Commercial Aviation Safety Team

Wrong Runway Departures

August 2007

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ABBREVIATIONS AND ACRONYM LIST

AIDS	FAA Accident Incident Data System
AIM	Aeronautical Information Management
AIXM	Aeronautical Information Exchange Model
ALPA	Air Line Pilots Association, International
AMASS	Airport Movement Area Safety System
ANC	Ted Stevens Anchorage International Airport
APO	FAA Aviation Policy and Plans
ARTCC	Air Route Traffic Control Center
ASAP	Aviation Safety Action Program
ASDE–3	Airport Surface Detection Equipment — Model 3
ASDE–X	Airport Surface Detection Equipment — Model X
ASDE–3X	Airport Surface Detection Equipment — Model 3X
ASRS	NASA Aviation Safety Reporting System
ATADS	Air Traffic Activity Data System
ATC	air traffic control
ATIS	Automatic Terminal Information Service
ATO	FAA Air Traffic Organization
CLE	Cleveland Hopkins International Airport
CRM	crew resource management
EFB	electronic flight bag
EOSL	End of Service Life
FAA	Federal Aviation Administration
FAROS	Final Approach Runway Occupancy Signal
FDC	Flight Data Center
FSS	flight service station
GAJSC	General Aviation Joint Safety Council
HOU	Houston Hobby Airport
JIMDAT	Joint Implementation Measurement Data Analysis Team
MIA	Miami International Airport
NADIN	National Airspace Data Interchange Network
NASA	National Aeronautics and Space Administration
NOTAM	Notice To Airmen
NPTRS	FAA National Program Tracking and Reporting Subsystem
NTSB	National Transportation Safety Board
OE/D	Operational Error or Operational Deviation
OEDS	FAA Operational Error/Deviation System

OEP	Operational Evolution Plan
PDS	FAA Pilot Deviation System
RAAS	Runway Awareness and Advisory System
RSAT	Runway Safety Action Team
RSL	runway status light
SLC	Salt Lake City International Airport
SME	subject matter expert
TIPH	Taxi Into Position and Hold
VPDS	Vehicle Pedestrian Deviation System
WILD	Wildlife Database
WMSCR	Weather Message Switching Center Replacement

EXECUTIVE SUMMARY

In light of the recent crash of Comair, Inc. (doing business as Comair Airlines doing business as Delta Connection), flight 5191 in Lexington, Kentucky, the Federal Aviation Administration's Aviation Safety Information Analysis and Sharing center conducted a review of event reports that involved airplanes departing from or taxiing into position on a wrong runway. The review involved gathering data from multiple databases (1981 through 2006); identifying event reports of interest; reviewing those reports to find contributing factors; identifying, assigning, and scoring mitigations. The review showed that wrong runway events occurred at many airports and under varying circumstances; however, they occurred most frequently at four airports: Cleveland Hopkins International Airport, Houston Hobby Airport, Salt Lake City International Airport, and Miami International Airport. These airports share the following common elements or contributing factors:

- Multiple runway thresholds located in close proximity to one another.

- A short distance between the airport terminal and the runway.

- A complex airport design.

- The use of a runway as a taxiway.

- A single runway that uses intersection departures.

The review found that the number of reported wrong runway departure events has decreased from its peak in the 1990s; however, the data show that the common elements are still present. The review identified areas where events have not yet occurred and shows that the following contributing factors can be mitigated and wrong runway events avoided when—

- Airport communities employ a coordinated effort similar to the one taken by Cleveland Hopkins International Airport;

- Technological, procedural, and infrastructure enhancements as proposed by the Commercial Aviation Safety Team are implemented by the Federal Aviation Administration, industry, and airport administrations;

- Aeronautical information enhancements are made;

- Threat analysis based on the contributing factors of past wrong runway departures are conducted at individual airports; and

- Electronic flight bags with own-ship moving map display functionality and/or an aural runway and taxiway advisory system are incorporated into the part 121 fleet.

BACKGROUND

Tremendous strides have been made in reducing the threat of runway incursions at our nation's airports. Focusing on preventing collisions between airplanes has led to new technologies, new air traffic control (ATC) and flightcrew procedures, and changes in how airports are illuminated and marked. The wrong runway event reports had very similar circumstances to runway incursion reports in that the actions taken by the flightcrews did not match their intentions. On August 27, 2006, Comair, Inc. (doing business as Comair Airlines doing business as Delta Connection) (Comair), flight 5191, operating under part 121 of Title 14, Code of Federal Aviation Regulations (14 CFR), crashed during takeoff from Blue Grass Airport in Lexington, Kentucky. The flight had been cleared for takeoff on runway 22[1]; however, the flightcrew inadvertently taxied onto runway 26[2] and ran off the end of the runway during the takeoff roll (see figure 1). The airplane was destroyed and of the 47 passengers and 3 flightcrew members aboard the airplane, 49 were killed and 1 received serious injuries.

Figure 1. Blue Grass Airport
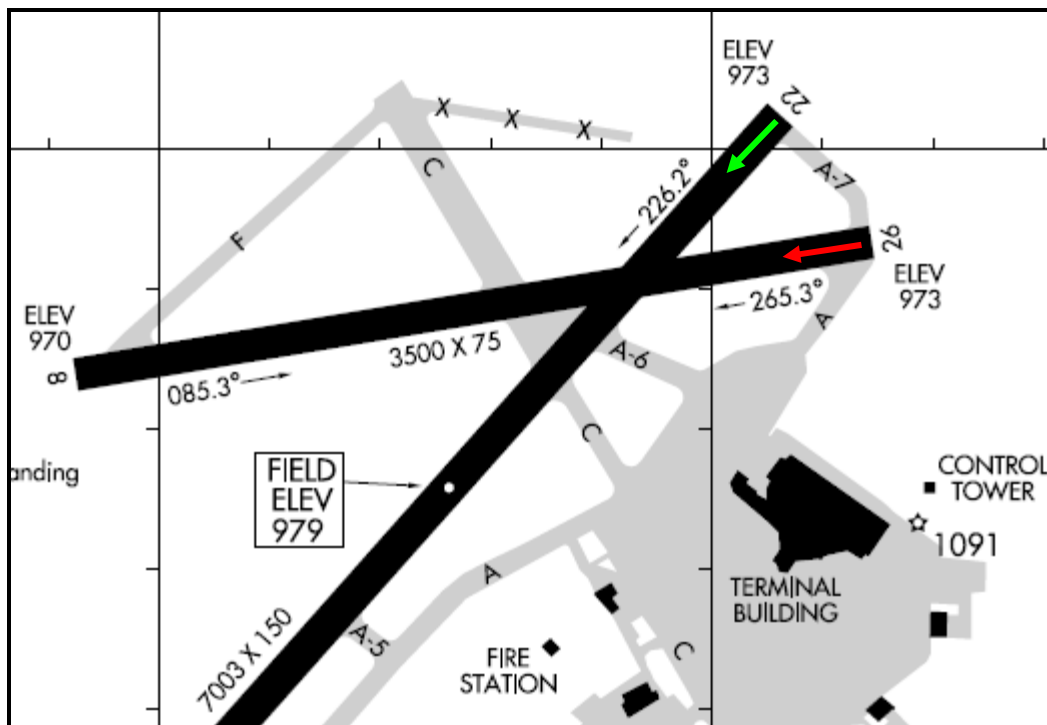
This event was the sole part 121 major accident in the United States in 2006 and is currently under investigation by the National Transportation Safety Board (NTSB) to determine the contributing factors and cause. Part 121 governs the operating requirements for U.S domestic, flag, and supplemental air carriers.

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[1] All intended departure runways are represented by a green arrow on the airport diagrams.
[2] All actual runways used for takeoff are represented by a red arrow on the airport diagrams.

Following the Comair accident, the Federal Aviation Administration (FAA) Aviation Safety Information Analysis and Sharing (ASIAS) center initiated a preliminary review of several databases to determine the extent of the wrong runway departure issue. Because of the significant number of identified relevant event reports, the ASIAS center undertook a study of wrong runway departures. This study involved gathering wrong runway event reports from many databases (dated 1981 through 2006) and reviewing the data with a panel of subject matter experts (SMEs), in conjunction with the Commercial Aviation Safety Team (CAST), to determine if the event report was applicable to the study, and to identify any contributing factors to the wrong runway events. The panel then proposed mitigations, which were scored by the Joint Implementation Measurement Data Analysis Team (JIMDAT), working for the CAST, which is comprised of Government and industry executives.

SCOPE OF THIS REPORT

This report focuses on the analysis of wrong runway departure events for part 121 operators that have occurred in the United States and proposes mitigations to reduce the risk of airplanes departing on the wrong runway. The preliminary review of wrong runway events related to operators operating under the following regulations also are summarized in this report and a more detailed study is currently underway:

- 14 CFR part 135, Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft;

- 14 CFR part 129, Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged In Common Carriage; and

- 14 CFR part 91, General Operating and Flight Rules.

This report is divided into three sections. The first section discusses the analysis of the wrong runway events and includes contributing factors, proposed mitigations, and examples. The second section describes, in general, the NOTAM process and how inconsistencies in that process may be a contributing factor to wrong runway events. A third section provides information on a study of 14 CFR part 139 class I airports undertaken to determine which airports have the common wrong runway contributing factors. Part 139 governs the certification of airports. This study attempted to find areas where events have not yet occurred to identify and fix threat areas before a wrong runway event does occur.

In addition, the report contains four appendixes. Appendix A is a list of the SMEs who helped with the analysis of event data. Appendix B presents the JIMDAT mitigation scoring table. Appendix C presents a visual description of the NOTAM process. Finally, appendix D shows the scoring table related to the part 139 airport contributing factors study.

EVENTS ANALYSIS

DATA SOURCES

The analytical process to generate proposed mitigations required a unique approach because departures from a wrong runway are not required to be reported to the FAA under any reporting and data collection program if there is no loss of separation or associated accident event. This made it difficult to obtain a pure data set of all of these events; instead, an effort was made to collect as many relevant reports as possible. Therefore, queries were designed to search both fixed field and free text forms from the following databases:

- National Transportation Safety Board,

- FAA Pilot Deviation System (PDS),

- FAA Accident/Incident Data System (AIDS),

- National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS),

- FAA National Program Tracking and Reporting Subsystem (NPTRS), and

- FAA Operational Error/Deviation System (OEDS).

The NTSB data was collected using the "Wrong Runway" subject code and "Takeoff" flight phase. Similarly, PDS data were focused on "Surface Deviations" that pertained to wrong runway takeoffs. The narrative fields for AIDS, ASRS, NPTRS, and OEDS were searched to find wrong runway departures. This approach was used because of the lack of subject or type of event categories in these databases and inconsistencies in event classifications. These queries captured events that involved airplanes departing from, or taxiing into position on, the wrong runway.

The database queries identified 696 event reports of interest. Seventy-nine of these event reports did not identify which part of 14 CFR the flight was operating under at the time of the incident or accident; the panel omitted those reports from the analysis. The remaining event reports were grouped according to which part of the regulations the flight was operating under at the time of the event, as follows:

- 117 event reports from part 121 air carriers,

- 53 event reports from part 135 operators,

- 7 event reports from part 129 air carriers, and

- 440 event reports from part 91 operators.

PART 121 OPERATORS

Review of Event Reports

The 117 part 121 event reports were reviewed by a panel of SMEs with expertise in flight operations, airport operations, and air traffic, and included FAA and aviation industry representatives (see appendix A for a list of the SMEs). This diverse panel decided on each event report's relevance to the topic, discussed the contributing factors of each event report, and assigned mitigations aimed at reducing the risk of wrong runway departures. The SME panel's mitigations were then scored by the JIMDAT for their effectiveness in mitigating each wrong runway event (see appendix B for the JIMDAT mitigation scoring table).

The ASRS database contained the majority of the part 121 events, followed by the PDS, NTSB, AIDS, and NPTRS (see figure 2). The reports collected in the ASRS database are voluntarily submitted and therefore capture only the occurrences that have been reported. The narrative fields of the ASRS event reports provided the best source of information for determining the contributing factors because they are first-hand accounts of the events from the flightcrew members involved.

Figure 2. Percent of Part 121 Event Reports By Database
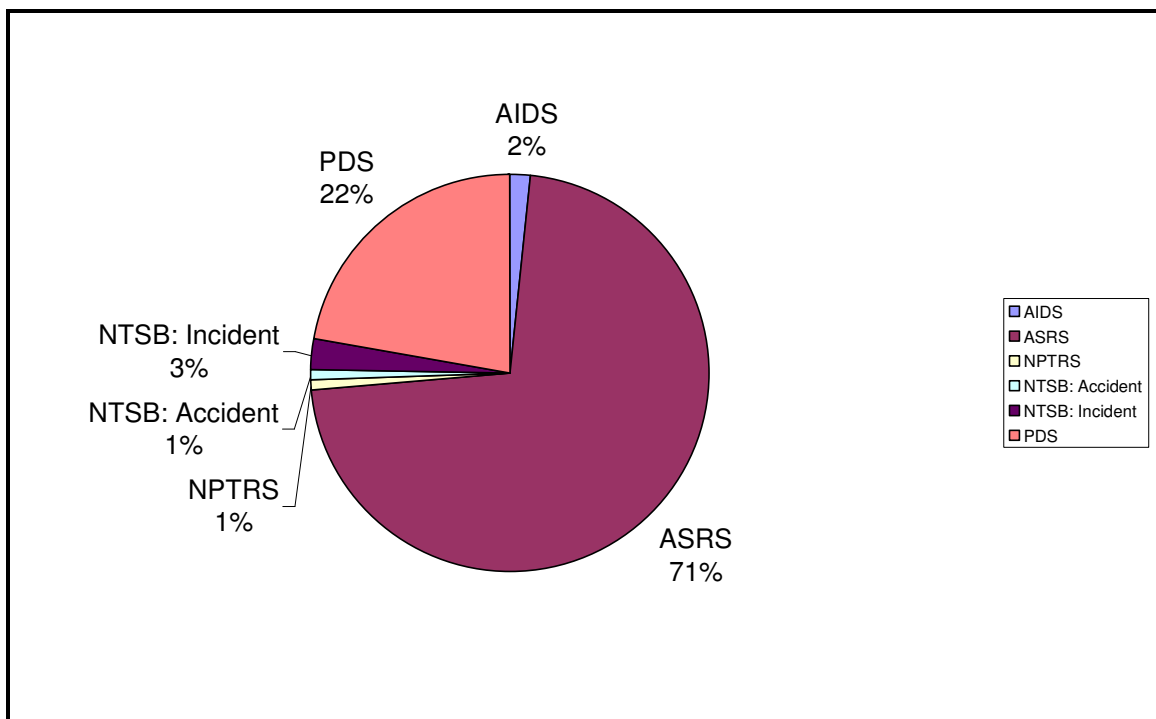
Reviewing incident data is significant in identifying safety threats before an accident occurs. The ASRS database, which is one of the main incident data sources, relies on reports that are voluntarily submitted by flightcrew members and submissions from Aviation Safety Action Programs (ASAPs). Over the past few years, the overall percentage of these reports submitted by part 121 flightcrew members appears to be decreasing. Therefore, it would not be valid to calculate a reliable trend of wrong runway events.

For air carrier operations, there are two main wrong runway departure categories in the databases. The first is departing from the wrong runway with regard to the airplane performance calculations. That is, the flightcrew taxied to the correct location but the airplane did not have adequate performance to safely use the runway. The second category includes events similar to the Lexington accident in which the flightcrew had been cleared to one runway but departed from or taxied onto a different runway. The SMEs concluded that the events involving the performance issues were not relevant to the issue of flightcrew members departing from a different runway than assigned, and these events were removed from the analysis and mitigation scoring process.

The original 117 part 121 reports were further reduced to a core set of 80. In addition to omitting events involving performance issues, the SMEs eliminated reports that classified an event as a wrong runway departure if the report did not contain sufficient information to determine the contributing factors and mitigations. Other event reports were eliminated because they were duplicate reports of the same event that had been captured in a different database.

Contributing Factors

The 80 remaining part 121 wrong runway events reviewed occurred at many airports (see figure 3); however, the following airports had the highest number of overall events:

- Cleveland Hopkins International Airport (CLE) 24%
- Houston Hobby Airport (HOU) 11%
- Salt Lake City International Airport (SLC) 8%
- Miami International Airport (MIA) 6%

Figure 3. Part 121 Wrong Runway Events by Airport (1981 – 2006)
(80 Events Scored by JIMDAT)
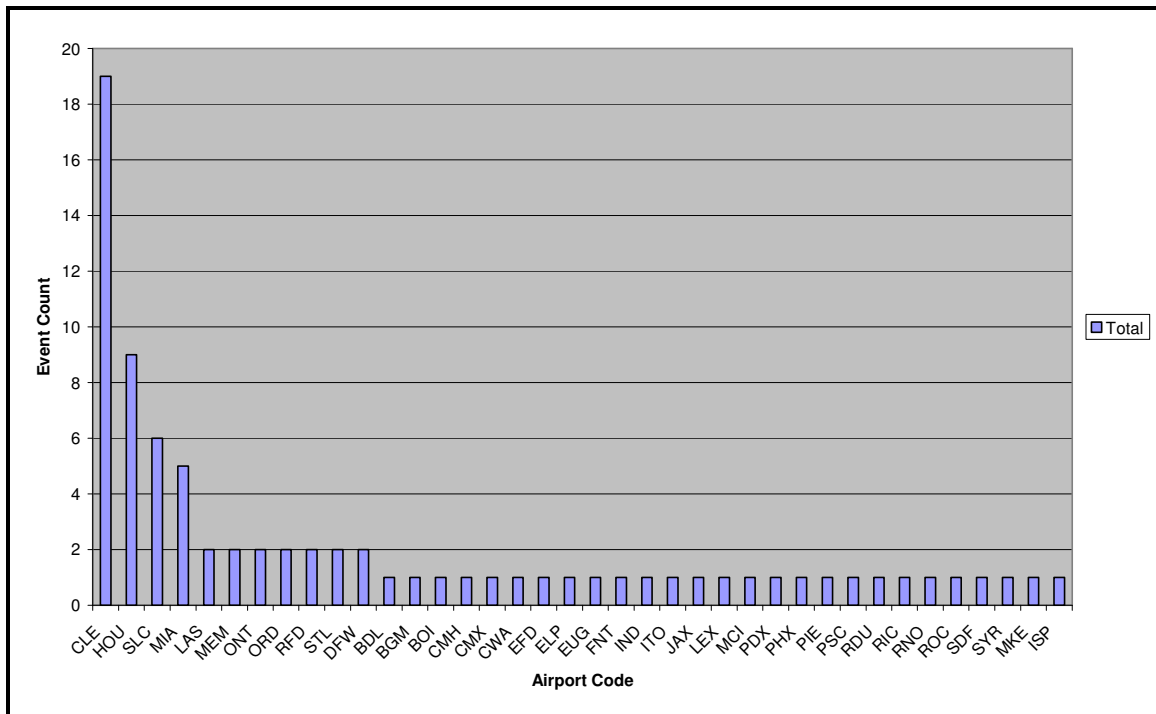
The SME review of these airports found the following contributing factors:

- *A similar layout, with one taxiway leading to an area with multiple runway thresholds located in close proximity to one another.* The analysis of the wrong runway events revealed that most events took place in the areas where multiple runway thresholds are in close proximity. These areas present an opportunity for flightcrew members to taxi the airplane onto the wrong runway. This is especially true when flightcrew members have to cross one or more runways on the same taxiway. In some cases, multiple runway ends are in the same location (see figure 4).

**Figure 4. Example of Multiple Runway Ends in the Same Location
(Salt Lake City International Airport)**
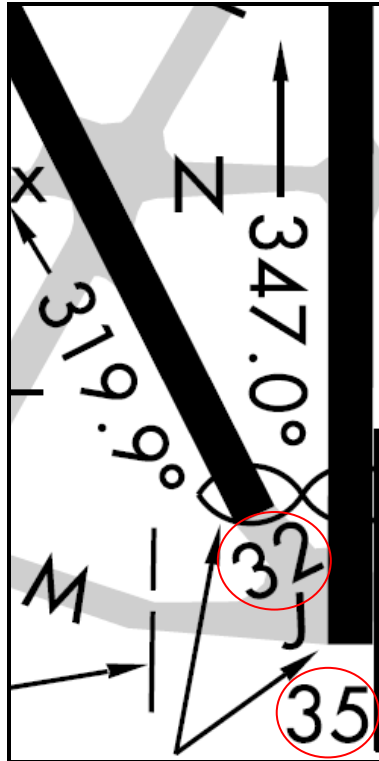
- *A short distance between the airport terminal and the runway.* A short distance between the terminal and the runway requires flightcrews to complete the same number of checklist items in a shorter timeframe and requires more heads-down time during taxi. Many of the event reports mentioned that the flightcrew members were rushing to complete their checklists or to expedite their departures.

- *A complex airport design.* A complex airport design can cause confusion among the flightcrew. The complexity of the airport layout includes factors such as high traffic volume, requiring the airplane to cross multiple runways to reach the departure runway, and complicated taxi instructions that involve the use of several taxiways.

- *The use of a runway as a taxiway.* In operations that required flightcrew members to use a runway to taxi to the assigned departure runway, pilots had a tendency to depart on the runway they were taxiing on instead of turning onto the correct runway when a takeoff clearance was issued.

- *A single runway that uses intersection departures.* Airports with a single runway layout were not immune to airplanes taking off on the wrong runway, especially when intersection departures were made. In these events, the flightcrew taxied onto the runway and turned in the wrong direction, taking off 180 degrees from the intended direction.

After determining that most wrong runway events occurred at airports sharing common wrong runway contributing factors, the ASIAS center undertook a study of all part 139 class I airports to identify airports that share these common factors. See Part 139 Airport Contributing Factors Study for the details of this review.

In addition to the common wrong runway contributing factors present at the airports, the factors referenced in figure 5 were identified and addressed in the mitigations.

Figure 5. Wrong Runway Contributing Factors Citations

Factor	Citations
Crew (CRM)	51
Airport geometry (Proximity of departure runway ends)	50
Check between hdg indicator and runway hdg	39
Human factors	31
Communications	28
Airport signage and markings	20
Time pressures	19
Airport Complexity	13
Information desemination	13
Using runway to taxi	10
Weather	10
Distraction	9
Safety culture	7
Aircraft conspicuity	4
ATC (CRM)	4
Crew experience level	4
Late runway change	4
Airport equipment	2
Construction	2
Plan continuation error	2
Tower closed	2
Air traffic line of sight	1
Airport familiarity	1
Non specific taxi instruction	1
Performance issue	1
Pilot did not have charts	1
Takeoff below runway minimums	1
Wooden barriers	1

Wrong Runway Event Examples

The following examples demonstrate how these common wrong runway factors contribute to an air carrier flightcrew attempting to takeoff from a different runway than that assigned.

Example 1 — Cleveland Hopkins International Airport (CLE)

The following is a summary of an event described in a report from Cleveland Hopkins International Airport submitted to the ASRS database following an event in 1993. Note that runway 23L referenced in the narrative is now designed as runway 24L as shown in figure 6.

> Because of confusion at the intersection of runways 23L and 23R and 28 at the approach end of the runways, we initiated a takeoff on the wrong runway for which we had been cleared. We had been cleared for takeoff on runway 23L. Because of the short distance between the terminal and the runways, we had a very short taxi time.

Just as we reached the hold short lines, we had completed our taxi checklist and were immediately cleared for takeoff on 23L. As the Captain taxied out to line us up (he has the nose steering on his side only), I ran my line-up checklist and he said "Hello" to the passengers over the PA system. Lined up on the wrong runway. I took the throttles and we proceeded down the wrong runway. The tower controller called us to tell us we were taking off on the wrong runway. We were at about 35 knots and so I aborted.

Figure 6. Cleveland Hopkins International Airport
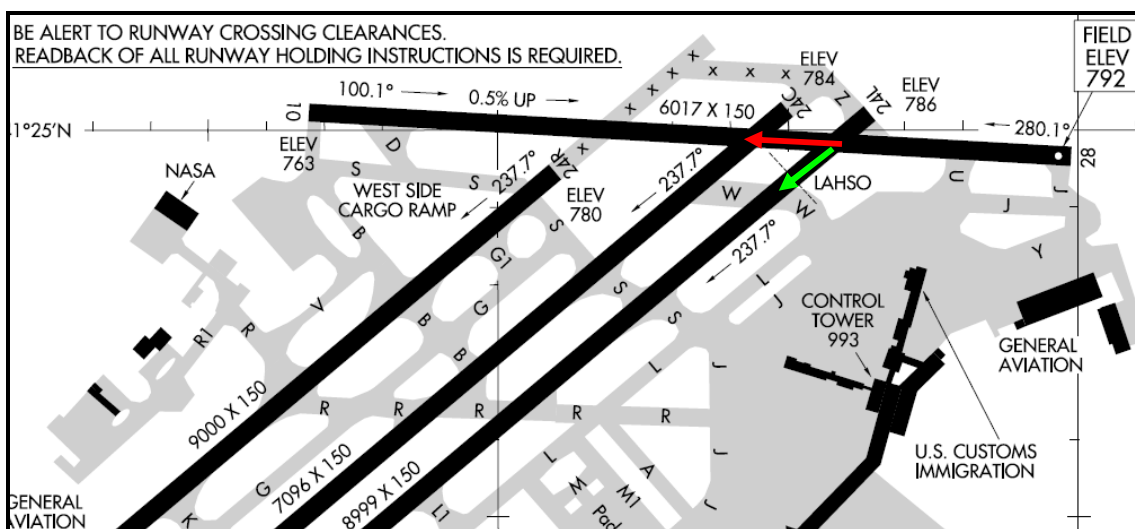
Example 2 — St. Louis Lambert International Airport (STL)

STL Accident Event

The analysis of the part 121 events included a review of the NTSB database. The NTSB has investigated two events where "Wrong Runway" was listed as a contributing factor or cause of the event, including a fatal accident that involved a pilot taxiing onto the wrong runway. This accident occurred at St. Louis Lambert International Airport in 1995 when a Trans World Airlines MD–82 collided with a Cessna 441 that had taxied onto the wrong runway and was waiting for takeoff clearance.

At the time of the accident, ATC used runway 31, which is depicted as taxiway F on the airport diagram, as a joint use runway and taxiway (see figure 7). Runway 31 was marked with standard runway markings but was only 75 feet wide, giving it the appearance of a taxiway. The Automatic Terminal Information System (ATIS) current at the time identified runways 30R and 30L as the active runways for arrivals and departures but failed to mention the occasional use of runway 31. ATC personnel were not able to maintain visual contact with the Cessna after it taxied from the well-lighted ramp area into the runway/taxiway environment of the northeast portion of the airport. The NTSB stated that the pilot of the Cessna acted on an apparently preconceived idea that he would use his arrival runway, runway 30R, for departure.

After receiving taxi clearance to back-taxi into position and hold on runway 31, the pilot taxied into a position at an intersection on runway 30R, which was the assigned departure runway for the MD–82. The flightcrew of the MD–82 was not able to see the Cessna until a moment before impact. The collision killed the two people aboard the Cessna.

Figure 7. St. Louis Lambert International Airport (Accident Event)

The NTSB concluded that the cause of the accident was the Cessna 441 pilot's mistaken belief that his assigned departure runway was runway 30R. This resulted in his undetected entrance onto runway 30R, which was being used by the MD–82 for its departure. Contributing to the accident was the lack of ATIS and other aeronautical information regarding the occasional use of runway 31 for departure.

The NTSB recommended the installation and use of Airport Surface Detection Equipment (ASDE–3), and particularly ASDE–3 enhanced with the Airport Movement Area Safety System (AMASS), which could have prevented this accident.

STL Incident Event

The technology-based solution referenced above is geared toward reducing a collision between two airplanes and may be an aid to ATC for detecting when an airplane has taxied to the wrong location. However, as the summary of a 2003 pilot deviation report from St. Louis illustrates, it is not effective in preventing pilots from losing their situational awareness in complex airport environments.

An air carrier MD–80 was the second airplane holding in line on taxiway P for a departure on runway 12L (see figure 8). The first airplane in line for runway 12L could not depart because of a traffic sequence conflict. The MD–80 was given amended taxi instructions to taxi onto runway 6, which was inactive, via taxiway E and to hold short of runway 12L on runway 6. The airplane was then cleared for takeoff on runway 12L. The flightcrew read back the instructions correctly, and then proceeded to commence takeoff on runway 6 with 3,000 feet remaining on the runway. The St. Louis tower observed this and advised the flightcrew to abort the takeoff. The airplane rolled out to the end of runway 6 and made a 180 degree turn.

Figure 8. St. Louis Lambert International Airport (Incident Event)
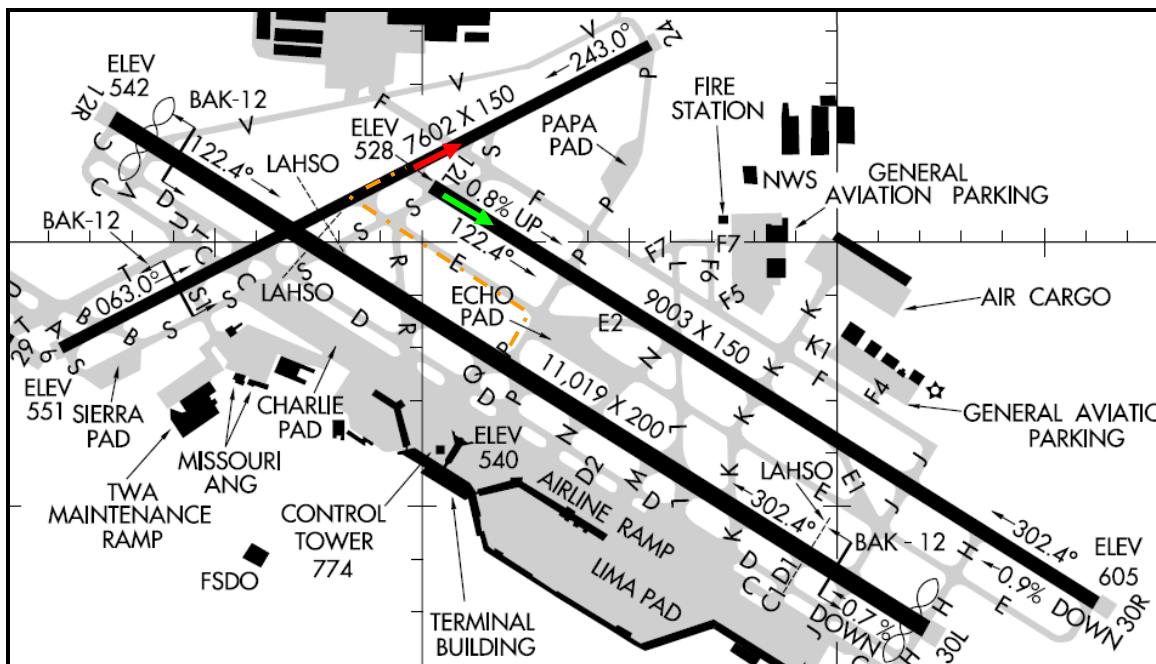
Example 3 — Houston Hobby Airport (HOU)

The NTSB also investigated an incident in 1989 where an American Airlines, Inc., MD–80 was cleared for takeoff on runway 12R, but departed from runway 17 (see figure 9). Making the matter worse was the fact that the south 2,200 feet of runway 17 was closed because of construction as noted by notices to airmen (NOTAMs) and ATIS. As the airplane rotated, it struck sections of wooden barriers that had been placed across runway 17, causing minor damage to the airplane. The flightcrew's failure to follow taxi instructions and to ensure they were on the proper runway before initiation of the takeoff roll was the cause of the incident. Seventy-three days before this incident, the NTSB noted that another air carrier airplane was cleared for takeoff on runway 12R and also inadvertently departed on runway 17.

Figure 9. Houston Hobby Airport
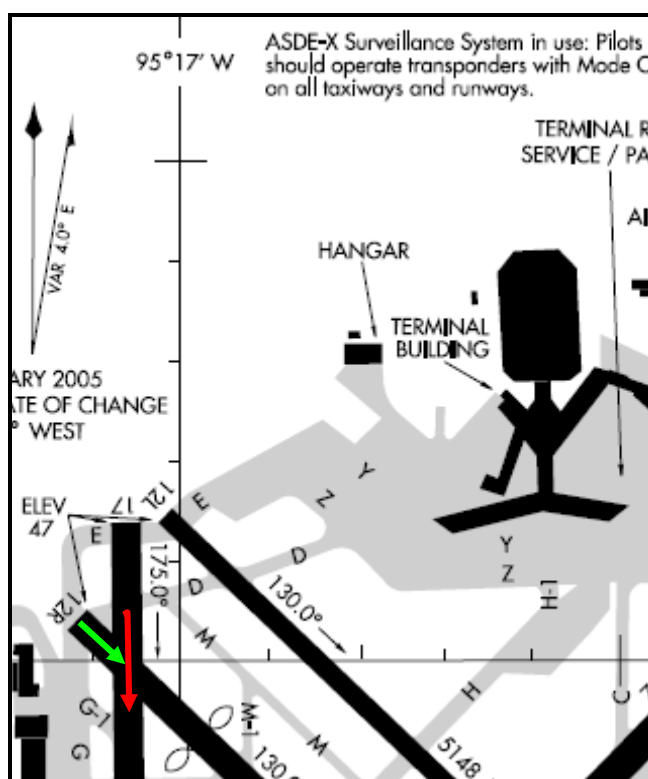
The circumstances described in the previous examples reflect those from the 80 part 121 wrong runway events. Even though each event was unique, common wrong runway contributing factors existed among the reports.

PART 129 AND 135 OPERATORS

The part 129 and part 135 event reports were reviewed in the same fashion as the part 121 reports and are in the process of being scored by the JIMDAT. The majority of circumstances and contributing factors summarizing the part 129 and 135 events were similar to the part 121 events.

An analysis of the part 135 events revealed that flightcrews encountered situations very similar to the part 121 air carriers at airports with a control tower, which produced events with the same contributing factors and mitigations.

However, the events at uncontrolled airports were very different. Without the support of a control tower, the pilots often selected a runway with a tailwind for departure. The flightcrew knew where they were on the airport; however, they selected an inappropriate runway for departure. The tailwind events were made even worse where the runway had an uphill slope, was at a high density altitude, or was a grass runway, or if the event occurred in high temperatures.

The aeronautical information for the uncontrolled airports was a major factor in these events as well. (See NOTAM Process later in this report.) In one instance, critical information could only be found in the Airport/Facility Directory. The regulations require that pilots become familiar with all available information before each flight; however, charter pilots may not always be issued Airport/Facility Directories by their company.

Part 129 air carriers exhibited the same contributing factors found in the part 121 events. Remarkably, four of the seven part 129 events occurred at Ted Stevens Anchorage International Airport (ANC) when the flightcrew was cleared for departure on runway 32 (see figure 10). With this runway assignment, flightcrews taxied to or departed from runways and taxiways other than the one assigned by ATC, as summarized below.

1983 — A Korean Airlines DC–10 was cleared to taxi to runway 32. The flightcrew inadvertently taxied onto runway 6L/24R (now designated as runway 7L/25R) and struck another airplane that was on runway 6L.

2002 — A China Airlines A–340 was cleared for takeoff on runway 32, but departed from taxiway K.

2002 — An airplane lined up on taxiway R for takeoff instead of runway 32.

2005 — An all-cargo MD–11 was issued a takeoff clearance for runway 32 but departed from taxiway Y.

Figure 10. Ted Stevens Anchorage International Airport
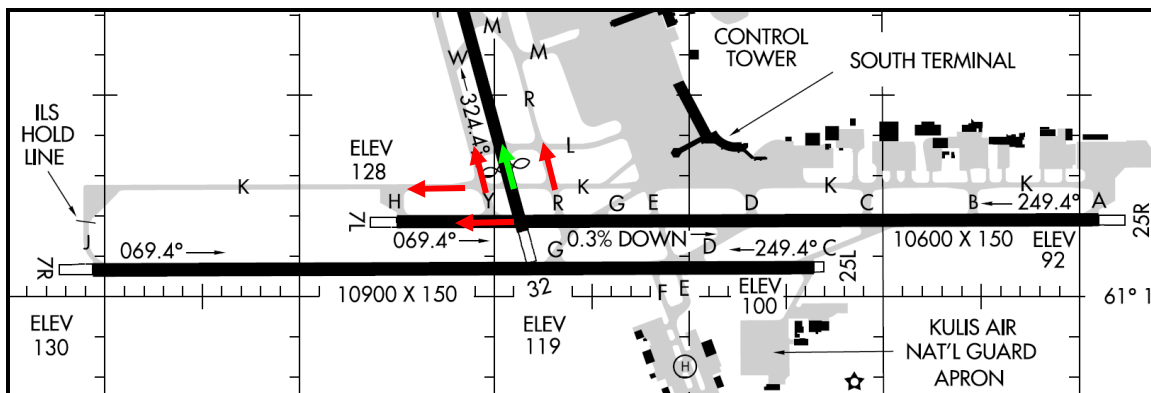
PART 91 OPERATORS

Part 91 events mostly involved pilots departing from a runway with a tailwind and will be reviewed in more detail with the General Aviation Joint Safety Council (GAJSC) in the next phase of the study.

Proposed Safety Enhancements

The following safety enhancements proposed by the SMEs cover technological, procedural, and infrastructure enhancements. These enhancements were then scored by the JIMDAT for their effectiveness as mitigations (see appendix B). Many of the following safety enhancements have already been implemented because of previous safety assessments. The CAST will consider a combination of the effective mitigations already in place and new mitigations based on the enhancements listed below.

Technological Enhancements

Own-Ship Moving Map Display

A class 2 electronic flight bag (EFB) with the own-ship position displayed on a surface electronic map for ground operation provides pilots with an invaluable tool — an immediate orientation of the airplane position on the airport surface. It has been identified as the most effective mitigation to prevent wrong runway and runway incursion events. Other benefits of an Own-Ship Moving Map Display include workload reduction by reducing heads-down time by facilitating faster interpretation of airplane position, which allows attention to remain outside the airplane. Ultimately, an Own-Ship Moving Map Display provides supplemental positional awareness by validating visual cues if flightcrew are confused. The enhanced models are described below:

Own-Ship Moving Map Display with Directed Path .... *80% risk eliminated*
This model includes all benefits of the Own-Ship Moving Map Display plus aural warnings to alert the flightcrew members of upcoming runway and taxiway intersections. The system depicts other aircraft on the display and, most importantly, depicts the taxi route the flightcrew is to take to the runway as selected by ATC.

Own-Ship Moving Map Display with Directed Path plus Aural Advisory System/Runway Awareness and Advisory System .... *80% risk eliminated*
This model includes all benefits of the Own-Ship with Directed Path plus an aural advisory system similar to the Runway Awareness and Advisory System.

Own-Ship Moving Map Display – Own-Ship plus Aural Advisory System/ Runway Awareness and Advisory System .... *58% risk eliminated*
This model includes all benefits of the Own-Ship Moving Map Display plus all of the benefits of an aural advisory system similar to the Runway Awareness and Advisory System.

Own-Ship Moving Map Display plus Warning .... *49% risk eliminated*
This model includes all benefits of the Own-Ship Moving Map Display, depicts other aircraft on the display, and adds aural warnings to alert the flightcrew members of upcoming runway and taxiway intersections.

Own-Ship Moving Map Display plus Other .... *46% risk eliminated*
This model includes all benefits of the Own-Ship Moving Map Display and depicts other aircraft on the display.

Own-Ship Moving Map Display – Own-Ship .... *46% risk eliminated*
This model includes all benefits of the Own-Ship Moving Map Display.

Aural Advisory System/Runway Awareness and Advisory
System .... *56% risk eliminated*
An aural advisory system similar to the Runway Awareness and Advisory System
provides improved situational awareness by providing timely aural advisories to the
flightcrew during taxi, takeoff, final approach, landing, and rollout.

Airport Surface Detection Equipment Model X (ASDE–X)........... *15% risk eliminated*
The ASDE–X system provides air traffic controllers with a visual representation of the
traffic situation on the airport surface movement area and arrival corridors in the form of
aircraft and vehicle position information and flight identifications or call signs. This
increased awareness of the situation on the airport surface movement area is essential in
reducing runway collision threats and critical category A and B runway incursions. The
ASDE–X Safety Logic is an enhancement to the situational awareness provided by the
ASDE–X system to air traffic controllers. ASDE–X Safety Logic uses surveillance
information from ASDE–X to determine if the current and/or projected positions and
movement characteristics of tracked aircraft/vehicles present a potential collision
situation. Visual and audible alerts are provided to the controllers, which include critical
information about the targets involved, such as identification and surface occupied.

In addition to improving safety through runway incursion prevention, the quality of the
ASDE–X data resulting from the fusion of multiple surveillance sources enables decision
support for (1) positive correlation of flight plan information with aircraft position on
controller displays, (2) seamless surveillance coverage of the airport from arrival through
departure, (3) elimination of blind spots and coverage gaps, and (4) highly accurate, high
update surveillance enabling situational awareness (even in inclement conditions) and
conflict detection and resolution.

CAST has established and completed SE–53 in previous safety assessments.

Airport Surface Detection Equipment Model 3/Airport Movement
Area Safety System (ADSE–3/AMASS)... *15% risk eliminated*
The ASDE–3/AMASS upgrade provides for the technical refresh of the ASDE–3 and
AMASS. Selected system components will be replaced or upgraded to extend the service
life of these systems through 2023 (ASDE–X End of Service Life (EOSL)), at which
point all ASDE systems (ASDE–3/AMASS, ASDE–3X, ASDE–X) will be replaced with
a common system. ASDE–3/AMASS is effective because it is currently in use; however,
it is being replaced by ASDE–X.

Procedural Enhancements

Flightcrew Crew Resource Management (CRM) .... *46% risk eliminated*
Flightcrew members must ensure complete pre-taxi/departure briefings are done and include the use of charts and aeronautical information. These briefings should include intended taxi route and any areas or items of concern that may be encountered during the taxi, as well as policies for changes to a briefed plan.

During the taxi, flightcrews should plan to minimize heads-down time, especially while taxiing in congested or confusing areas, and verbally confirm when a flightcrew member is heads-down.

Finally, effective CRM should include a checklist item to ensure the aircraft is aligned with the correct runway, with verification from the airplane's flight instruments.

CAST has established and completed SE–60 in previous safety assessments.

ATC Clearance Procedure Review.. *32% risk eliminated*
ATC should review procedure for clearances that specify all runways to be crossed before reaching the departure runway and restrict early takeoff clearances when flightcrews must cross multiple runways before reaching the departure runway.

In addition, the FAA Taxi Into Position and Hold (TIPH) policy should be reviewed for appropriate limits or prohibition depending on airport characteristics. A policy change will have to take into consideration any impact on capacity.

ATC Crew Resource Management.. *22% risk eliminated*
ATC should adhere to policy and procedures described in "Visually Scanning the Runway" and "Position Determination" from FAA Order 7110.65, Air Traffic Control; use positive control phraseology and clearance read back techniques; and use proper runway crossing phraseology.

These procedures can be trained and tested in ATC simulator scenario-based training.

CAST has established SE–47 in previous safety assessments.

Flightcrew Scenario-based Training... *21% risk eliminated*
Enhancements to simulator training during taxi segments need to be made with special emphasis on wrong runway and runway incursion scenarios that promote identification of threat areas and effective CRM techniques demonstrated by the flightcrew.

ATC Scenario-based Training... *13% risk eliminated*
The training would focus on scenarios that promote awareness of the ground environment using ATC simulators. The training would incorporate operations in complex airports, the dangers of runway illusions from gradient, understanding and managing fatigue and time pressures, Taxi Into Position and Hold (TIPH) and parallel departures with mixed experience operations scenarios.

Aeronautical Information Dissemination... *5% risk eliminated*
The NOTAM distribution method (see NOTAM Process later in this report, and appendix C) highlights the urgent need for a replacement system to help ensure critical safety information reaches the pilot and other system users. The FAA has a major initiative underway to address the collection and dissemination of critical aeronautical information.

Aircraft External Lighting.. *3% risk eliminated*
The use of exterior airplane lights makes airplanes more visible during takeoff and when cleared on a runway. For takeoff, many part 121 air carriers turn on all exterior lights when clearance is received or when commencing takeoff roll at an airport without an operating tower to be as conspicuous as possible.

Infrastructure Enhancements

Taxiway and Runway Configuration... *45% risk eliminated*
Airports that have areas with multiple runway thresholds in close proximity could be redesigned to move the thresholds and eliminate the threat of a wrong runway departure. In addition, future airports may consider designs without these areas.

Runway Safety Action Team (RSAT) Evaluations........................... *30% risk eliminated*
A Runway Safety Action Team is established at either the regional or local level to develop a Runway Safety Action Plan for a specific airport. The Runway Safety Action Team's primary purpose is to address existing runway safety problems and issues. A secondary purpose is to identify and address potential runway safety issues. Currently, the main focus of RSATs is runway incursion areas; however, it could be expanded to include assessing the threat of wrong runway events.

Enhanced Surface Marking and Lighting... *29% risk eliminated*
In areas that have been identified with a higher threat of having a wrong runway event, runway status lights (RSLs), such as those in Cleveland, should be installed, as well as the Final Approach Runway Occupancy Signal (FAROS) system.

JIMDAT Scoring

Calculation of a Safety Enhancement's JIMDAT Score

The JIMDAT spreadsheet tool determines the severity eliminated by each specific proposed safety enhancement by summing the products of effectiveness, incident/accident severity, future risk factor, and implementation for each incident/accident in the accident set. The JIMDAT score is then calculated by dividing the severity eliminated by the total severity of the incident/accident set. The JIMDAT score represents the portion of the risk associated with the incident/accident set that would have been eliminated by the particular enhancement acting on its own. The JIMDAT score is often expressed as a percentage by multiplying by 100. (See appendix B to this report.)

The JIMDAT spreadsheet tool will also develop the Total Risk eliminated for a combination of enhancements against the data set. This is done by using a logic diagram mathematical model similar to that used in fault tree calculations (see figure 11). The effectiveness and implementation of each safety enhancement are inputs to the model.

Figure 11. Logic Diagram Mathematical Model
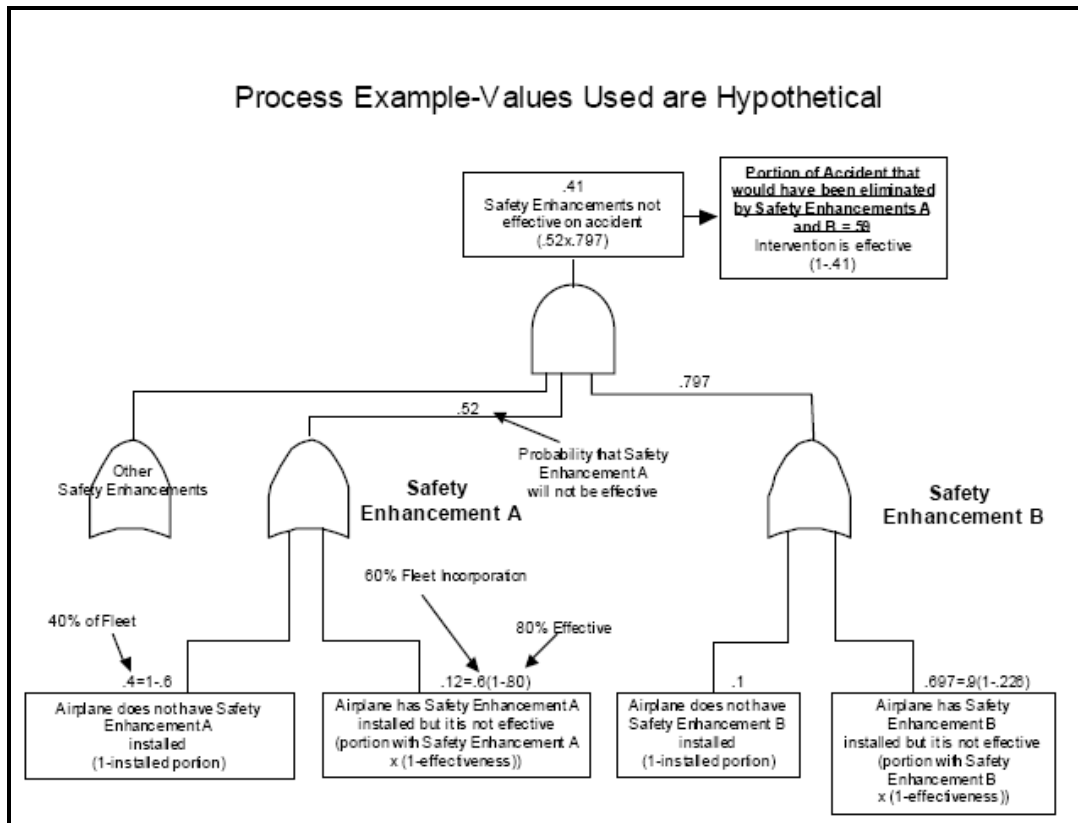
The severity eliminated by a set of safety enhancements is determined by summing the products of the logic diagram mathematical model values, incident/accident severity, and future risk factor across all incident and accidents in the data set. The Total Risk Eliminated is then calculated by dividing the severity eliminated by all safety enhancements working together by the total severity of the incident/accident data set. The Total Risk eliminated for a set of enhancements also represents a portion of the threat eliminated and is often expressed as a percentage by multiplying by 100.

The percentage risk reductions, or JIMDAT scores, for the various enhancements can be compared with one another to determine which of the proposed safety enhancements will create the most benefit across the range of incidents and accidents examined. Different combinations of enhancements can also be assessed to develop the set that produces the greatest threat reduction. The individual enhancement scores and the combined scores can be an important component in the CAST decisionmaking process for selecting enhancements for implementation.

Using the JIMDAT scoring methodology, the enhancements recommended by the SMEs were found to have the potential to eliminate 98 percent of the risk of wrong runway departures (see figure 12).

**Figure 12. JIMDAT Scoring of Risk Eliminated
by Wrong Runway Safety Enhancements**
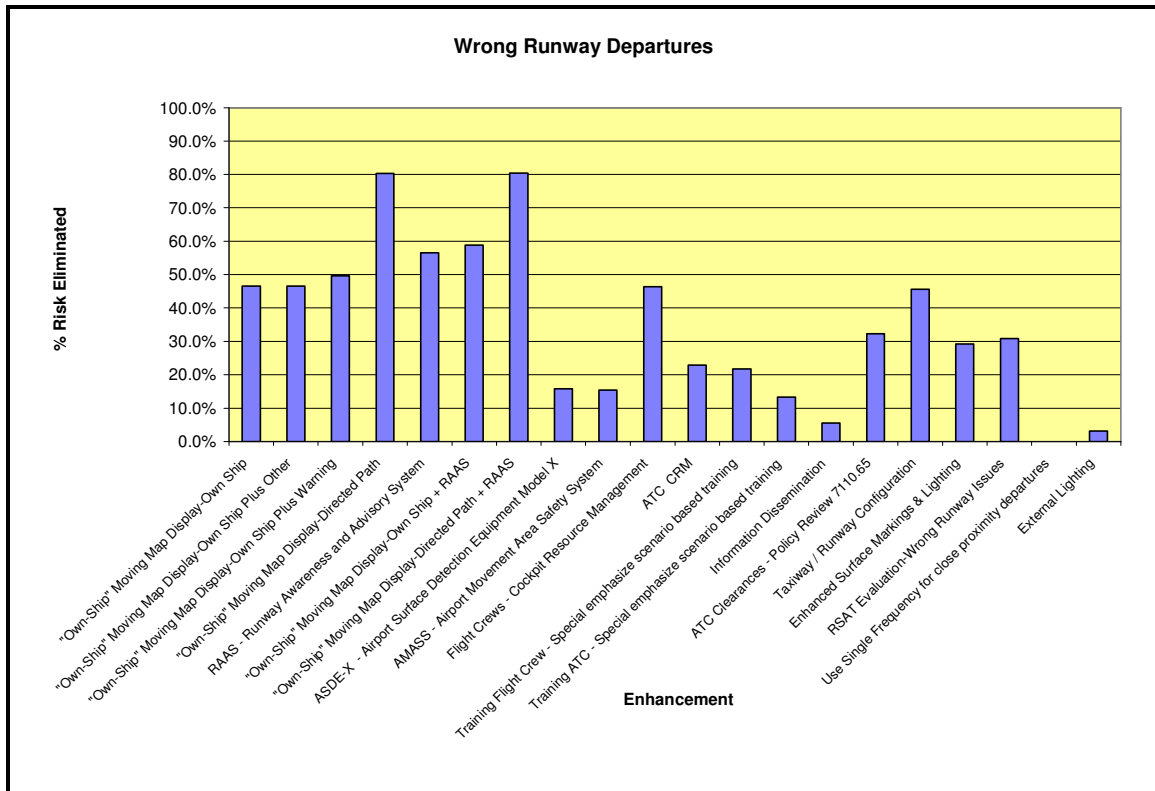
Mitigation Strategy Recommendations

Using the JIMDAT scoring and implementation methodology previously described, the most recommended mitigation strategy is a combination of the most effective mitigations with regard to risk reduction. These mitigations are own-ship moving map display – own-ship and/or an aural advisory system, flightcrew and ATC CRM, flightcrew and ATC special emphasis scenario based training, taxiway and runway configuration and enhanced surface markings, ATC clearance and policy review of FAA Order 7110.65, RSAT evaluations, ASDE–X, information dissemination, and external lighting.

Own-ship moving map display – own-ship and/or an aural advisory system offer very powerful mitigation strategies. The own-ship moving map display – own-ship solution would offer a path for flight decks to migrate toward own-ship moving map – directed path, which would offer a greater than 80-percent risk reduction. At this time, the directed path option is cost-prohibitive. Because the effectiveness of the mitigations strategy is dependent on fleet-wide penetration, the EFB-based own-ship moving map display – own-ship solution would help provide effective mitigations for aircraft with

limited space for additional standalone equipment in the flight deck. This solution also would offer risk reductions for runway incursions and other safety initiatives.

A combination of own-ship moving map display – own-ship and an aural advisory system would offer a combined risk elimination of nearly 60 percent.

Flightcrew member and ATC CRM combined offer a 57-percent risk reduction. The CAST already has completed SE–60, pertaining to flightcrew CRM and has begun work on SE–47 for ATC CRM. Therefore, no new action is proposed for these mitigation strategies; however, the existing work should be updated to incorporate the wrong runway departure information for future flightcrew and ATC CRM training.

The wrong runway special emphasis scenario-based training offers a 21-percent risk reduction. In addition, ATC wrong runway special emphasis scenario-based training has a 13-percent risk reduction. The combined training mitigation would use the lessons learned from this report to ensure both flightcrew members and ATC personnel are aware of the risks and trained appropriately.

The taxiway and runway configuration changes coupled with enhanced surface markings offer significant risk elimination, 45% and 29% respectively. The high cost of these projects will require integration of the mitigation strategies into existing airport improvement projects.

A review of the ATC Clearances and Policy established in FAA Order 7110.65 would offer a 32-percent risk reduction. The mitigation example described in the next section developed by Cleveland Hopkins International Airport offers a powerful example of the benefit of reviewing these procedures to reduce the risk of a wrong runway departure.

RSAT evaluations are already scheduled at 60 percent of the airports that have experienced wrong runway departure issues and offer a 32-percent risk reduction. The focus of these evaluations should be expanded from runway incursions to include wrong runway departures.

The installation of ASDE–X equipment has already been established as a CAST safety enhancement for certain airports as SE–53. This study has found that it will provide a 15-percent risk reduction for wrong runway airports. Twelve of the 38 wrong runway airports have ASDE–X, or are on the implementation schedule. This existing and future work will continue to reduce the risk of wrong runway departures.

The FAA ATO is in the process of redesigning aeronautical information products and the notice to airmen system. This work is expected to reduce the risk of wrong runway departures by 5 percent. The wrong runway working group is working with ATO to establish the best strategy to incorporate wrong runway departure finding into this process.

Finally, a mitigation strategy has been established to explore the feasibility of enhancing airplane external lighting to provide additional conspicuity from behind and is expected to offer a 3-percent wrong runway departure risk reduction.

While each of these safety enhancements are effective in reducing the risk of wrong runway departures, the discussion below offers an example of the effectiveness of multiple strategies to address the issues identified in this study.

Cleveland Hopkins International Airport Mitigation Example

The study of wrong runway airplane departures highlighted the Cleveland Hopkins International Airport. Twenty-four percent of the part 121 events occurred in Cleveland, which exhibited many of the contributing factors found in the incident review. The contributing factors found included a short taxi distance from the terminal to the runway 28 and 24L departure ends, multiple runway departure ends in close proximity to one another, the use of a runway as a taxiway, complex airport layout, one taxiway leading to multiple runways, and areas where multiple runways and/or taxiways converge.

This airport is unique also because the trend in reported events at Cleveland has decreased dramatically. To determine the mitigations implemented at Cleveland to reduce the threat of wrong runway departures, the FAA, working with the Air Line Pilots Association, International (ALPA), interviewed several airport administration personnel, FAA personnel, and pilots with knowledge of the operating environment during the 1990s. The discussions revealed that during the early 1990s, Cleveland airport began to experience an increase in wrong runway departures. As the incident reports began to accumulate, ALPA, Cleveland airport administration, and the FAA began a cooperative effort and used a combination of safety enhancements to improve the airport signage and markings, implement new air traffic and flightcrew procedures, and obtain funding to redesign the airport layout.

The first changes to the Cleveland airport design and construction to occur during the last 20 years were changes to signage resulting from changes to FAA standards following a high profile collision at Detroit Metro Airport between two Northwest Airlines airplanes. The primary change at Cleveland was the addition of runway location signs between 1991 and 1993.

The addition of signage did not, however, address some of the most significant problems encountered at Cleveland: pilots inadvertently departing from incorrect runways or failing to hold short of active runways. In particular, there was a tendency for pilots taxiing to runway 24L to either inadvertently use runway 28 and/or fail to hold short of runway 24L. A number of efforts were made to address this situation.

First, taxiway T was removed. The taxiway used to extend from the terminal area to roughly the intersection of runways 24L/6R and 10/28, between current taxiways W and U. (Taxiway W did not exist at the time.) (See figure 13.) Ground control used taxiway T to stage airplanes for departure on runway 24L. This was problematic because the intersection of the two runways, with the threshold of a third runway (24C) relatively close by, presented an opportunity for pilot deviations and inadvertent use of runway 28 instead of runway 24L. The threat was worsened by the fact that at the time there were no holding position markings for runway 24L on runway 28. Removal of taxiway T also

lengthened the taxi time from the terminal to the runway environment, which lessened time pressures on flightcrews attempting to complete pre-takeoff checklists while taxiing.

Figure 13. Cleveland Hopkins International Airport
(Taxiway T Shown in Orange)
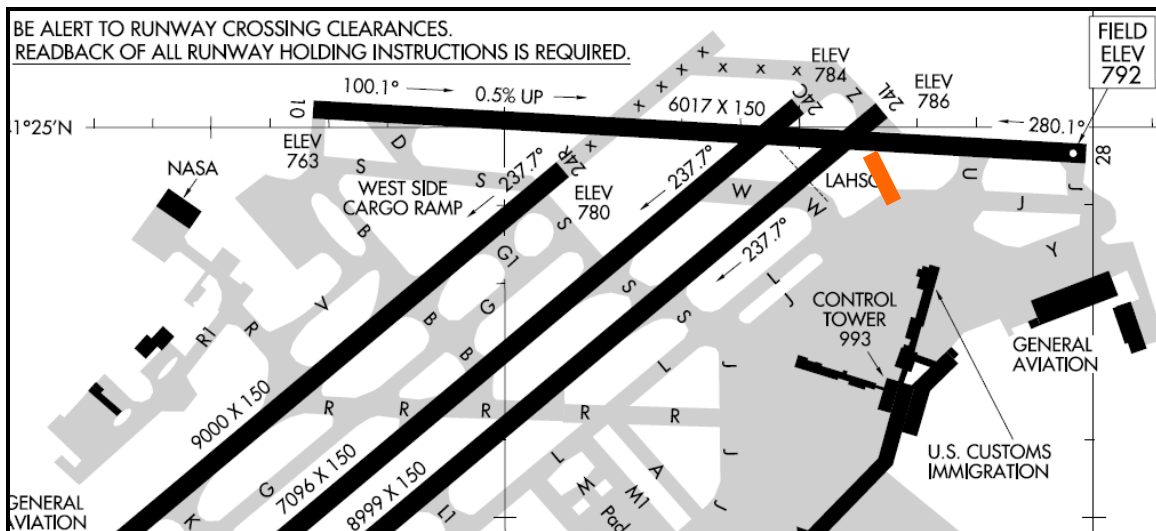
Another change that occurred in the mid-1990s at the Cleveland airport was the implementation of new marking standards. The primary impact of these new standards was the use of surface painted holding position and runway signs on taxiway surfaces. Unfortunately, surface painted runway signs could not be used at Cleveland to address the problems with pilots taxiing to runway 24L, because surface painted signs could not be employed on runway 10/28, which is an active runway.

Finally, because runway 10/28 was frequently used as a taxiway to gain access to runway 24L, the airport obtained waivers from the standards to install some innovative lighting and marking improvements. Runway 28 now has holding position markings and in-pavement and elevated runway guard lighting at the holding position for runway 24L. The runway also has taxiway centerline lights installed. When these lights are activated, they are required to be set to intensity level three, and the runway side lights for runway 28 are deactivated. Since the installation of these devices, incidents involving failure to hold short of runway 24L or inadvertently use the wrong runway when cleared for departure from runway 24L have decreased significantly.

An additional change to the Cleveland airport environment made in the late 1990s was the addition of taxiway W. Taxiway W was added at the urging of the Great Lakes Region Airports Division in the hope that commuter airplanes could be cleared for intersection departures on runway 24L from intersection taxiway W. By taxiing on taxiway W to the intersection, the airplane would be kept from inadvertent use of runway 28. This initiative has had only limited success because of pilots' hesitation to perform intersection departures.

The most recent changes to the airport layout have been in connection with the construction of runway 6L/24R. Runway construction began in 2001 as part of a three-phase Operational Evolution Plan (OEP) intended to provide greater separation between parallel runways to permit simultaneous instrument operations. FAA funding was designated for this project to reduce the threat of a collision or accident. Phase I included initial construction of the northern portion of the new runway. At that time, the northern runway threshold was contiguous with the northern end of the pavement, and the runway intersected existing crosswind runway 10/28. In phase II, runway 6L/24R was extended to the south to its current extent, and the threshold was moved south to its current location. The pavement to the north of the threshold is currently still paved. The runway surface itself no longer intersects runway 10/28, but the pavement that is not yet removed does. The plan is to remove the pavement to mitigate the threat of runway incursions and wrong runway events, but this has not occurred yet because of the lack of funding, despite pressure from the FAA and ALPA. Phase III will involve the extension of runway 6R/24L to the south, with a displacement of its northern threshold, similar to runway 6L/24R's. This will uncouple runway 24L from runway 28 and effectively eliminate the area of greatest threat for departures on the incorrect runway and runway incursions. The use of the center runway, 6C/24C, will eventually be discontinued, and the runway will be converted to a taxiway.

Construction of runway 6L/24R and supporting taxiways was substantial and involved moving a road and a portion of the NASA facility on the west side of the field. During the addition of runway 6L/24R, changes also were made to taxiway K1, which used to be runway 18/36. Taxiway K1 used to extend to the intersection of taxiways A, L, Q, and R. The confluence of the multiple taxiways was extremely confusing, and posed a threat of airplanes turning onto the wrong taxiway, with potential for a runway incursion.

Following the opening of runway 6L/24R, problems arose involving airplanes crossing runways 6R/24L and 6C/24C while taxiing to and from the new runway. The presence of two parallel runways so close to each other presented a possibility for confusion. For example, a flightcrew cleared to cross one runway might accidentally cross both runways. After incursions or near incursions and complaints from ALPA, and at the urging of the Great Lakes Region Airports Division, holding position markings were added on the taxiways between each of the runways. Before this, there were no such markings, possibly because it was believed there was inadequate space to hold between the two runways.

Changes also were made to ATC and flightcrew procedures. ATC conducted tower controller briefings following each airplane departing on the wrong runway. From these briefings, two basic policies were implemented. First, airplanes departing runway 24L or runway 24C are issued a TIPH clearance. Secondly, the ATC tower controller visually verifies the airplane is on the correct runway before issuing a takeoff clearance.

Likewise, the pilot community began to adjust their procedures to reduce the threat of a departure on the wrong runway. A part 121 air carrier added the area around runways 24L and 28 at Cleveland to the Jeppesen 10–7 chart as an area of concern. This chart pointed out the hazards at the airport based on the event reports that had been reviewed. The air carrier also implemented a heading check for departures from runway 24L. Finally, the air carrier eliminated its taxi checklist to maximize the heads-up time during the taxi for both the pilot taxiing and the pilot monitoring the taxi. At this air carrier, after push back from the gate, the engines are started and the after-start checklist is completed. Part of the after-start checklist involves completely configuring the airplane for departure and is completed before the taxi begins.

The cooperative effort and use of a combination of safety enhancements to improve the overall safety proved to be successful in Cleveland and can be a useful method for other airport communities to adopt.

NOTAM PROCESS

Part of the wrong runway study included a review of how notices to airman (NOTAMs) are issued. At the time of the Comair accident, updated taxiway information for Lexington was available via NOTAM.[3] However, the NTSB stated that Comair's system was not set up to receive local NOTAMs and it was instructed to contact the local flight service station (FSS) for local NOTAMs.[4] The NTSB also noted that the ATIS only informed the flightcrew of "construction on the air carrier ramp." Aero-News.net noted that the NOTAM did not explicitly direct the pilots on how to get to the correct runway with part of the taxiway closed. Aero-News.net also noted that the NOTAM was revised after the crash to explicitly direct pilots on how to taxi to runway 22.[5]

There are a number of different NOTAMs, issued depending on the information to be conveyed, as follows:

- NOTAM D — NOTAM Ds are widely disseminated by means of telecommunications and concern the establishment, condition, or change in any aeronautical facility, service, procedure, or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

- NOTAM L — NOTAM Ls are locally disseminated and contain information regarding airport and taxiway construction and certain airport lighting directly related to surface movement guidance, and control or contain information concerning navigation aids, lighting, and runways expected to be in effect for less than 1 hour.

- FDC (Flight Data Center) NOTAM — FDC NOTAMs contain regulatory information such as changes to instrument flight rules charts, procedures, and airspace use.

The need for a NOTAM can be generated by a number of different entities, including airport management or the facility responsible for the lighting, navigation aid, communications, or services in the case of NOTAMs D and L and the FAA, the air route traffic control center, technical operations personnel, and other authorized personnel in the case of FDC NOTAMs. (See figure C–1 in appendix C for further information on types of NOTAMs and who initiates the action.) The office generating the need for a NOTAM will pass that information to the responsible FSS or the U.S. NOTAM office. Generally, NOTAMs D and L are issued by an FSS, and FDC NOTAMs are issued by the U.S. NOTAM office. Figure C–2 in appendix C provides a flowchart detailing what it appears the steps are in the NOTAM process. However, it should be noted that it is not clear whether these are the exact steps; FAA guidance material is more detailed in some areas than others and required some interpretation. The biggest difference between a NOTAM D and a NOTAM L is in the distribution process. NOTAM Ds are distributed

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[3] NOTAM L No. L0808 (airport authority No. A-1682), "T/W Alpha North of R/W 8-26 Closed UFN"; issued August 2, 2006, at 2:05 p.m.
[4] National Transportation Safety Board, Group Chairman's Factual Report, Operation Factors, DCA06MA064, December 17, 2006.
[5] http://aero-news.net, "Was Lexington ATIS, NOTAM too Vague," September 25, 2006.

electronically via the National Airspace Data Interchange Network[6] (NADIN) to the Weather Message Switching Center Replacement[7] (WMSCR) and then to all locations receiving the affected location's tie-in FSS weather. A NOTAM L, on the other hand, is disseminated by the local FSS to all ATC facilities affected, the Air Route Traffic Control Center responsible for forwarding NOTAMs to affected locations, and any local aviation companies, airline operations offices, and other interested users. (See figure C–3 in appendix C for a flowchart depicting the issuance and distribution of NOTAMs D and L. Also provided for reference is figure C–4 in appendix C, which depicts the issuance and distribution of FDC NOTAMs). It appears, therefore, that if an entity is not part of the FSS's NOTAM L distribution, the only way that entity will receive a NOTAM L is to request all local NOTAMs regarding that facility from the FSS.

On January 9, 2007, the FAA issued CertAlert 07–01 on the Need for Better Dissemination of Runway/Taxiway Closure Information and Construction on Airports. Note that this CertAlert was not issued because of the Lexington accident. In this CertAlert, the FAA encouraged the dissemination, to the air carriers and fixed-base operators on an airport, of better and more detailed information on runway/taxiway closures and construction taking place on airports and noted that the NOTAM system may be inadequate. In response to this CertAlert, ALPA stated the following:

> The Certalert is welcome recognition that the current NOTAM system, developed for the teletype era, is inadequate and must evolve with the times. The FAA's Certalert falls short, however, by recommending that only carriers and fixed-base operators receive information about construction and closures on an airport. Of all parties, pilots have the greatest need for timely and accurate information on these issues. The information must be available from anywhere in the system, so that pilots will have the opportunity to incorporate it into predeparture flight planning.[8]

The FAA has a significant effort underway to redesign the Aeronautical Information Management (AIM) process that follows the international Aeronautical Information Exchange Model (AIXM) of adoption and implementation.

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[6] A data communication system server used for data interchange within the United States, and between the United States and other nations to communicate flight plans for commercial and general aviation, weather, and advisory notices to pilots.

[7] A network that serves as the FAA gateway for the receipt and distribution of weather data and NOTAMs within the National Airspace System.

[8] www.alpa.org, "Pilots Need Aircraft Position Information in the Cockpit," January 17, 2007, Capt. Terry McVenes, Executive Air Safety Chairman, Air Line Pilots Association, International.

PART 139 AIRPORT CONTRIBUTING FACTORS STUDY

SCOPE OF THE STUDY

Airports certified by the FAA to accommodate large scheduled and nonscheduled air carrier airplanes as well as scheduled small air carrier airplanes are classified as part 139 class I airports. It was imperative not only to study airports where wrong runway departure events occurred, but to review all airports to proactively identify and mitigate the physical characteristics of wrong runway event threat areas. Based on these physical factors, a matrix was created to record each element present at all 355 class I airports (see appendix D). The airport received an "*" for each wrong runway event threat item described below.

The data was loaded into the ASIAS Event Monitoring System – Airports (EMS–Airports). The system enables users to visually compare the event trend around a selected airport with the average trend for all airports of the same class.

> **Note: It is important to note that risk reduction strategies that may be underway at individual airports were not considered in the scoring. For example, the Cleveland airport received an "*" for the area with multiple runway thresholds in close proximity even though there is a plan to decouple the runways, as discussed in the Cleveland Hopkins International Airport mitigation example.**

WRONG RUNWAY EVENT THREATS

Short Taxi Distance

A short distance between the terminal and the runway requires pilots to complete the same number of checklist items in a shorter timeframe and can lead to flightcrew rushing to complete their checklists or expedite their departure.

Airport Complexity

The complexity of an airport layout includes factors such as a high traffic volume, requiring an airplane to cross multiple runways to reach the departure runway, and complicated taxi instructions that involve the use of several taxiways.

One Taxiway Leading to Multiple Runway Thresholds

These areas present an opportunity for flightcrews to taxi the airplane onto the wrong runway. This is especially true when the airplane has to cross one or more runways on the same taxiway.

Close Proximity of Multiple Runway Thresholds

Many wrong runway events took place in areas with multiple runway thresholds in close proximity. In some cases, multiple runway ends are in the same location.

More Than Two Taxiways Intersecting in One Area

These areas often confuse pilots and present the opportunity to turn in an incorrect direction.

Short Runway (Less Than 5,000 feet)

Wrong runway departures typically result in the airplane taking off without conflict because there is sufficient runway available. Part 139 class I airports with runways less then 5,000 feet located in close proximity to longer runways were identified to point out potential situations where the runway is too short for a large air carrier jet to safely takeoff.

Joint Use Runway/Taxiway

In the wrong runway events, identified pilots had a tendency to depart on the runway that they were taxiing on instead of turning onto the correct runway when a takeoff clearance was issued.

Single Runway

Airports with a single runway layout present the opportunity for an airplane to taking off in the wrong direction, especially when intersection departures are made.

A preliminary review of the 355 part 139 class I airports shows that even though wrong runway events have not occurred at each location, many of the airports have similar physical characteristics that were found to be contributing factors (see figure 14).

Figure 14. Percentage of Part 139 Airports With Associated Wrong Runway Threat Areas
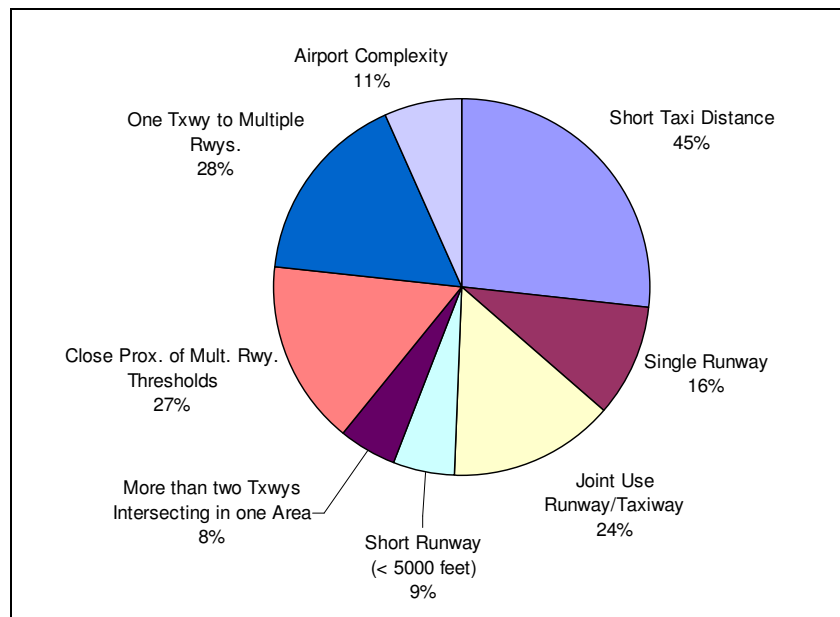
CONCLUSIONS AND RECOMMENDATIONS

Wrong runway departure events continue to occur even after the Lexington accident. Only 60 days after the Lexington accident, an air carrier flightcrew departed from the wrong runway at Seattle Tacoma International Airport. To effectively prevent more of these events, the recommended strategy is implementation of a combination of the most effective JIMDAT mitigations with regard to risk reduction. These mitigations are own-ship moving map display – own-ship and/or an aural advisory system, flightcrew and ATC CRM, flightcrew and ATC special emphasis scenario based training, taxiway and runway configuration and enhanced surface markings, ATC clearance and policy, RSAT evaluations, ASDE–X, information dissemination, and external lighting.

Own-ship moving map display – own-ship and/or an aural advisory system combine to form a very powerful mitigation strategy. A combination of own-ship moving map display – own-ship and an aural advisory system would produce a combined risk elimination of nearly 60 percent while offering a path for flight decks to migrate toward own-ship moving map – directed path, which has a risk reduction greater than 80-percent. This solution also would offer risk reductions for runway incursions and other safety initiatives.

Flightcrew member and ATC CRM combined offer a 57-percent risk reduction. The CAST already has established initiatives for these mitigations; therefore, the existing work should be updated to incorporate the wrong runway departure information for future flightcrew and ATC CRM training.

RSAT evaluations are already scheduled at 60 percent of the airports that have experienced wrong runway departure issues. At a cost of $1,500 and offering a 32-percent risk reduction, the focus of these evaluations should be expanded from runway incursions to include wrong runway departures.

A review of the ATC clearances and policies offer a 32-percent risk reduction. The mitigation used by Cleveland Hopkins International Airport offers a powerful example of the benefit of reviewing these procedures to reduce the risk of a wrong runway departure.

The wrong runway special emphasis scenario-based training for flightcrew offers a 21-percent risk reduction. In addition, ATC wrong runway special emphasis scenario-based training would produce a 13-percent risk reduction. The combined effort would use the lessons learned from this report to ensure both flightcrew members and ATC personnel are aware of the risks and trained appropriately.

The installation of ASDE–X equipment has already been established as a CAST safety enhancement for certain airports. This study has found that it will provide a 15-percent risk reduction for wrong runway airports. Twelve of the 38 wrong runway airports have ASDE–X, or are on the implementation schedule. This existing and future work will continue to reduce the risk of wrong runway departures.

The taxiway and runway configuration changes coupled with enhanced surface markings offer significant risk elimination. The high cost of these projects will require integration of the mitigation strategies into existing airport improvement projects.

The FAA ATO has taken action to encourage the better dissemination of airport construction information with the AIM process that follows the international AIXM of adoption and implementation. This work is expected to reduce the risk of wrong runway departures by 5 percent.

The feasibility of enhancing airplane external lighting to provide additional conspicuity from behind should be explored and is expected to offer a 3-percent wrong runway departure risk reduction.

Finally, the review of the NOTAM process highlighted that the FAA guidance and documentation that describes the NOTAM process is inconsistent and unclear. In addition, NOTAMs L are only disseminated as determined by the local FSS issuing them and have to be specifically requested to be received. While the FAA has taken action to encourage the better dissemination of airport construction information, the AIM process that follows the international AIXM of adoption and implementation will have an additional positive impact in reducing these events.

APPENDIX A — SUBJECT MATTER EXPERT PANEL

Executive Steering Committee

Anthony Ferrante	FAA, AVS Air Traffic Safety Oversight
Jay Pardee	FAA, AVS Safety Analysis Unit
Paul Russell	Boeing Commercial Airplane Group, Airplane Safety

Working Group Co-Chair

Vivek Sood	FAA, Aviation Safety Information Analysis and Sharing
Corey Stephens	Air Line Pilots Association, Engineering and Accident Investigation

Subject Matter Expert Panel

Darryel Adams	FAA, AAS Airport Safety and Operations
AJ Bayuk	Air Line Pilots Association, Air Safety Volunteer
David Bennett	FAA, ARP Office Airport Safety and Standards
Chad Brewer	FAA, AOV Safety Management Division
Steve Bush	Regional Airline Association
Rick Clarke	FAA, AFS Air Carrier Operations
Nathan Enders	FAA, AOV Air Traffic Oversight Service
Jim Fee	Phaneuf Associates Incorporated, Aviation Safety Analyst
Paul Friedman	FAA, AAS Airport Engineering Division
Jeff Gorney	FAA, AAI Recommendation Branch
Pierre Huggins	Air Line Pilots Association, Engineering and Air Safety
George Legarreta	FAA, AAS Airport Engineering Division
Joe Mantello	FAA, AOV Air Traffic Operations Oversight Division
Robert Noges	Boeing Commercial Airplane Group, Aviation Safety
Dave Patterson	Data Union, Aviation Safety Information Analysis and Sharing
Greg Peoples	FAA, ATO Terminal Services
Bill Phaneuf	Air Line Pilots Association, Engineering and Air Safety
Henry Reed	Boeing Commercial Airplane Group, Safety Analyst
Mitchell Serber	Air Line Pilots Association, Air Safety Volunteer
Don Slaughter	Data Union, Aviation Safety Information Analysis and Sharing
Jared Smith	Regional Airline Association
Frank Stadmeyer	FAA, Aircraft Certification Service
John Timmerman	FAA, ATO System Operations
Larry Wippman	Phaneuf Associates Incorporated, Aviation Safety Information Analysis and Sharing

Matt Wise	Regional Airline Association
Jerry Wright	Air Line Pilots Association, Engineering and Air Safety
James White	FAA, ARP Office Airport Safety and Standards

APPENDIX B — JIMDAT MITIGATION SCORING TABLE

Source	Locator	Airport	Own-Ship Moving Map Display-Own Ship	Own-Ship Moving Map Display-Own Ship Plus Other	Own-Ship Moving Map Display-Own Ship Plus Warning	Own-Ship Moving Map Display-Directed Path	RAAS - Runway Awareness and Advisory System	Own-Ship Moving Map Display-Own Ship + RAAS	Own-Ship Moving Map Display-Directed Path + RAAS	ASDE-X - Airport Surface Detection Equipment Model X	AMASS - Airport Movement Area Safety System	Flight Crews - Cockpit Resource Management	ATC CRM	Training Flight Crew - Special emphasize scenario based training	Training ATC - Special emphasize scenario based training	Information Dissemination	ATC Clearances - Policy Review of FAA Order 7110.65	Taxiway / Runway Configuration	Enhanced Surface Markings & Lighting	RSAT Evaluation-Wrong Runway Issues	Use Single Frequency for close proximity departures	External Lighting
			Safety Enhancement Effectiveness (%/100)																			
NTSB	20001206X02586	STL	.000	.000	.850	.850	.000	.000	.850	.850	.850	.000	.000	.000	.000	.350	.300	.850	.850	.200	.000	.750
NTSB	20001213X27893	HOU	.800	.800	.800	.850	.850	.850	.850	.100	.100	.500	.500	.100	.250	.100	.650	.850	.700	.800	.000	.000
PDS	PSWTHOU98001	HOU	.750	.750	.750	.850	.850	.850	.850	.100	.100	.450	.000	.250	.000	.000	.100	.850	.700	.850	.000	.000
PDS	P89HOU71	HOU	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
PDS	PSWTDFW93001	DFW	.800	.800	.800	.850	.850	.850	.850	.100	.100	.650	.300	.250	.000	.000	.200	.100	.750	.000	.000	.000
PDS	PEATBGM05001	BGM	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.850	.000	.000	.000	.000	.000	.000
PDS	PSOTMEM06003	MEM	.800	.800	.800	.850	.850	.850	.850	.100	.100	.650	.000	.200	.000	.000	.000	.000	.350	.000	.000	.000
PDS	PNMTEUG93003	EUG	.000	.000	.000	.000	.000	.000	.000	.000	.000	.250	.250	.100	.100	.850	.650	.000	.850	.000	.000	.000
PDS	PNMTSLC97006	SLC	.800	.800	.800	.850	.850	.850	.850	.200	.200	.650	.250	.350	.100	.000	.200	.000	.200	.000	.000	.000
PDS	PWPTPHX03009	PHX	.650	.650	.650	.850	.850	.850	.850	.100	.100	.650	.250	.350	.100	.000	.000	.850	.350	.750	.000	.000
PDS	PGLTCLE96011	CLE	.650	.650	.650	.850	.500	.650	.850	.000	.000	.300	.300	.100	.100	.000	.000	.850	.350	.850	.000	.000
PDS	PNMTSLC93003	SLC	.650	.650	.650	.850	.850	.850	.850	.000	.000	.350	.000	.100	.000	.000	.000	.850	.550	.850	.000	.000
PDS	PNETBDL00003	BDL	.750	.750	.750	.850	.850	.850	.850	.200	.200	.650	.500	.200	.200	.000	.750	.850	.500	.850	.000	.000
PDS	PNMTSLC94007	SLC	.650	.650	.650	.850	.850	.850	.850	.100	.100	.650	.100	.250	.000	.000	.000	.850	.650	.850	.000	.000
PDS	PCETSTL03005	STL	.700	.700	.700	.850	.850	.850	.850	.200	.200	.650	.100	.250	.000	.000	.750	.600	.550	.000	.000	.000
PDS	PWPTLAS99002	LAS	.650	.650	.650	.850	.850	.850	.850	.100	.100	.250	.100	.100	.100	.000	.000	.450	.450	.450	.000	.000
PDS	PGLTCLE03012	CLE	.700	.700	.700	.850	.850	.850	.850	.200	.200	.650	.100	.300	.100	.000	.500	.350	.350	.000	.000	.000

Source	Locator	Airport	Own-Ship Moving Map Display-Own Ship	Own-Ship Moving Map Display-Own Ship Plus Other	Own-Ship Moving Map Display-Own Ship Plus Warning	Own-Ship Moving Map Display-Directed Path	RAAS - Runway Awareness and Advisory System	Own-Ship Moving Map Display-Own Ship + RAAS	Own-Ship Moving Map Display-Directed Path + RAAS	ASDE-X - Airport Surface Detection Equipment Model X	AMASS - Airport Movement Area Safety System	Flight Crews - Cockpit Resource Management	ATC CRM	Training Flight Crew - Special emphasize scenario based training	Training ATC - Special emphasize scenario based training	Information Dissemination	ATC Clearances - Policy Review of FAA Order 7110.65	Taxiway / Runway Configuration	Enhanced Surface Markings & Lighting	RSAT Evaluation-Wrong Runway Issues	Use Single Frequency for close proximity departures	External Lighting
			Safety Enhancement Effectiveness (%/100)																			
PDS	PGLTCLE95015	CLE	.800	.800	.800	.850	.850	.850	.850	.200	.200	.250	.250	.250	.350	.350	.300	.850	.850	.850	.000	.000
PDS	P90MKE135	MKE	.800	.800	.800	.850	.850	.850	.850	.200	.200	.650	.200	.250	.200	.000	.000	.000	.500	.000	.000	.000
PDS	PNMTSLC92009	SLC	.800	.800	.800	.850	.850	.850	.850	.100	.100	.200	.000	.100	.000	.000	.000	.850	.500	.850	.000	.000
PDS	PSWRELP98007	ELP	.800	.800	.800	.850	.850	.850	.850	.200	.200	.200	.100	.200	.000	.000	.300	.650	.300	.750	.000	.000
PDS	PSOTRDU99009	RDU	.150	.150	.150	.850	.100	.150	.850	.750	.750	.650	.750	.250	.400	.000	.300	.000	.100	.000	.000	.000
PDS	PGLTCLE01021	CLE	.800	.800	.800	.850	.850	.850	.850	.200	.200	.650	.000	.450	.000	.000	.750	.850	.200	.850	.000	.000
PDS	PSOTJAX98003	JAX	.000	.000	.000	.850	.000	.000	.850	.100	.100	.200	.000	.000	.000	.000	.100	.000	.000	.000	.000	.000
ASRS	101787	HOU	.800	.800	.800	.850	.850	.850	.850	.750	.750	.650	.200	.100	.250	.200	.750	.850	.500	.500	.000	.000
ASRS	256844	CLE	.200	.200	.500	.850	.250	.250	.850	.200	.200	.650	.150	.450	.100	.000	.100	.250	.000	.400	.000	.000
ASRS	265310	CLE	.150	.150	.150	.850	.250	.250	.850	.150	.150	.850	.650	.300	.100	.000	.000	.250	.000	.400	.000	.000
ASRS	279307	RIC	.150	.150	.150	.850	.750	.750	.850	.100	.100	.700	.300	.300	.100	.000	.250	.700	.000	.200	.000	.000
ASRS	382130	CLE	.150	.150	.150	.850	.000	.150	.850	.100	.100	.500	.450	.300	.100	.000	.000	.000	.000	.000	.000	.000
ASRS	393273	ONT	.800	.850	.900	.900	.850	.850	.900	.850	.750	.750	.150	.450	.100	.200	.750	.800	.800	.400	.000	.300
ASRS	198846	CLE	.650	.650	.650	.850	.850	.850	.850	.200	.200	.650	.100	.450	.100	.000	.200	.850	.450	.850	.000	.000
ASRS	415992	HOU	.700	.700	.700	.850	.850	.850	.850	.100	.100	.600	.500	.350	.250	.000	.750	.850	.700	.850	.000	.000
ASRS	531029	CLE	.700	.700	.700	.850	.850	.850	.850	.300	.300	.450	.750	.450	.100	.000	.750	.850	.800	.400	.000	.000
ASRS	96386	CLE	.800	.800	.800	.850	.700	.850	.850	.100	.100	.350	.500	.350	.400	.100	.750	.750	.000	.450	.000	.100
ASRS	229084	HOU	.350	.350	.350	.850	.350	.350	.850	.000	.000	.500	.000	.350	.000	.000	.350	.850	.100	.450	.000	.000
ASRS	267749	MIA	.000	.000	.350	.850	.000	.000	.850	.100	.100	.350	.000	.000	.250	.000	.300	.000	.000	.000	.000	.000

Source	Locator	Airport	Own-Ship Moving Map Display-Own Ship	Own-Ship Moving Map Display-Own Ship Plus Other	Own-Ship Moving Map Display-Own Ship Plus Warning	Own-Ship Moving Map Display-Directed Path	RAAS - Runway Awareness and Advisory System	Own-Ship Moving Map Display-Own Ship + RAAS	Own-Ship Moving Map Display-Directed Path + RAAS	ASDE-X - Airport Surface Detection Equipment Model X	AMASS - Airport Movement Area Safety System	Flight Crews - Cockpit Resource Management	ATC CRM	Training Flight Crew - Special emphasize scenario based training	Training ATC - Special emphasize scenario based training	Information Dissemination	ATC Clearances - Policy Review of FAA Order 7110.65	Taxiway / Runway Configuration	Enhanced Surface Markings & Lighting	RSAT Evaluation-Wrong Runway Issues	Use Single Frequency for close proximity departures	External Lighting
			Safety Enhancement Effectiveness (%/100)																			
ASRS	282894	ORD	.500	.500	.500	.850	.600	.600	.850	.000	.000	.650	.000	.250	.000	.000	.000	.350	.250	.000	.000	.000
ASRS	324130	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.350	.500	.350	.400	.100	.000	.750	.000	.450	.000	.100
ASRS	327113	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.350	.500	.350	.400	.100	.750	.750	.000	.450	.000	.100
ASRS	409227	RNO	.800	.800	.800	.850	.650	.800	.850	.100	.100	.300	.000	.100	.000	.000	.500	.500	.300	.200	.000	.000
ASRS	539578	MCI	.650	.650	.650	.850	.850	.850	.850	.200	.200	.650	.500	.350	.200	.000	.000	.000	.250	.000	.000	.000
ASRS	168242	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.400	.100	.350	.000	.100	.750	.750	.000	.450	.000	.100
ASRS	196075	MIA	.000	.000	.000	.850	.100	.100	.850	.350	.350	.500	.250	.350	.000	.000	.750	.250	.000	.000	.000	.000
ASRS	201560	MIA	.000	.000	.000	.850	.100	.100	.850	.350	.350	.500	.250	.350	.000	.000	.750	.250	.000	.000	.000	.000
ASRS	360360	BOI	.800	.800	.800	.850	.750	.800	.850	.100	.100	.650	.200	.100	.000	.000	.350	.000	.300	.000	.000	.000
ASRS	407080	IND	.800	.800	.800	.850	.850	.850	.850	.200	.200	.650	.500	.100	.200	.000	.000	.000	.450	.000	.000	.000
ASRS	438760	RFD	.750	.750	.750	.850	.850	.850	.850	.100	.000	.650	.450	.100	.200	.000	.000	.000	.000	.000	.000	.000
ASRS	579516	ONT	.000	.000	.000	.550	.000	.000	.550	.000	.000	.300	.000	.000	.000	.550	.350	.200	.850	.000	.000	.000
ASRS	142069	DFW	.000	.000	.000	.000	.000	.000	.000	.850	.750	.300	.500	.100	.400	.000	.650	.000	.500	.000	.000	.500
ASRS	155035	PSC	.750	.750	.750	.850	.850	.850	.850	.100	.100	.650	.500	.250	.400	.000	.000	.750	.500	.450	.000	.000
ASRS	195280	PIE	.800	.800	.800	.850	.850	.850	.850	.100	.100	.650	.500	.100	.400	.000	.750	.500	.500	.500	.000	.000
ASRS	290221	ROC	.500	.500	.500	.850	.850	.850	.850	.200	.200	.650	.450	.150	.200	.000	.000	.000	.000	.000	.000	.000
ASRS	353698	CWA	.000	.000	.000	.850	.000	.000	.850	.100	.100	.650	.450	.300	.300	.000	.750	.500	.000	.500	.000	.000
ASRS	128051	ITO	.250	.250	.250	.850	.850	.850	.850	.000	.000	.350	.100	.200	.100	.000	.100	.000	.000	.000	.000	.000
ASRS	252682	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.350	.500	.350	.400	.100	.750	.750	.000	.450	.000	.100

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			Safety Enhancement Effectiveness (%/100)																			
ASRS	256788	LEX	.800	.800	.800	.850	.850	.850	.850	.100	.100	.650	.250	.350	.100	.000	.550	.850	.650	.500	.000	.000
ASRS	320220	HOU	.350	.350	.350	.850	.350	.350	.850	.000	.000	.450	.000	.350	.000	.000	.350	.850	.000	.450	.000	.000
ASRS	324652	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.350	.500	.350	.400	.100	.000	.750	.000	.450	.000	.100
ASRS	420824	HOU	.800	.800	.800	.850	.500	.800	.850	.000	.000	.650	.500	.350	.400	.000	.350	.650	.500	.250	.000	.000
ASRS	83934	HOU	.500	.500	.500	.750	.850	.850	.850	.400	.400	.650	.200	.150	.150	.000	.750	.850	.250	.500	.000	.000
ASRS	180490	ISP	.250	.250	.500	.850	.850	.850	.850	.200	.200	.500	.200	.250	.100	.000	.000	.850	.850	.500	.000	.100
ASRS	187280	CMX	.250	.250	.250	.850	.250	.250	.850	.000	.000	.650	.000	.150	.000	.000	.100	.000	.000	.000	.000	.000
ASRS	260492	MEM	.100	.100	.100	.850	.750	.750	.850	.350	.350	.350	.500	.150	.200	.000	.750	.000	.500	.000	.000	.000
ASRS	263236	MIA	.800	.800	.800	.850	.850	.850	.850	.000	.000	.500	.250	.150	.000	.150	.850	.850	.450	.000	.000	.000
ASRS	329560	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.350	.500	.350	.400	.100	.750	.750	.000	.450	.000	.100
ASRS	395904	SDF	.250	.250	.500	.850	.850	.850	.850	.000	.000	.100	.100	.100	.000	.000	.100	.850	.200	.450	.000	.000
ASRS	194746	ORD	.500	.500	.500	.850	.600	.600	.850	.000	.000	.650	.300	.250	.250	.000	.000	.350	.250	.000	.000	.000
ASRS	213976	EFD	.200	.200	.200	.850	.500	.500	.850	.100	.100	.450	.000	.100	.000	.000	.000	.100	.250	.250	.000	.000
ASRS	226136	SLC	.200	.200	.200	.850	.850	.850	.850	.100	.100	.450	.000	.250	.000	.000	.250	.350	.350	.450	.000	.000
ASRS	245145	CLE	.200	.200	.550	.850	.000	.200	.850	.100	.100	.200	.250	.100	.250	.000	.500	.100	.000	.250	.000	.000
ASRS	322966	CLE	.800	.800	.800	.850	.700	.800	.850	.100	.100	.450	.500	.350	.400	.100	.750	.750	.000	.450	.000	.100
ASRS	344740	PDX	.000	.000	.000	.850	.350	.350	.850	.200	.200	.200	.000	.000	.000	.200	.000	.300	.300	.200	.000	.000
ASRS	438749	RFD	.700	.700	.700	.850	.750	.750	.850	.200	.200	.350	.250	.200	.200	.000	.750	.000	.000	.000	.000	.000
ASRS	463977	MIA	.000	.000	.000	.850	.000	.000	.850	.150	.150	.250	.250	.000	.100	.000	.400	.250	.000	.000	.000	.000

Source	Locator	Airport	Own-Ship Moving Map Display-Own Ship	Own-Ship Moving Map Display-Own Ship Plus Other	Own-Ship Moving Map Display-Own Ship Plus Warning	Own-Ship Moving Map Display-Directed Path	RAAS - Runway Awareness and Advisory System	Own-Ship Moving Map Display-Own Ship + RAAS	Own-Ship Moving Map Display-Directed Path + RAAS	ASDE-X - Airport Surface Detection Equipment Model X	AMASS - Airport Movement Area Safety System	Flight Crews - Cockpit Resource Management	ATC CRM	Training Flight Crew - Special emphasize scenario based training	Training ATC - Special emphasize scenario based training	Information Dissemination	ATC Clearances - Policy Review of FAA Order 7110.65	Taxiway / Runway Configuration	Enhanced Surface Markings & Lighting	RSAT Evaluation-Wrong Runway Issues	Use Single Frequency for close proximity departures	External Lighting
			Safety Enhancement Effectiveness (%/100)																			
ASRS	159401	SYR	.000	.000	.000	.850	.000	.000	.850	.200	.200	.350	.000	.100	.100	.000	.500	.000	.000	.000	.000	.000
ASRS	179343	SLC	.100	.100	.100	.850	.700	.700	.850	.000	.000	.350	.000	.250	.000	.000	.350	.250	.250	.250	.000	.000
ASRS	221120	FNT	.100	.100	.100	.850	.100	.100	.850	.000	.000	.450	.000	.100	.000	.000	.350	.350	.000	.250	.000	.000
ASRS	331026	CMH	.000	.000	.000	.850	.100	.100	.850	.000	.000	.250	.000	.100	.000	.000	.000	.850	.000	.250	.000	.000
ASRS	331566	CLE	.000	.000	.000	.850	.250	.250	.850	.000	.000	.650	.000	.250	.000	.000	.150	.500	.000	.000	.000	.000
ASRS	636995	LAS	.000	.000	.000	.850	.250	.250	.850	.000	.000	.200	.000	.100	.000	.000	.000	.300	.300	.200	.000	.000

APPENDIX C — NOTAM PROCESS

NOTAM Acronym List and Explanation of Certain Terms

AIM   Aeronautical Information Manual

ARTCC   Air Route Traffic Control Center

DOD   Department of Defense

DP   departure procedures

FDC NOTAM Flight Data Center NOTAM
(Information that is regulatory in nature including (a) interim instrument flight rules flight procedures (airway structure changes, instrument approach procedure changes excluding departure procedures and standard terminal arrivals, airspace changes in general, special instrument approach procedure changes); and (b) temporary flight restrictions (disaster areas, special events generating a high degree of interest, hijacking).)

FPO   Flight Procedures Office

FSS   Flight Service Station
(An air traffic facility that provides pilot briefings regarding current weather and possible hazards along a route of flight; gives en route communication services and visual flight rules search and rescue assistance; relays air traffic control clearances; creates NOTAMs; receives instrument flight rules flight plans; and monitors navigation aids.)

HOO   hours of operation

IFR   instrument flight rules

NADIN   National Airspace Data Interchange Network
(Data communication system server used for data interchange within the United States, and between the United States and other nations to communicate flight plans for commercial and general aviation, weather, and advisory notices to pilots.)

NAS   National Airspace System

NATP   Notices to Airman Publication

NAVAID   navigation aid

NFDC   National Flight Data Center

NOTAM D   Wide dissemination NOTAM
(Information distributed by means of telecommunications concerning the establishment, condition, or change in any aeronautical facility, service, procedure, or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.)

NOTAM L   Local dissemination NOTAM
(Information that requires local dissemination.)

NOTAM   Notice to Airman

ODP   obstacle departure procedure

SID   standard instrument departure

PJE   parachute jumping/sky diving

SIAP   standard instrument approach procedures

SMO   System Management Office

STAR   standard terminal arrivals

USNOF   U.S. NOTAM Office

USNS   U.S. NOTAM System

VFR   visual flight rules

WMSCR   Weather Message Switching Center Replacement
(Network that serves as the Federal Aviation Administration gateway for the receipt and distribution of weather data and NOTAMs within the National Airspace System.)

Figure C–1. NOTAMs by Type and Who Initiates the NOTAM for What Type of Action

FDC NOTAMs

FAA Flight Operations and Inspection Personnel	ARTCC	U.S. Secret Service	Technical Operations SMO Personnel	Who?	Authorized Personnel at Affected Location	Service Area Office Where Laser Activity Occurs
Interim IFR Flight Procedures Revisions Unable to be Published before Effective Date	Temporary Flight Restrictions	Flight Restrictions in Proximity of the President and others	Snow Conditions Affecting Glide Slope Operation	Air Defense Emergency	Special Data	Laser Light Activity

Military NOTAMs

Military Personnel

Certain Army	Alaska	All Others

International NOTAMs

NOTAMs issued by Canada	NOTAMs issued by individual countries	NOTAMs issued by the U.S. (OMEGA, LORAN, GPS systems, and certain special use airspace for ARTCCs that control oceanic airspace)

Other

Who?

Miscellaneous NOTAMs (those not covered by Order 7930.2)

Special Data NOTAMs

Technical Operations Personnel or Other Observer

Who?

Weather/ Weather Reporting Equipment

Airspace

Airspace/Altitude Rescue, DPs/STARs	HOO, Restricted Area, Aircraft Ops, Aerial Refueling, PJE, Moored Balloons

NOTAMs (L)/(D)

Airport Management/ Authorized Personnel	Facility Responsible for Controlling and Monitoring Light	Facility with NAVAID Monitoring Responsibility	Facility the Monitors Communications	Facility with Service Reporting Responsibility
Movement Area NOTAMs	Lighting Aid NOTAMs	NAVAID NOTAMs	Communications Outlets NOTAMs	Service NOTAMs

Figure C–2. NOTAM Flow

```
                              Is it a temporary condition
                              (less than 30 days)??  ──No──▶  Send to NFDC

                                        │ Yes
                                        ▼
                              ┌─────────────────────┐
                              │  Begin NOTAM process │
                              └─────────────────────┘
```

NOTAMs (D)/(L)	Miscellaneous NOTAMs (those not covered by Order 7930.2)	Military navigational aids that are part of the NAS	Special Data NOTAMs	International NOTAMs	FDC NOTAMs

- Coordinate with USNOF
- All Others
- In Alaska
- Certain Army
- Weather/ Weather Reporting Equipment
- Airspace
- NOTAMs issued by individual countries
- NOTAMs issued by U.S.
- NOTAMs issued by Canada

See FDC NOTAM flowchart for details.

- Military Units issue military NOTAM in accordance with DOD procedures
- Base Operations
- HOO, Restricted Area, Aircraft Ops, Aerial Refueling, PJE, Moored Balloons
- Airspace/Altitude Reservations, DPs/ STARs
- Stored in USNS

- Stored in USNS
- Issue and distribute

Or if unable to transmit data

See Issuance and Distribution Flow Chart

Does the data meet U.S. criteria for selected locations? ──No──▶ Stored in Canadian NOTAM System (available via NADIN)

Flight Service Station receives NOTAM information ──Coordinate──▶ **U.S. NOTAM Office** ◀──Yes──

Notify appropriate Technical Operations and AIM ◀──No── Is the info received regarding a Federal facility?

│ Yes
▼
Does the condition occur within the next 3 days? ──No──▶ What happens if it isn't?

│ Yes
▼
Is it covered by another FSS? ──Yes──▶ Forward to appropriate FSS

│ No
▼
Is there an immediate hazard? ──No──▶ Verify info if from other than authorized source

│ Yes
▼
Notify airport management as soon as practical

Does the NOTAM need to be extended? ──No──▶ Cancel NOTAM

│ Yes
▼
Cancel NOTAM
▼
Reissue original NOTAM with new date & time

Issue and distribute

See Issuance and Distribution Flow Chart

Figure C–3. NOTAM Issuance and Distribution

Prepare message

Enter into system

No (Receive reject notice)

Accepted?

Yes (Receive copy with number)

Stored in USNS

FSS logs NOTAMs it issues

Reviewed by USNOF, as appropriate

FSS takes no action

Yes

Is NOTAM still appropriate?

No

FSS cancels and issues new NOTAM

USNOF returns NOTAM to issuing FSS

Yes

Edited by USNOF?

No

No action

Presidential?

No

NOTAM D?

No

NOTAM L?

Yes

Relayed via NADIN to all FSS

Affected FSS notify all air traffic facilities

Yes

Relayed via NADIN to WMSCR to-

NFDC

All locations receiving affected location or tie-in FSS weather

Review and track NOTAMs re: instrument procedures

Compile NOTAMs for publication in NATP

Updates charts as necessary

Cancel NOTAM when updated

Forwarded by FSS to-

ATC facilities affected

ARTCC responsible for forwarding FDC NOTAMs to affected facilities

Local aviation companies, airline operations offices, interested users

Forwarded by monitoring facility of NAVAID not monitored by FSS to-

All affected facilities

Figure C–4. Flight Data Center NOTAMs

Does the NOTAM correct/amend IFR en route, VFR sectional? — No → Is the NOTAM a procedural or airway NOTAM? — No → Is the NOTAM initiated by FPO or AVN-200? — No → Is the NOTAM a change to graphic ODP & SID (NOTAM D)

Does the NOTAM correct/amend IFR en route, VFR sectional? — Yes → ATA-130 coordinates with AVN-100, AVN-300, ATA-110 to determine if NOTAM should be issued.

Is the NOTAM a procedural or airway NOTAM? — Yes → AVN-100 formats and coordinates with affected ARTCC → Does it affect FAA-developed military procedures at civil, joint-use airports?

Is the NOTAM initiated by FPO or AVN-200? — Yes → FPO/AVN-200 formats and coordinates with AVN-100

Is the NOTAM a change to graphic ODP & SID (NOTAM D) → AVN-100 formats

Does it affect FAA-developed military procedures at civil, joint-use airports? — Yes → Format separate FDC NOTAM for military procedures

Does it affect FAA-developed military procedures at civil, joint-use airports? — No → U.S. NOTAM Office

ATA-130 coordinates... → Should a NOTAM be issued? — No → Forward to NFDC

Should a NOTAM be issued? — Yes → ATA-130 formats → U.S. NOTAM Office

U.S. NOTAM Office → Prepare/revise message and enter into system → Accepted? — No (loop back)

Accepted? — Yes → AVN-100 / Stored in USNS / USNOF forwards to military authority as necessary for military NOTAM action

AVN-100 → Track NOTAM Ds → Cancel when necessary

AVN-100 → Review amended SIAP charts to ensure amendment is correct → Cancel NOTAM as necessary when amended

Stored in USNS → Relayed via NADIN to WMSCR to- → All FSS / NFDC

APPENDIX D — PART 139 AIRPORT THREAT MATRIX

Airports certified by the FAA to accommodate large scheduled and nonscheduled air carrier airplanes as well as scheduled small air carrier airplanes are classified as part 139 class I airports. It was imperative not only to study airports where wrong runway departure events occurred, but to review all airports to proactively identify and mitigate the physical characteristics of wrong runway event threat areas. Based on these physical factors, the following matrix was created to record each element present at all 355 class I airports. The airport received an "*" for each wrong runway event threat item described below.

Note: It is important to note that risk reduction strategies that may be underway at individual airports were not considered in the scoring. For example, the Cleveland airport received an "*" for the area with multiple runway thresholds in close proximity even though there is a plan to decouple the runways, as discussed in the Cleveland Hopkins International Airport mitigation example.

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Alabama	BHM		*	*	*	*			
	DHN	*		*	*				
	HSV								
	MOB	*	*		*	*			
	MGM								
	MSL	*							
Alaska	ADK			*	*			*	
	ADQ		*	*	*			*	
	AKN	*	*					*	
	ANC	*	*	*	*	*			
	BET			*					*
	BRW	*						*	*

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Alaska (*continued*)	CDB	*					*	*	
	CDV	*						*	*
	DLG	*						*	*
	DUT	*							
	ENA								
	FAI								
	GST								
	HOM								
	ILI								
	JNU								
	KTN								
	OME	*	*	*				*	
	OTZ								
	PSG	*						*	*
	SCC	*							*
	SDP	*					*	*	*
	SIT								
	VDZ	*							*
	WRG	*						*	*
	YAK								
American Samoa	PPG	*		*	*		*	*	
Arizona	FLG								*
	IFP								*
	PHX			*					
	TUS			*					
	YUM	*	*	*	*	*			

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Arkansas	FSM								
	LIT		*	*	*	*			
	TXK	*							
	XNA								*
California	ACV	*							
	BFL	*		*	*		*		
	BUR	*							
	CRQ								*
	FAT			*	*				
	LAX			*	*				
	LGB		*	*	*	*	*	*	
	MRY								
	OAK		*	*	*	*			
	ONT			*	*	*			
	PSP								
	RDD			*					
	SAN	*							*
	SBA	*		*	*				
	SBP								
	SFO	*	*	*	*	*			
	SJC			*	*				
	SMF								
	SNA	*		*	*		*		

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Colorado	ASE							*	*
	COS			*	*				
	DEN		*						
	DRO							*	*
	EGE								*
	FNL	*							
	GJT				*			*	
	GUC								
	HDN	*							*
	MTJ	*						*	
	TEX	*						*	*
Connecticut	BDL							*	
	HVN							*	
District of Columbia	DCA	*	*			*	*		
	IAD								
Florida	APF								
	DAB								
	EYW								*
	FLL	*	*		*				
	GNV				*		*	*	
	JAX								
	MCO			*					
	MIA			*	*	*			
	MLB	*		*	*	*	*		
	PBI								
	PFN								

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Florida (*continued*)	PIE	*		*	*		*	*	
	PNS								
	RSW			*	*				
	SFB								
	SRQ								
	TLH								
	TPA								
	VPS			*	*			*	
Georgia	ABY								
	AGS			*					
	ATL		*	*					
	CSG					*			
	MCN	*		*					
	SAV								
	VLD	*		*	*			*	
Guam	GUM	*		*	*			*	
Hawaii	HNL			*	*				
	ITO								
	JHM								
	KOA								*
	LIH								
	LNY	*						*	*
	MKK							*	
	OGG			*	*		*		

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Idaho	BOI								
	IDA								
	LWS								
	SUN								*
Illinois	BLV								
	BMI	*						*	
	CMI	*			*				
	MDW		*	*					
	MLI	*							
	ORD		*	*	*	*			
	PIA								
	RFD								
	SPI								
Indiana	EVV	*			*			*	
	FWA	*						*	
	GYY								
	IND								
	SBN								
Iowa	ALO	*		*	*				
	CID	*		*					
	DBQ			*	*				
	DSM	*							
	FOD							*	
	MCW	*		*	*				
	SUX							*	
Kansas	ICT				*				

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Kentucky	CVG	*							
	LEX	*		*	*		*		
	PAH								
	SDF	*						*	
Louisiana	AEX	*		*				*	
	BTR								
	LCH			*	*				
	LFT	*							
	MLU	*		*	*				
	MSY	*						*	
	SHV								
Maine	BGR								*
	PQI	*						*	
	PWM				*				
Marshall Islands	GRO	*						*	*
	GSN	*							*
	TNI								
Maryland	BWI		*						
	SBY								
Massachusetts	ACK	*		*	*		*	*	
	BED								
	BOS	*	*			*		*	
	HYA	*			*				
	MVY							*	
	ORH							*	

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Michigan	APN	*						*	*
	AZO	*		*	*				
	CIU	*							
	CMX								
	DTW		*		*				
	FNT	*			*		*	*	
	GRR								
	LAN					*			
	MBS								
	MKG	*		*	*		*		
	PLN								
	SAW								*
	TVC								
Minnesota	BJI	*		*					
	BRD	*							
	DLH	*							
	HIB	*		*	*				
	INL	*							
	MSP		*						
	RST	*							
	STC								
	TVF	*							

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Mississippi	GLH			*				*	
	GPT	*						*	
	GTR								*
	JAN								
	MEI								
	PIB	*							*
	TUP								*
Missouri	MCI	*			*	*			
	SGF	*							
	STL		*		*	*		*	
Montana	BIL			*	*		*		
	BTM								
	BZN							*	
	FCA								
	GTF	*					*	*	
	HLN	*			*			*	
	MSO								
Nebraska	LNK	*	*		*				
	OMA	*		*	*	*			
Nevada	EKO	*			*		*		
	LAS		*	*	*	*			
	RNO	*		*	*				
New Hampshire	MHT								
	PSM								*
New Jersey	ACY								
	EWR		*	*	*				

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
New Mexico	ABQ	*	*	*	*				
New York	ALB								
	BGM								
	BUF								
	ELM							*	
	HPN	*							
	ISP	*		*	*		*		
	ITH							*	
	JFK		*	*	*				
	JHW	*							
	LGA	*	*			*			
	ROC	*	*						
	SWF							*	
	SYR	*		*	*				
North Carolina	AVL								*
	CLT			*					
	EWN	*							
	FAY						*	*	
	GSO			*					
	HKY					*			
	ILM	*							
	INT	*							
	ISO								*
	OAJ	*							*
	PGV			*					
	RDU	*							

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
North Dakota	BIS								
	DVL	*						*	
	FAR							*	
	GFK								
	JMS	*							
	MOT	*							
Ohio	CAK								
	CLE	*	*	*	*	*		*	
	CMH								
	DAY								
	LCK			*	*				
	TOL	*							
Oklahoma	LAW	*							*
	OKC	*							
	TUL	*							
Oregon	EUG								
	LMT	*							
	MFR								
	OTH	*	*					*	
	PDT	*		*	*		*	*	
	PDX	*		*	*				
	RDM	*							

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Pennsylvania	ABE								
	AOO	*							*
	AVP	*						*	
	BFD	*		*			*	*	
	ERI							*	
	IPT			*	*		*		
	JST								
	LBE								*
	MDT								*
	PHL	*	*	*					
	PIT	*						*	
	UNV								*
Puerto Rico	BQN	*							*
	PSE	*							*
	SJU								
	VQS								
Rhode Island	PVD	*							
South Carolina	CAE								
	CHS	*		*					
	FLO	*							
	GSP								*
	HXD	*					*		*
	MYR								*

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
South Dakota	ABR	*		*	*			*	
	ATY	*						*	
	FSD							*	
	PIR	*						*	
	RAP							*	
Tennessee	BNA	*	*			*			
	CHA	*							
	MEM			*	*	*			
	MKL	*							
	TRI	*							
	TYS								
Texas	ABI	*			*		*	*	
	ACT			*	*			*	
	AMA								
	AUS								
	BPT			*	*			*	
	BRO			*	*				
	CLL			*	*				
	CRP			*	*				
	DAL	*							
	DFW		*	*	*				
	DRT								*
	ELP	*						*	
	GGG	*							
	GRK	*							*

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Texas (*continued*)	HOU	*	*	*	*				
	HRL	*		*	*			*	
	IAH	*	*		*	*			
	ILE	*							*
	LBB	*							
	LRD			*					
	MAF	*		*	*		*	*	
	MFE								
	SAT			*	*			*	
	SJT							*	
	SPS	*							
	TYR	*		*	*		*		
Utah	ENV	*	*	*				*	
	SLC			*	*		*		
Vermont	BTV								
Virgin Islands	STT	*							*
	STX	*							*
Virginia	CHO								*
	LYH	*				*		*	
	ORF	*							
	PHF	*		*	*				
	RIC			*	*	*			
	ROA								
	SHD	*							*

State	Airport	Short Taxi Distance	Complexity	One Taxiway To Multiple Runways	Close Proximity To Multiple Runway Departure Ends	Multiple Option (Excess of 4)	Short Runway (< 5,000 ft)	Runway Used As Taxiway	Single Runway
Washington	ALW	*		*	*		*	*	
	BLI								*
	EAT	*							
	GEG								
	PSC	*		*	*		*		
	PUW	*						*	*
	SEA	*		*	*				
	YKM								
West Virginia	CKB								*
	CRW	*						*	
	HTS			*	*				
	LWB	*							*
	MGW			*	*		*	*	
	PKB								
Wisconsin	ATW								
	CWA	*		*	*			*	
	EAU	*							
	GRB	*							
	LSE			*	*				
	MKE	*	*	*	*		*	*	
	MSN	*			*				
	RHI	*							
Wyoming	COD	*							*
	CPR	*			*			*	
	JAC	*							*

Total Citations	161	39	99	97	27	32	84	58
Citation % by Part 139 Airports	45%	11%	28%	27%	8%	9%	24%	16%