAST, a coalition of government, manufacturer, and industry experts, chartered the Runway Incursion Joint Safety Analysis Team (RI JSAT) in October 1998 and produced a report in August 2000. The CAST plan directly influenced the FAA Runway Safety Office's Runway Safety Blueprint in 2000, presented as the FAA's corporate approach to reducing runway incursions.

In December 2002, CAST published the Results and Analysis document of the Runway Incursion Joint Safety Implementation Team (RI JSIT). This report outlined 115 strategies for mitigating runway incursion risk. The FAA's Office of Runway Safety then published its second edition (Blueprint 2002–2004), which mirrored the recommendations of the RI JSIT report mentioned above.

In addition to the history of FAA and CAST reports mentioned above, the NTSB, as a result of its investigations, has issued recommendations to the FAA aimed at addressing identified runway incursion risks since at least 1973. Some resulted in FAA action; others did not.

In 1986, the NTSB published a Special Investigative Report (SIR) of runway incursions. The SIR contained an additional 14 recommendations to the FAA and covered a wide range of topics.

Reviewing this history shows clearly that items such as controller and pilot training and awareness, revised and standardized ATC communications, signage and marking, aircraft conspicuity, and defined, identified taxi routes have been known to be contributors to the risk of runway incursion for more than 30 years. The RI JSAT report highlights five fatal runway incursion accidents investigated by the NTSB between 1990 and 1996. Together, these five accident investigations resulted in 48 recommendations to the FAA, some new and others reiterations of previously issued recommendations.

The FAA has acted on many of these NTSB recommendations, and many safety improvements recommended by the NTSB are embodied in procedures and guidance in place today. Others, however, have not yet led to action. As a result, the runway incursion issue is included on the NTSB's list of "Most Wanted Transportation Safety Improvements" (see Appendix 1).

Other U.S. studies have included a report by the Runway Incursion Task Force conducted in 1990–1991; Mitre Corporation studies on incursions based on interviews with pilots and controllers (1993–1998); the Research, Engineering, and Development Advisory Committee's Subcommittee on Runway Incursions (1998–1999); and numerous Runway Incursion Action Teams at the local airport level conducted since 1991. Runway Incursion Action Teams are composed of government and stakeholder representatives from pilot, air traffic controller, airport operations, and FAA management perspectives and have been used to review airport-specific runway incursion risk.

Canada

In 1999, Transport Canada (TC) created a subcommittee of the National Civil Aviation Safety Committee (NCASC) to specifically address the runway incursion issue. Prompting this action was an observation by the government of an increase in the number of runway incursions within the country and determination that a national strategy should be developed to address it.

The Sub-Committee on Runway Incursions (SCRI) was created with the participation of numerous departments within Transport Canada and NAV Canada. The SCRI held meetings with users at several airports to collect feedback, undertook a comprehensive literature search to examine what other entities have written about the subject, and used a panel of experts to develop preventive strategies that could be implemented by NAV Canada. The group published a final report in September 2000.

The SCRI proposed that a runway incursion be defined as "any occurrence at an airport involving the unauthorized or unplanned presence of an aircraft, vehicle, or person on the protected area of a surface designated for aircraft landings or departures." SCRI examined the severity and frequency of incursion events and created five categories for them:

1. **Negligible—**the occurrence would not have caused a collision with an aircraft or vehicle. No intervention required to keep the runway clear. (Example: An aircraft or vehicle was near [within 200 feet] but not on a serviceable runway and stopped short of the runway surface without intervention.)

2. **Low—**the occurrence was unlikely to result in a collision with an aircraft or vehicle. ATS [air traffic services] or pilot intervention was required to keep the runway clear. (Example: A vehicle or aircraft was near [within 200 feet] but not on a serviceable runway and stopped short of the runway surface when contacted by ATC.)

3. **Medium—**the occurrence could have resulted in a collision with an aircraft or vehicle. A vehicle or aircraft was on a serviceable runway without authorization or was cleared onto (or across) a serviceable runway in error. (Example: An aircraft crosses a serviceable runway without clearance.)

4. **High—**the occurrence could have resulted in a collision with an aircraft or vehicle. A vehicle or aircraft was on a serviceable runway without authorization or cleared in error and a **clear risk of collision** existed. Normally requires ATS intervention to correct. (Example: Two aircraft take off from the same runway at the same time.)

5. **Extreme—**the occurrence would have resulted in a collision with a vehicle and/or aircraft and was prevented only by **last-minute evasive action** by the flight crew and/or vehicle operator(s). (Example: A pilot rejects a takeoff to avoid a collision with a vehicle or another aircraft.)

The committee concluded that airport traffic congestion had led to a sharp increase in the frequency of incursions, which is explained in detail in Section IV of this document.

The complete text of SCRI recommendations is included as Appendix 2.

Australia

The Australian Transport Safety Bureau (ATSB) published a report in June 2004,[9] which stated that "although most runway incursions do not result in accidents, the potentially catastrophic consequences of runway incursions place them high on the agendas of aviation safety agencies internationally." The Bureau reported that Australia has never experienced a large-scale accident as a result of an incursion.

Communication problems between controllers, pilots, and others were found to be responsible for 79–91 percent of

Table 5: Severity Levels

Level	Description
D	Little or no chance of collision but met the definition of a runway incursion.
C	Separation decreased, but there was ample time and distance to avoid a potential collision.
B	Separation decreased, and there was a significant potential for collision.
A	Separation decreased, and participants took extreme action to narrowly avoid a collision.
Accident	An incursion that resulted in a collision.

incursions, depending on the size of the airport. Other causal factors included airport configuration complexity and traffic mix and volume. The ATSB categorizes incursions by operational error, pilot deviation, and vehicle, pedestrian, and animal intrusions.

ATSB defines a runway incursion as "any intrusion of an aircraft, vehicle, person, animal, or object on the ground within a runway strip or helicopter landing site that creates a collision hazard or results in a reduction of safety for aircraft." Ninety-two (92) percent of runway incursions in Australia were categorized as low-severity (level D). The Bureau categorizes runway incursion severity according to Table 5.

Following are some of the paper's verbatim conclusions: "The data in both samples indicated that most incursions could best be described as low severity (level D) incursions. Of the incursions reported in Australia, only two in every million operations posed a severe risk of collision. While these results are encouraging, the problem of runway incursions still requires attention, particularly at aerodromes with elevated incursion rates.

"Overall, the data confirm the need for constant vigilance and implementation of all practicable measures for reducing runway incursions."

Europe

A runway safety initiative was established in July 2001 with the involvement of numerous European associations representing aviation authorities and regulators, air traffic control entities, airports, airlines, and pilots, and including ICAO, the Joint Aviation Authorities, and the International Federation of Air Line Pilots Associations.

The group conducted a survey of airport incidents to determine contributing and causal factors that led to potential or actual runway incursions. The survey demonstrated that air traffic controllers and pilots believe that runway incursions are a very serious safety issue. The result of these efforts is a European action plan[10], published by Eurocontrol, which includes a discussion of best practices for communications and recommends use of standard ICAO phraseology. Guidelines are provided on numerous subjects, including the functions of a runway safety team, finding "hotspots" at airports with a runway incursion problem, guidance on vehicle driver training, flight crew and air traffic controller best practices, airport authority responsibilities, performing a risk analysis, safety management systems, and others. The plan does not include a definition of runway incursions nor a table that establishes an event's degree of severity, as is included in other reports. Appendix 3 contains the study's recommendations.

One notable runway incursion that occurred in Europe within the past few years took place on Oct. 8, 2001, at Italy's Milan–Linate Airport. An MD-87 speeding down Runway 36R for takeoff struck a Cessna CitationJet, which entered the runway without clearance at Taxiway R6. This accident resulted in 114 fatalities, and four officials involved were sentenced to jail terms ranging from 6½ to 8 years for negligence and manslaughter.[11]

An investigation of the event resulted in a finding that airport deficiencies, inadequate procedures, and faulty layout were among some of the causes of this catastrophe.

International Civil Aviation Organization

ICAO began an effort in 2001 to address the runway incursion problem by focusing on radio phraseology, situational awareness and human factors, operational aspects, airport charts, airport lighting and marking equipment, language proficiency, and other areas of concern. ICAO initiated an education campaign between 2002 and 2005 in many regions of the world to disseminate information about this problem and to help aviation authorities develop and implement risk mitigations.

ICAO has published an excellent resource on this subject, the *Manual for Preventing Runway Incursions*, First Edition, 2006.

V. U.S. Commercial Aviation Safety Team (CAST) Initiatives

The most comprehensive study on runway incursion risk completed to date was conducted by CAST. Its report, "Runway Incursion Joint Safety Implementation Team (RI JSIT) Results and Analysis," was released in December 2002. The data-driven approach used by CAST, combined with an objective cost/benefit analysis of each mitigation, provides reason for placing trust in the ability of the recommended mitigations to actually reduce the level of risk to a considerable degree.

CAST and the General Aviation Joint Steering Committee (GA JSC) chartered the Runway Incursion Joint Safety Implementation Team (RI JSIT) to develop a plan to effectively reduce the severe threat of fatalities and loss caused by airline and general aviation runway incursion accidents/incidents. The RI JSIT brought together expert representatives from across the aviation community, including participants from government, industry, and pilot and controller unions. These experts developed, prioritized, and coordinated a plan to implement the most effective, analytically data-driven intervention strategies recommended by the RI Joint Safety Analysis Team (RI JSAT). The RI JSIT analyzed the RI JSAT's 115 intervention strategies, together with 37 GA JSC intervention strategies, to determine the feasibility of gaining significant safety benefits through implementation. From the overall effectiveness and feasibility scores, 22 "Safety Enhancements" were incorporated into seven (7) Detailed Implementation Plans.

The government and industry have succeeded in implementing a number of CAST-recommended safety enhancements.

VI. Accomplishments

ALPA has been directly involved in developing and getting implemented several runway incursion-related safety enhancements; a description of some of them follows:

SOPs for Ground Operations (FAA Advisory Circular 120-74A)

This FAA document was published to encourage airlines to standardize their ground operations. The AC was an accomplishment of the CAST Joint Safety Action Team and was brought to publication by the CAST RI JSIT. Not all airlines have totally embraced all of the AC's recommendations. Consequently, individual procedures vary. ALPA recommends that airlines standardize their implementation of the AC's recommendation.

On-Line Pilot Education

A runway safety training aid resides on the ALPA public website at www.alpa.org, available to any pilot seeking runway incursion training. To date, more than 50,000 pilots have availed themselves of the opportunity to use this training module.

Pilot Education—FAA/ALPA DVD, "Was That for Us?"

During 2006, the FAA, United Airlines, and ALPA collaborated to distribute thousands of copies of a DVD specifically related to runway incursion training and AC 120-74A. The information on the DVD is presented in such a manner that airlines and individual pilots may use it as a training aid. It has been distributed internationally; continued publication of the DVD is recommended.

Paint and Markings (Advisory Circular 150/5340-1J)

ALPA has been instrumental in the continual upgrading of standards for taxiway and runway paint markings. This AC has been enhanced to describe new standards for marking runway holding locations, and the holding locations themselves. The emphasis is accomplished by using wider contrasting taxiway hold lines and enhanced centerlines to mark runway entrances. The 73 busiest U.S. civil airports are required to implement these markings, and that work is expected to be completed by 2008.

Runway Incursion Information Evaluation Program (RIIEP)

This FAA program gathers critical safety data not otherwise available concerning the root causes of airport surface events, including runway incursions. Pilots who are involved in runway incursion events who cooperate with FAA aviation safety inspectors by providing information are extended some protections against legal action. RIIEP was begun March 2000 and was reinstated in 2004 and again in 2006.

VII. Conclusions

- The U.S. government and airline industry have expended, over a period of many years, considerable time and resources to address the runway incursion problem.
- The likelihood of a runway incursion in the United States is high; the severity is catastrophic. Therefore, the current level of risk is unacceptable.
- Strong and immediate mitigations need to be implemented to move the nationwide runway incursion risk into an acceptable category.
- Various international studies confirm many of the same problems and mitigations that have been described in the United States.
- The U.S. CAST, in 2002, made numerous recommendations about needed mitigations that have not been enacted. The strongest mitigation requires the deployment of a cockpit moving map display with "own ship" position information, and other technologies to provide flight crews with greatly enhanced situational awareness on the ground. Electronic flight bags (EFBs) being installed on airliners offer numerous safety and economic benefits for airlines.

VIII. Recommendations

ALPA strongly recommends that the U.S. government and aviation industry make good on the commitments that were made to implement the recommendations of the CAST RI JSIT. These recommendations were thoroughly debated and analyzed before that body adopted them, and they are just as needed today as they were when first published. The recommendations are described in the executive summary of the RI JSIT report, which is provided in its entirety in Appendix 4.

Following is a list of specific action items needing priority attention (they are described in more general terms in Appendix 4):

- **Use moving map displays with own-ship position in airliners.** *CAST determined that 95 percent of all runway incursions could be prevented* by having (1) a cockpit moving map display with own-ship position for improved situational awareness, (2) integration of ADS-B to enable pilots and controllers to see all aircraft and vehicles on the surface and aircraft up to 1,000 feet above ground level, (3) automatic runway occupancy alerting, and, (4) digital data-linked clearances that are then displayed on the moving map.

  Electronic flight bags, which provide computer-generated displays of aircraft and flight information, can be used to display moving maps and own-ship position. The FAA recently announced its intention to amend its policies on the use of EFBs with moving maps and own-ship position to give airline pilots the safety benefits from these EFBs as soon as possible. Only a very few airliners have EFBs with moving maps and own-ship position installed, but it is widely used on general aviation and corporate aircraft. Installation of this vital equipment on airliners should become a national aviation safety priority.

- **Install runway status lights**. MIT Lincoln Laboratory conducted an operational evaluation of red runway status lights (RWSLs), which automatically provide a direct indication of runway status to pilots, at Dallas-Fort Worth International Airport (DFW) in late 2005. ALPA has recommended that the system become a standard, technological upgrade for large hub airports.
- **Install red takeoff hold lights**. DFW is also the site for testing red takeoff hold lights, which are offset and embedded along a line two (2) feet from the runway centerline. The lights automatically warn the pilots of departing aircraft if an incursion occurs ahead of them. ALPA recommends that the system be finalized and adopted as a standard for large hub airports.
- **Enhance airport markings.** In 2005, the FAA published Advisory Circular 150/5340-1J, requiring airports with 1.5 million operations or more per year to enhance taxiway centerlines near runway intersections, and runway stop bars at the runway edges, with wider and more contrasting surface guideline presentations and stop bars. In addition, an

alternative of red surface signage in the vicinity of the stop bars can clearly depict the adjacent runway information. The FAA recommends that airports complete these enhancements by 2008. ALPA recommends that these surface markings be standard for all Part 139 certificated airports, and that the process be completed as soon as practicable.

- **Install perimeter taxiways.** Atlanta Hartsfield and Dallas-Fort Worth International Airports are constructing end-around (or perimeter) taxiways that will allow traffic to proceed from arrival runways to terminals without crossing other arrival or departure runways and will eliminate the incursion danger described above. ALPA supports the expenditure of funds to install perimeter taxiways, which enhance both safety and capacity.

- **Create SOPs for aircraft ground operations.** ALPA recommends use of improved standard operating procedures (SOPS) and training for aircraft ground operations throughout the aviation industry—current standardization is woefully inadequate.

- **Provide better ATC ground movement training.** Provide improved ground movement training for air traffic controllers, particularly with the use of high-fidelity visual tower simulators, which are similar in quality to aircraft flight simulators routinely used for pilot training.

- **Provide controllers with better technology.** The situational awareness of air traffic controllers should be enhanced through technology such as ASDE-X airport surface radar and emerging capabilities demonstrated in the FAA's Safe Flight 21 Program.

- **Improve technology at airports.** Enhance visual aids and automation technology for airports, including improved all-weather conspicuity signs, visual runway occupancy systems (e.g., RAAS) for flight crews on final approach, and automated "smart lighting" to indicate taxi routes.

Appendix 1: National Transportation Safety Board Item from Agency's "Most Wanted" Transportation Safety Improvements List

Recommendations & Accomplishments

Most Wanted
Transportation Safety Improvements
Federal Issues

AVIATION

Stop Runway Incursions/Ground Collisions of Aircraft

Objective

- Give immediate warnings of probable collisions/incursions directly to flight crews in the cockpit.

Importance

In March 1977, in what remains the world's deadliest aviation accident, two passenger jumbo jets collided on a runway at Tenerife, Canary Islands, causing the deaths of 583 passengers and crew. The deadliest U.S. runway incursion accident was a collision between a USAir 737 and a Skywest Metroliner commuter airplane at Los Angeles International Airport (LAX) in February 1991, which killed 34 people.

Most recently, in July 2006, at O'Hare International Airport, a United 737 passenger jet and an Atlas Air 747 cargo airplane nearly collided. The 747 had been cleared to land and was taxiing on the runway towards the cargo area when the 737 was cleared to take off on the intersecting runway, over the 747. The pilot of the United 737 passenger jet took off early to avoid a collision with the 747. This collision was avoided by about 35 feet.

The runway incursion issue has been on the Safety Board's Most Wanted list since the list's inception in 1990. In the late 1980s, an inordinate number of runway incursions/ground collision accidents resulted in substantial loss of life, and the Board issued numerous safety recommendations addressing the issue. The FAA has since taken action to inform controllers of potential runway incursions, improve airport markings, and install the Airport Movement Area Safety System (AMASS) and Airport Surface Detection Equipment Model X (ASDE-X). These systems are an improvement, but are not sufficient as designed to prevent all runway incursions. The runway incursion rate in the United States has not appreciably changed over the past 4 years, and stands at about 5.2 runway incursions per 1,000,000 tower operations, despite these improvements.

Information needs to be provided directly to the flight crews as expeditiously as possible to prevent runway incursions. The issue is one of reaction time. Safety Board investigations have found that AMASS is not adequate to prevent serious runway collisions, because too much time is lost routing valuable information through air traffic control. After an AMASS alert, the controller must determine the nature of the problem, determine the location, identify the aircraft involved, and determine what action to take. Only after all of these determinations have been made can appropriate warnings or instructions be issued. The flight crew must then respond to the situation and take action. Simulations of AMASS performance using data from actual incursions show that alerts may occur as little as 8 to 11 seconds before a potential collision. In recent incidents, AMASS did not alert controllers in time to be effective, and the situations were instead resolved by flight crew actions that sometimes bordered on heroics or just plain luck.

Until there is a system in place to positively control ground movements of all aircraft, with direct warning to pilots, the potential for this type of disaster will continue to be high.

Summary of Action

In FY 2005, the FAA conducted a study to determine whether a direct warning capability to flight crews could be developed. A solution set with three technology levels was proposed, and simulations were conducted in May 2005 to assess the proposal's effectiveness. Thirty-six commercial and general aviation pilots participated in simulations of 15 different incursion scenarios. The FAA found that a significant reduction of runway incursion risk was possible. The same year, the FAA initiated field tests of a Runway Status Lights system at the Dallas/Fort Worth International Airport. Initial test results have been promising and the FAA is performing additional testing to determine the extent to which this technology can be applied nationwide. In FY 2006, MITRE/CAASD, in conjunction with the FAA, was scheduled to coordinate the findings from the simulations with airports, pilots, representatives of other aviation user groups, and experts in runway safety technology. The FAA plans to explore alternative operational and system solutions to address shortcomings with the systems evaluated in the simulation study. The FAA also plans an analysis of a flight deck-based direct warning system.

While these technologies may offer added safety by providing information directly to cockpit crews, they are many years away from possible national implementation. More than 6 years after this recommendation was issued, the FAA is still evaluating technology, and has not yet developed plans for funding and installing these systems at airports. In view of the very real and continuing threat posed by runway incursions, and the failure of previously developed systems and procedures to reduce the rate of runway incursions, this is not an acceptable response.

Action Remaining

Implement a safety system for ground movement that will ensure the safe movement of airplanes on the ground and provides direct warning capability to the flight crews.

Safety Recommendation

A-00-66 (FAA)
Issued July 6, 2000
Added to the Most Wanted List: 2001
Status: Open-Unacceptable Response

Require, at all airports with scheduled passenger service, a ground movement safety system that will prevent runway incursions; the system should provide a direct warning capability to flight crews. In addition, demonstrate through computer simulations or other means that the system will, in fact, prevent incursions. (Source: Letter of recommendation dated July 6, 2000, to the FAA addressing runway incursions)

November 2006 (source: http://www.ntsb.gov/recs/mostwanted/runways.htm)

Appendix 2: Recommendations from Transport Canada's National Civil Aviation Safety Committee, Subcommittee on Runway Incursions, September 14, 2000

4.1. In consultation with NAV CANADA, Transport Canada formalize and promulgate the following runway incursion definition: "Any occurrence at an aerodrome involving the unauthorized or unplanned presence of an aircraft, vehicle or person on the protected area of a surface designated for aircraft landings or departures."

4.2. Transport Canada develop and administer a comprehensive and recurring runway incursion awareness program, possibly in collaboration with NAV CANADA, the Canadian Airports Council and other professional aviation organizations.

4.3. Transport Canada focus on developing preventive strategies for runway incursions that result from pilot deviations. Immediate action should be taken to disseminate, on a recurring basis, information to pilots about human performance vulnerability to error due to workload, and potential distractions associated with the performance of cockpit tasks.

4.4. Transport Canada training guidelines and audit processes be revised to place additional emphasis on radio-telephony procedures and ICAO standard phraseology, familiarity with SIRO operations, pre-planning and briefing of intended taxi routes prior to arrival and departure, and minimizing other cockpit tasks while taxiing. The Transport Canada Flight Instructor's Guide should be amended to reflect these principles.

4.5. Transport Canada require that an explicit ATC clearance be given for an aircraft to cross any runway.

4.6. Transport Canada ensure that existing "line up and wait" procedures are revised to preclude aircraft from being positioned on an active runway if a takeoff delay is anticipated.

4.7. Transport Canada work in collaboration with ATS service providers to develop a policy regarding runway intersection departures. The intent of this policy should be to minimize or, when practicable, eliminate the use of intersection departures.

4.8. Transport Canada establish guidelines for the promulgation of standard taxi routes and encourage the implementation of standard taxi routes, where practicable, at controlled airports.

4.9. Transport Canada develop and implement common standards and recommended practices (CAR 322) for all Canadian aerodromes.

4.10. Transport Canada place more emphasis, particularly during airport inspections, on ensuring that airport signs and markings are clearly visible to aircraft on the manoeuvring surface and are unambiguous.

4.11. In consultation with airport authorities, Transport Canada investigate the viability of an automated runway incursion warning system, using inductive loop or similar technology, that provides a direct warning of an approaching hold line to the pilot.

4.12. Transport Canada establish standards pertaining to the number of runways and/or taxiways that can intersect at approximately the same point and for the minimum angle of divergence of intersecting taxiways and runways.

4.13. Transport Canada promulgate ICAO standard naming conventions for taxiways and, if applicable, standard taxi routes.

4.14. Transport Canada investigate the feasibility of developing an objective methodology, and associated equipment, to determine when airport surface markings need repainting due to rubber obscuration, normal wear, fading, lack of contrast with the pavement, or other reasons.

4.15. Transport Canada investigate the feasibility of making aerodrome maps available to pilots at reduced cost, possibly by making them available on the INTERNET or by producing these maps in a format similar to terminal area charts.

4.16. Transport Canada extend the intent of CAR 705.07(2), Air Operator Flight Safety Program and CAR 573.09 (NPA 2000-031), Quality Assurance Program, to include certified airports, possibly by amending CAR 302.07.

4.17. Transport Canada initiate a program, possibly in cooperation with NAV CANADA, to better understand the human factors that are contributing to runway incursions and, in particular, to examine the influence of increasingly complex procedures and layouts on the performance of pilots and ATS personnel engaged in ground operations. The value of requesting a TSB Class 4 investigation, as a means of collecting detailed occurrence information, should be considered.

4.18. Transport Canada and NAV CANADA establish a shared database to record runway incursion occurrences, investigation, analysis and follow-up actions.

4.19. Transport Canada provide regular updates to airport authorities, commercial operators and other stakeholders on runway incursion statistics and ongoing preventive measures.

4.20. Transport Canada place increased emphasis on the investigation and enforcement of aircraft runway incursions and, in particular, on communicating enforcement decisions to the aviation community.

4.21. Transport Canada adopt a risk-based, data-driven approach to monitor runway incursion occurrences, on an ongoing basis, to measure the efficacy of newly implemented preventive strategies and to proactively target preventive actions at specific airports where the risk associated with runway incursions is particularly high.

4.22. Transport Canada, working in partnership with NAV CANADA, the airport authority and local stakeholders, conduct an in-depth study of the runway incursion risk at Calgary International Airport and assess the adequacy of existing and future preventive measures.

4.23. Transport Canada monitor and, if necessary, facilitate the development and implementation of runway incursion preventive measures at Edmonton City Centre Airport.

Appendix 3: Recommendations from the "European Action Plan for the Prevention of Runway Incursions," Release 1.2, May 2006

4.1—General principles

4.1.1 At individual aerodromes, as designated by the National Aviation Safety Authorities, a Runway Safety Team should be established and maintained to lead action on local runway safety issues.

4.1.2 A local runway safety awareness campaign should be initiated at each aerodrome for Air Traffic Controllers, Pilots and Drivers and other personnel who operate on or near the runway. The awareness campaign should be periodically refreshed to maintain interest and operational awareness.

4.1.3 Confirm that all infrastructure, practices and procedures relating to runway operations are in compliance with ICAO provisions.

4.1.4 Where practicable, ensure that specific joint training and familiarisation in the prevention of runway incursion is provided, to the pilots, air traffic controllers and vehicle drivers, to increase understanding of the roles and difficulties of personnel working in other areas. This may include visits to the manoeuvring area to increase awareness of signage and layout where this is considered necessary.

4.2—Recommendations for the Aerodrome Operator

4.2.1 Verify the implementation of ICAO Annex 14 provisions and implement maintenance programmes relating to Runway operations e.g. markings, lighting, signage. Ensure that signs and markings are clearly visible, adequate and unambiguous in all relevant conditions.

4.2.2 Works in progress—Ensure that information about temporary work areas is adequately disseminated and that temporary signs and markings are clearly visible, adequate and unambiguous in all relevant conditions.

4.2.3 Assess the need for additional ICAO standards for aerodrome signage markings and lighting. Make recommendations to ICAO where appropriate.

4.2.4 Implement safety management systems in accordance with ICAO provisions.

4.2.5 Ensure a continued focus on runway safety in internal audit activities.

4.2.6 Introduce a formal Driver training and assessment programme, or where already in place review against the Driver training guidelines.

4.2.7 Introduce formal communications training and assessment for Drivers and other personnel who operate on or near the runway.

4.2.8 Implement the standard ICAO naming conventions for taxiways.

4.3—Communications (Language, Radiotelephony, Phraseologies and Procedures)

4.3.1 To avoid the possibility of call sign confusion, use full aircraft or vehicle call signs for all communications associated with runway operations.

4.3.2 Verify the use of standard ICAO RT phraseologies.

4.3.3 Use the ICAO read-back procedure (including Drivers and other personnel who operate on the manoeuvring area).

4.3.4 Improve situational awareness, when practicable, by conducting all communications associated with runway operations using aviation English.

4.3.5 Improve situational awareness, when practicable, by conducting all communications associated with runway operations on a common frequency. (note—aerodromes with multiple runways may use a different frequency for each runway.)

4.4—Recommendations for Aircraft Operators

4.4.1 Provide training and assessment for Pilots regarding Aerodrome signage, markings and lighting.

4.4.2 Pilots shall not cross illuminated red stop bars when lining up or crossing a runway, unless contingency procedures are in force, for example to cover cases where the stop bars or controls are unserviceable.

4.4.3 Ensure that flight deck procedures contain a requirement for explicit clearances to cross any runway. Includes non-active runways.

4.4.4 When in receipt of line-up clearance, Flight Crew must advise ATC if they will need to hold on the runway for more than 90 seconds beyond the time it would normally be expected to depart.

4.4.5 Promote best practices on flight deck procedures while taxiing—to include the "Sterile flight deck" concept.

4.4.6 Promote best practices for pilots' planning of ground operations.

4.5—Recommendations for Air Navigation Service Providers

4.5.1 Implement safety management systems in accordance with ESARR3 provisions.

4.5.2 Survey the different methods and techniques in use to indicate to controllers that a runway is temporarily obstructed and recommend Best Practice.

4.5.3 Whenever practical give ATC en-route clearance prior to taxi.

4.5.4 Develop an ICAO compliant procedure applicable if an aircraft or vehicle becomes lost on the aerodrome manoeuvring area.

4.5.5 Develop an ICAO compliant procedure applicable if an aircraft or vehicle becomes lost on the aerodrome manoeuvring area.

4.5.6 Ensure that ATC communication messages are not over long or complex.

4.5.7 Ensure that ATC procedures contain a requirement for explicit clearances to cross any runway. Includes non-active runways.

4.5.8 Identify any potential safety benefits of carrying out runway inspections in the opposite direction to runway movements and if appropriate adopt the procedure.

4.5.9 Use standard taxi routes when practical to minimise the potential for pilot confusion, on or near the runway.

4.5.10 Where applicable use progressive taxi instructions to reduce pilot workload and the potential for confusion.

4.5.11 Avoid infringing sight lines from the tower and assess any existing visibility restrictions from the tower, which have a potential impact on the ability to see the runway, and disseminate this information as appropriate. Recommend improvement when possible and develop appropriate procedures.

4.5.12 Ensure that runway safety issues are included in training and briefing for ATC staff.

4.5.13 Identify any potential hazards of runway capacity enhancing procedures when used individually or in combination and if necessary develop appropriate mitigation strategies. (Intersection departures, multiple line up, conditional clearances etc.)

4.5.14 Do not issue line up clearance to an aircraft if this aircraft will be required to hold on the runway for more than 90 seconds beyond the time it would normally be expected to depart.

4.5.15 When using multiple line-ups, do not use oblique or angled taxiways that limit the ability of the Flight crew to see the runway threshold or the final approach area.

4.6—Data collection and lesson sharing

4.6.1 Promote the implementation of occurrence reporting compatible with an international

harmonised reporting system i.e. ADREP 2000.

4.6.2 Improve the quality of runway occurrence data by starting work to extend the AGA taxonomy in ADREP 2000, used in occurrence reporting.

4.6.3 On a Europe-wide basis, disseminate de-identified information on actual runway incursions to increase understanding of causal and contributory factors to enhance lesson learning.

4.7—Recommendations for Regulators

4.7.1 Confirm that all infrastructure, practices and procedures relating to runway operations are in

compliance with ICAO provisions.

4.7.2 Make the appropriate regulations available to ensure implementation of safety management systems is in accordance with the applicable standards.

4.7.3 Ensure that safety assurance documentation for operational systems (new and modified) demonstrates compliance with regulatory and safety management system requirements.

4.7.4 National Aviation Safety Authorities should focus on runway safety in their inspection activities.

4.7.5 Certify aerodromes according to ICAO provisions, Annex 14.

4.8—Aeronautical Information Management

4.8.1 Significant aerodrome information which may affect operations on or near the runway should be provided to pilots 'real-time' using radio communication.

4.8.2 Verify that the collection, provision and dissemination of the content of aeronautical information are in accordance with ICAO provisions.

4.8.3Providers of databases and charts of aeronautical information (including Aircraft Operators) must establish a process with AIS with the objective of ensuring the data accuracy, timeliness, availability and integrity.

4.8.4 Ensure that an accuracy feedback process exists for the users of aeronautical information.

4.8.5 The ergonomics of Maps and Charts and relevant documentation should be improved to enhance their readability and usability.

4.8.6 Aerodrome operators should provide aeronautical information in standard electronic format (AIXM) for upload into the European AIS Database.

5. FUTURE WORK

5.1—New technology and Human Factors

5.1.1 Data on the implementation guidelines for surface movement radar and information about the development of new technologies that can be applied to runway safety shall be disseminated as part of the general runway safety awareness campaign.

5.1.2 Identify any ICAO guidance material that should be upgraded to ICAO standards and recommended practices and review other relevant materials.

5.1.3 Initiate a programme to better understand human factors contribution to runway incursions.

5.1.4 Review "Heads up, Heads down" time requirement of procedures and working methods and assess their potential impact on runway safety and recommend improvement when appropriate.

Appendix 4: "Results and Analysis," Executive Summary, December 2002, Runway Incursion Joint Safety Implementation Team (RI JSIT)

EXECUTIVE SUMMARY

The Runway Incursion Joint Safety Implementation Team (RI JSIT) was chartered by the Commercial Aviation Safety Team (CAST) and General Aviation Joint Steering Committee (GA JSC) to develop a plan to effectively reduce the severe threat of fatalities and loss caused by commercial and general aviation runway incursion accidents/incidents. CAST's goal is to reduce the US commercial aviation fatal accident rate by 80 percent by the end of the year 2007. To help accomplish this goal, the RI JSIT brought together expert representatives from across the aviation community including participants from government, industry, and pilot and controller unions. These experts developed, prioritized, and coordinated a plan to implement the most effective analytically data-driven intervention strategies recommended by the RI Joint Safety Analysis Team (JSAT). Those 115 intervention strategies were joined with 37 GA JSC intervention strategies and were analyzed by the RI JSIT to determine the feasibility of gaining significant safety benefits through implementation. From the overall effectiveness and feasibility scores, twenty-two "Safety Enhancements" were incorporated into seven Detailed Implementation Plans.

FAA data on runway incursion incidents and accidents from 1997-2000 reflects that 55 percent were caused by pilot deviations, 25 percent were caused by controller operational errors, and the remaining 20 percent were caused by vehicle or pedestrian deviations. Further break down of this data indicates that of the most serious incursions (Category A and B) 54 percent were due to pilot deviations, 35 percent were controller operational errors, and the remaining 11 percent were vehicle or pedestrian deviations.

An executive overview of the seven Detailed Implementation Plans follows:

Standard Operating Procedures (SOPs) for Ground Operations

Industry wide, standard operating procedures have been among the highest scoring safety enhancements across five accident categories including Controlled Flight into Terrain, Approach and Landing, Loss of Control, Runway Incursion, and Turbulence. The implementation of Standard Operating Procedures (SOPs) for surface operations is one of the most powerful near-term interventions in mitigating the risk of runway incursions. This project would build upon Advisory Circular 120-74, "Flight Crew Procedures During Taxi Operations", to develop templates of SOPs. These templates would be used by air carriers, general aviation pilots, and ground personnel who tow or otherwise operate aircraft on the airport surface.

Just as pilot deviations in the air (e.g., altitude deviations) have been reduced by increased standardization of cockpit procedures, the incidence of runway incursions and other surface incidents could also be reduced by increased standardization of pilot procedures for ground operations. Although most airlines have detailed procedures for airborne operations, relatively few airlines have standard procedures for operating in the increasingly complex surface environment. The purpose of this project is to reduce the risk of runway incursions and surface incidents by recommending that all FAR Part 121 operators and Part 135 operators: establish, document, train to, and follow, standard operating procedures (SOPs) for ground operations.

The enhancements, recommended in the SOP for the ground operations plan, call for:

1. Developing SOPs from a survey of industry "best practices". Operators would implement these SOPs by training to proficiency and ensuring their use.

2. Adapting these best practices for use in single-pilot (Part 91) operations.

3. Developing "best practices" for ground personnel that taxi or tow aircraft on the airport movement area.

4. Developing "best practices" for ground vehicle operations in the aircraft movement area and incorporating them into training programs for drivers.

This plan is highly cost-effective, and could be implemented immediately with minimal additional effort on the part of the air carriers. With industry-wide implementation of the proposed SOPs, pilot behavior would become more standardized, and less likely to result in a runway incursion.

Air Traffic Control Training

More than a third of the most serious runway incursions have been attributed to controller operational errors. These errors have been attributed to: memory lapses, a lack of controller teamwork, improper scanning, poor prioritization of duties, and on-the-job training (OJT) being conducted during actual operations. All of these causal factors could be mitigated by the interventions proposed by the ATC Training Detailed Implementation Plan. The initiatives within this plan are interdependent and should be viewed as a whole.

1. Training controllers on the capabilities and limitations of human memory is an important first step in preventing operational errors due to controller memory lapses. Providing controllers with tools to help manage their memory resources while working in ever-changing, dynamic conditions can help prevent memory lapses, and prevent and correct these errors before they develop into incidents or accidents.

2. Air Traffic Controller course curriculums for initial and refresher training need to be revised to ensure that controllers utilize the essential skills of scanning, anticipated separation, and prioritization of control duties. Notably, these skills could be taught and strengthened with simulator training.

3. Team effectiveness training would provide a version of cockpit resource management (CRM) for all tower controllers. This training fosters a culture of teamwork in the tower environment to help prevent, detect, and correct controller and pilot errors before they result in runway incursions and accidents.

4. Currently, tower controllers do not benefit from training in visual simulators. Simulators have been recognized as a successful and cost-effective means for flight training for decades and it is the industry standard to provide training in simulators for emergencies and unusual situations. Simulators provide an optimum environment for training to improbable, but safety-critical situations. Providing training for controllers in a visual high-fidelity tower simulator is an efficient, effective use of resources. Also, the use of simulators for initial controller training would ensure that this training is conducted with no risk to the flying public. Finally, providing initial training in a simulator would cut training time, and increase the knowledge base and experience of new hires before they work in an operating tower. This will become increasingly important with the expected attrition due to retirement and the concurrent influx of hundreds of new controllers.

Air Traffic Control Procedures

The ATC Procedures project will help to reduce the incidence of runway incursions by:

Increasing controller situation awareness;

Reviewing (and revising as necessary): capacity enhancement programs, required controller and pilot phraseology, and implicit clearances to cross a runway.

These two objectives will be accomplished by:

1. Establishing national standards for tower control positions to help promote increased situational awareness for controllers with respect to surface operations.

2. Reviewing capacity enhancement programs to determine whether they contribute to surface incidents; if so, they would be revised or eliminated.

3. Reviewing phraseology used for surface operations for greater efficiency and clarity, and then revised as needed.

4. Conducting a study to determine whether revising FAR 91.129(i) would help reduce runway incursions.

5. Initiating rulemaking to require that pilots read back all instructions to: “hold short”, “taxi into position and hold” or otherwise enter a runway.

Situational Awareness Technologies for Air Traffic Control

This project will develop and implement technology tools to provide and/or enhance airport surface situational awareness for air traffic controllers. Examples of these technology tools include, but are not limited to, Airport Movement Area Safety System (AMASS), Airport Surface Detection Equipment (ASDE-X), Automated Dependent Surveillance—Broadcast (ADS-B), Next Generation Air-Ground Communications System (NEXCOM), Surface Movement Advisor (SMA), and Airport Target Identification System (ATIDS). These technologies will also support pilots with a clear understanding of airport layout and clearance instructions to avoid deviations in all visibility conditions. The implementation of these interventions would be accomplished through the following activities:

1. New technology tools would be developed by the FAA to enable enhanced surveillance, information, communication and conflict detection for ATC operations.

2. FAA and airport operators would provide airport surface surveillance equipment with conflict alerting capability at air traffic control towers.

3. Digital data link capability would be developed and implemented to enable automatic transmission of ATC instructions/information (between the ground and aircraft).

4. Situational Awareness Displays developed in support of the above listed strategies would incorporate industry best practices for computer-human interface (CHI) design to enhance and support ATC decision-making.

Visual Aids Enhancement and Automation Technology for Airports

Numerous runway incursion incidents and accidents have resulted from pilot and vehicle operator ground movement navigation errors. Substantially improved ground movement navigation guidance is needed to prevent such accidents and incidents. The four Visual Aids Enhancement & Automation Technology Project safety enhancements that follow provide the capability to present needed information in the normal field of view of pilots and vehicle operators:

1. Variable message signs would have the capability to present critical clearances such as “hold”, “cross” or “takeoff.”

2. Improved airfield marking & lighting would enhance the conspicuity of runway and taxiway centerlines and other critical airport markings.

3. Providing runway occupancy information to pilots on final approach would prevent accidents and incidents due to a “land over” where an aircraft on final approach jeopardizes, or collides with, an aircraft on the runway awaiting takeoff clearance.

4. "Smart" ground movement lighting that indicates the taxi route clearance would substantially reduce runway incursions resulting from pilots getting lost and proceeding onto a runway or taxiway without a clearance.

Pilot Training

Pilot deviations account for more than half of all runway incursions. Enhancements to pilot training would substantially contribute to runway safety by helping pilots to avoid, detect, and correct errors before they result in runway incursions. By increasing the number of surface movement tasks on written and practical test standards, and incorporating new and revised training material significant improvements in pilot training can be achieved. The training material would entail

- increasing situational awareness in the airport environment,
- effective pre-taxi planning and briefing,
- use of standard operating procedures for surface operations,
- task prioritization, and
- effective crew resource management.

These interventions proposed by the pilot training workgroup would be implemented through the existing infrastructure within the FAA and industry. Policies, procedures, and implementation guidelines for pilot training programs to prevent runway incursions would be developed and implemented using resources available to FAA, GA, military, and air carrier pilots (such as advisory circulars, and safety material compiled from government, industry, academia and DOD).

Aircraft /Vehicle Upgrade and Installation (Moving Map Display)

The Runway Incursion JSIT determined that the moving map display systems were the most powerful intervention for runway incursion prevention. As mentioned previously, pilot deviations account for more than half of all runway incursions. The RI JSIT estimated that nearly half of these deviations can be prevented using a moving map display with only GPS own-ship position. Using the JIMDAT process, the RI JSIT determined that a moving map display with own-ship position and airport traffic displayed (e.g., ADS-B/TIS-B), would have been highly effective in preventing the runway incursion accidents and incidents considered by the RI JSAT. Further enhancements such as runway occupancy alerting and graphical taxi clearances, would provide additional benefits.

There is a range of hardware solutions to implement these capabilities, from that of a hand-held device to a moving map integrated into the primary flight display. This range of implementation solutions is provided to address the diversity of aircraft type and operational capabilities.

While cost remains the biggest barrier to implementation, a phased approach is proposed which minimizes cost and provides an immediate and measurable safety benefit. The initial phase will address the development and installation of an airport moving map cockpit display with own-ship position (enabled by GPS). Subsequent phases will address the addition of data-linked traffic information, runway occupancy advisory systems, and taxi routes and clearance limits. Operational benefits achieved through the implementation of moving map technologies (such as those that will enhance capacity and efficiency) will also help to offset equipage investment.

The enhancements proposed in these plans would reduce the number of runway incursions by:

Improving pilot situational awareness with the implementation of moving map displays in the cockpit. This is proposed as a voluntary equipage with a phased implementation. The first phase provides the capability of a moving map showing GPS own-ship position. The second phase adds traffic to the display via datalink technologies. The third phase adds runway occupancy advisories. The final stage adds graphical and/or textual presentation of taxi clearances and clearance limits.

Improving situational awareness of airport vehicle drivers with the voluntary implementation of moving maps in vehicles that operate on the airport. This would help prevent runway incursions caused by driver error and enhance their understanding of the operations on the airport.

Recommendations

The unifying goal of the Runway Incursion JSIT was to produce a practical agenda yielding significant safety benefits, not for a selected group of organizations, but for the entire aviation community. Because not all organizations comprising the general and commercial aviation communities are represented on CAST and GA JSC, the RI JSIT recommends that CAST and GA JSC ensure prompt distribution of this report to all major organizations comprising the U.S. commercial and general aviation community, the presidents of IATA, IFALPA, the Chairman of the JAA Board, and the President of the Council of ICAO.

Additionally, the RI JSIT is the first of the CAST JSAT and JSIT teams to focus on incident data analysis as their primary source of generating Safety Enhancements. As industry and government collectively move toward a National Strategic Plan for Aviation Safety, they will be required to increasingly move from a reactive to a preventive model of mishap elimination. Achieving the next order of magnitude reduction of risk in aviation may require an expanded focus on other sources of data (e.g., incident data as well as accident data) to identify the precursors of catastrophe. The move from studying primarily accident data to a reliance on incident data will require improved data collection systems, procedures, and protections among all the stakeholders within the aviation community. Most importantly, the RI JSIT recommends that CAST and its member organizations implement the seven projects identified as soon as possible.

In summary, the data driven and consensus based process that the RI JSIT has used yielded seven major project areas with twenty-two specific Safety Enhancements. It is the consensus of this group that the implementation of the recommended "Safety Enhancements" should be pursued with a system approach. The causes (precursor events) of runway incursion are many and varied.

The mitigation of the growing threat of Runway Incursion will require a multi-faceted approach.

Aviation stakeholders will have to CAST a broad net if we are to significantly reduce the risk of fatal runway incursions.

Appendix 5, Recommended Reading and References

FAA Runway Safety Report, August 2005, FAA Air Traffic Organization—Safety Services, 65 pages

FAA Flight Plan 2006-2010, August 2005, Federal Aviation Administration, 115 pages

National Civil Aviation Safety Committee, Subcommittee on Runway Incursions, Final Report, September 14, 2000, Transport Canada, 44 pages

Manual for Preventing Runway Incursions, First Edition, International Civil Aviation Organization, 2006, 86 pages

Next Generation Air Transportation System Integrated Plan, December 12, 2004, Office of the Secretary and Administrator, Federal Aviation Administration, U.S. Department of Transportation, 35 pages

An Analysis Of Runway Incursion "Hot Spots" Incidents, July 17, 2002, prepared for Mr. William Davis, Director, FAA Office of Runway Safety, ARI-1, NASA Aviation Safety Reporting System (ASRS), 55 pages

Research Report—Runway Incursions (extracted information from FAA's 2002-2004 Runway Safety Blueprint) Human factors, Human Factors Newsletter # 02-14, July 27, 2002—August 16, 2002, 5 pages

Results and Analysis, December 2002, Runway Incursion Joint Safety Implementation Team (RI JSIT), chartered by Commercial Aviation Safety Team (CAST) and General Aviation Joint Steering Committee (GAJSC), 188 pages

Excerpts from National Desk/Transportation Reporter, June 26, 2001, U.S. House Committee on Transportation and Infrastructure, U.S. Representative Don Young, Chairman, 3 pages

Further Actions Are Needed To Reduce Runway Incursions, June 26, 2001, Statement of the Honorable Kenneth M. Mead, Inspector General, U.S. Department of Transportation, 12 pages

Results and Analysis, August 11, 2000, Runway Incursion Joint Safety Analysis Team (JSAT), chartered by Commercial Aviation Safety Team (CAST) and General Aviation Joint Steering Committee (GAJSC), 142 pages

Special Investigation Report, *Runway Incursions at Controlled Airports in the United States*, May 6, 1986, NTSB SIR-86/01, National Transportation Safety Board, 111 pages

European Action Plan for the Prevention of Runway Incursions, Release 1.2, May 2006, Eurocontrol, May 2006, 80 pages.

Runway Incursions: 1997 to 2003, June 2004, Australian Transport Safety Bureau, 39 pages.

Footnotes

[1] FAA Runway Safety Report, August 2005

[2] "Why a Little More Traffic Makes a Lot More Runway Incursions," Lincoln Lounsbury, *Air Line Pilot*, May 1999.

[3] National Civil Aviation Safety Committee, Subcommittee on Runway Incursions, Sept. 14, 2000

[4] Australian Transport Safety Bureau, "Runway Incursions: 1997 to 2003," June 2004.

[5] FAA "Forecasts of IFR Aircraft Handled by FAA Air Route Traffic Control Centers, FY 2006-2017."

[6] www.faa.gov/runwaysafety/data/ri_tot.cfm?fy1=2006&fy2=2005

[7] FAA Runway Safety Report, August 2005

[8] Statement of FAA Associate Administrator for Aviation Safety Nicholas Sabatini, Sept. 20, 2006

[9] Australian Transport Safety Bureau, "Runway Incursions: 1997 to 2003," June 2004.

[10] "European Action Plan for the Prevention of Runway Incursions, Release 1.2," May 2006.

[11] http://aviation-safety.net/database/record.php?id=20011008-0