ACRP Project 06-08

Appendix C

Research White Paper for

ACRP Research Report 246: Airside Operations Safety: Understanding the Effects of Human Factors

Prepared for

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of
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1. Introduction

Significant attention has been put on the prevention and reduction of runway incursions internationally for decades. The air transportation industry understands the consequences of an incursion and has dedicated significant resources toward mitigating the investigated causes of accidents resulting from incursions and vehicle/pedestrian deviations (V/PDs), and causes of incursions where an accident was narrowly avoided. Yet in spite of the dedicated efforts, the number of annual runway incursions continues to climb. According to FAA statistics over a five year period from 2014 to 2018, the number of reported incursions increased by nearly 50%.

During this five year period, the percentage of V/PDs remained relatively consistent. Research performed by the Volpe Institute and reported in a Technical Report in December 2016 entitled *Runway Safety Analysis: Runway Incursion Characteristics and Mitigation Recommendations* confirms this and reveals that most V/PDs (just under 80%) are Class D, with the others falling primarily under Class C incursions. While rarely do V/PDs result in Class A or B incursions, a focused effort into an area of airport activity under the control of those that work on the airfield could result in a significant contribution to improved airport safety and the reduction of these deviations. That is the purpose of this research project—to explore the human factors issues that lead to V/PDs, examine mitigation strategies that airport leaders can readily and perhaps easily implement, and provide recommendations for actions that can positively address human performance in a way that improves safety in the airside environment.

This White Paper presents the results from Phase I of the research project. It not only offers a summary of the research findings from the first five planned project tasks for the review by the Oversight Panel Members, it also paves the way for the research to be performed in Phases II and III.

2. Project Objectives and Phase I Tasks

The specified project objectives as defined in the Problem Statement are as follows:

- Identify and describe the cognitive tasks and required abilities used in airside operations (e.g., vehicle and pedestrian activity inside the fence)
- Describe the demands that can limit or complicate situational awareness, thus, increasing risk of runway incursions and V/PDs
- Identify risks associated with reduced cognitive ability and situational awareness caused by fatigue or overload
- Discuss how technologies and processes potentially could be used to reduce or mitigate risks from reduced human performance
- Identify and describe the most effective technologies and processes that affect and could potentially improve situational awareness for airport employees and others working airside
- Estimate resource requirements, including cost, of technology and process introduction
- Discuss the limitations and complications that technology introductions and process changes may add to the demands of people working in the airside environment
- Create unformatted content for a stand-alone executive summary for decision makers to help develop strategies for identifying and implementing strategies for their unique situations

The Phase I efforts lay the foundation for accomplishing these objectives. The research in this first project phase was organized under five tasks, with Task 6 being the development and authoring of this White Paper. Task 1 was administrative in nature and included completing the project Kick-Off Meeting, along with the submission and approval of the Amplified Work Plan (AWP).

This paper discusses the findings, observations and some initial recommendations made during Tasks 2 through 5. These tasks were defined as follows:

- Task 2 – Literature Review and Safety Data Analysis
- Task 3 – Technology and Process Research
- Task 4 – Human Factors Impacts and Mitigations Analysis
- Task 5 – Develop White Paper, Executive Summary Outline, and Revised Work Plan

While Task 4 was included for completion in this Phase, the research team found that the analysis of the information uncovered in Tasks 2 and 3 was extensive. It was decided that the heavy lifting for comprehensive analysis of the human factors impacts and mitigation strategies for reducing the risk of these impacts should wait until after the Phase I meeting with the Oversight Panel. This paper does include some impact analysis and discussions of mitigations, however the research team felt that waiting to engage with the panel in a substantive discussion of the findings with the panel members would greatly aid in refining the scope of the research and ensure optimum results.

In addition, while the crafting of this paper was the main objective of Task 5, two additional deliverables for this project phase were proposed in the AWP: 1) the development of an outline for the Executive Summary content, and 2) a review and submission of change recommendations for the project work plan. The results of these two elements of Task 5 are included in this paper as Sections 7 and 8.

3. Literature Review (Task 2)

Task 2 of the project was divided into two parts; the first part was the Literature Review, and the second part was the analysis of V/PD data. This section discusses the results of the Literature Review.

As was described in the AWP, the review initially focused on previous ACRP studies relating to runway incursions and V/PDs, but also took full advantage of the human factors research experience members of the research team possess. Some key goals of the literature review (per the AWP) were to:

- Identify and review past human factors and airport safety research projects conducted by the airport industry.
- Identify and review ongoing human factors and airport safety research projects along with their objectives conducted by the airport industry.
- Identify and review past and current human factors and airport safety research that pertains to airport operations being conducted by key airport stakeholders, such as airlines and air traffic management organizations.

In total, 223 resources were referenced. An annotated bibliography of the primary resources determined to best contribute to achieving the project objectives are included as Appendix 1. Citations of all 223 resources reviewed are included as Appendix 2.

What follows in the remainder of this section is a summary of key findings discovered in the literature review. Each summary paragraph identifies the resource by a reference number which corresponds to the specific citation in Appendix 2.

No single cause – No single solution. In the early 1990s, Adam, Lentz and Bair (1992) (#22) conducted an analysis of runway incursion causes and note that airport surface operations are very complex, and incursions usually occur due to multiple variables. Since there is no single cause, they argue that there may not be a single solution to the problem. Some three decades later, runways incursions remain a threat to aviation safety. While the likelihood of runway incursions has been minimized, the threat of catastrophe remains high, thus resulting in a constant level of risk. There have also been minimal studies which examine, specifically, vehicle and pedestrian human factor causal issues of runway incursions.

Airside driver factors. McLean and Monro (2004) (#35) conducted a review of runway incursions in the United States and United Kingdom and found that the incursion rates are similar between the two countries. They noted the need for both countries to focus on runway incursion prevention. They concluded that preventive measures should emphasize better airside signage and training, which could relate not only to pilots but also vehicle and pedestrians. However, they did not provide empirical evidence that that these two issues would alleviate the problem. Young and Vlek (2009) (#65) focused on identifying safety risks at civil use airports where incursions are specifically caused by ground vehicles. They reported that 20% of all reported incursions in the US are due to ground vehicle errors. The authors concluded that there are four main causes for these ground vehicle incursions: 1) driver distraction, 2) insufficient training, 3) poor situation awareness, and 4) failure to communicate effectively. The findings

of these studies highlight training as a possible mitigation strategy for increasing awareness and minimizing distraction.

Airside driver training. Rankin and Cokley (2009) (#69) examined runway incursions at towered airports in the United States and attempted to assess the training received by drivers. Similar to Young and Vlek (2009), they noted that vehicle deviations accounted for 20% of all incursions between 2000 and 2003. Using a correlational design, Rankin and Cokley (2009) looked at what types of demographic characteristics impact driver training that employees receive at the airports. They reported that Age, Education Level and Income were significant predictors, while Race was not significant outside of South Florida. The authors suggested requiring annual recurrent training for these drivers. Rankin and Cokley (2009) (#130) conducted a correlational analysis to determine if demographic factors were significant factors related to airport driver training. The study was conducted through the use of a survey instrument at Operational Evolution Plan (OEP-35) US towered airports. The findings indicated that driver demographics were significant factors, which varied by geographic region and cultural influences.

Human error and airport design. Cardosi, Chase and Eon (2016) (#26) conducted research examining how human error is related to runway incursions, including vehicle pedestrian deviations. In their report, they summarized the literature and identified potential contributing factors related to runway incursions. They argue that future successful designs require prior knowledge of common characteristics of runway incursions. In addition, we should examine previously implemented strategies in order to determine what can be learned from them. This data can help in future designs of runways and offers error mitigation strategies. In addition to airport design, signage, markings, and lighting seems to be an understudied area of factors which may affect vehicle and pedestrian runway incursions.

FAA initiative effectiveness. Barnett, Paull and Iadeluca (2016) (#36) reviewed 292 US runway incursions from 1997 and noted that runway collisions are responsible for hundreds and deaths and injuries. These predictions apply to towered airports. Adam, Lintz and Bair (1992) (#22) conducted an analysis on the potential causes of runway incursions, noting the complexity of airport surface operations. They pointed out that runway incursions tend to occur because of multiple interacting factors that form a critical chain of events. Rankin (2008) (#32) examined runway incursions at the largest US towered airports, along with the perceptions of industry officials on the effectiveness of FAA initiatives. A related study from 2007 also investigated industry official perceptions on the effectiveness of FAA objectives. The current paper compared the previous two studies mentioned in order to detect possible similarities in the results. They focused primarily on airport driver training.

Winter operations and their impacts. Another threat area related to vehicle and pedestrian runway incursions surround winter operations, when the number of vehicles operating on the airport surface increases. Quilty (2008) (#117) conducted an ACRP related study which examined V/PDs and winter operations at airports. Data in the study was conducted via a literature review and interviews. Due to the increased vehicles operating on the airport surface, this may result in an increased risk of a V/PD related runway incursion. As part of the current study, questions regarding airports affected by winter operations may provide insights into mitigation strategies to prevent V/PD incursions.

Driver to ATC communication. Zhang and Yang (2010) (#41) presented an analysis that examined the main reasons for runway incursions with different severities. They suggested that the key factor that causes class A/B incursions are vehicle/pedestrian deviations. The key causal factor of class C/D incursions is pilot deviations. The authors suggested that increased communication between air traffic control and vehicle drivers is a solution. However, other studies have found the opposite effect (see Mathew, Major, Hubbard, and Bullock (2017) (#2)), and thus this is an area that warrants further investigation.

Situational awareness improvement technology. In 2011, A FAA report (#103) examined additional ways to prevent runway incursions. The report looked at a stand-alone system which could be used by airport drivers using GPS to provide location and warning alerts. The devices demonstrated favorable results and could be implemented for approximately $1,000-$4,000 per vehicle or approximately $100,000 for system-wide implementation. While a number of complex technological solutions have been investigated to mitigate runway incursions, the system presented in this FAA study required minimal equipment and a relatively minimal cost of implementation.

Incursion severity analysis. Mathew, Major, Hubbard and Bullock (2017) (#2) argued that runway incursions are a critical safety concern in aviation, which remains the case since the studies from the early 1990s highlighted this issue. Mathew, Major, Hubbard and Bullock's goal was to identify correlating factors that tend to affect or influence runway incursions. Using econometric based modeling techniques, the authors scoured data provided by FAA websites with regard to incursions. The model indicated that the likelihood of operational incidents was higher at large hub airports. Pilot deviations were more common at GA/non-hub airports and tended to be less severe (severity C or D). Vehicle pedestrian deviations were most likely at GA/non-hub airports with severity level of D. This may be due to having fewer access roads at the smaller airports.

Synthetic vision to improve situational awareness. In the literature, the majority of the focus on runway incursions relates to pilot deviations, software/technological solutions, and statistical modeling. However, since the 1990s, runway incursions remain a consistent threat to the aviation industry worldwide. Sridhar and Chatterji (1994) (#118) looked at the use of aircraft synthetic vision for pilots to improve their ground navigation while on the airport surface. While this study was older and mostly conceptual, it provided a beginning look at how synthetic vision can help with better situation awareness. Synthetic vision technology has become more accessible in the recent decade, even on smaller general aviation aircraft, but its usage within vehicles remains rather minimal.

Displaying pilot and driver information. Other types of flight deck technology may help mitigate runway incursions and could possibly be applied to vehicle operation. McCann and Foyle (1995) (#63) reviewed pilot situational awareness with Heads Up Displays (HUDs) and Head Mounted Displays (HMDs) in a series of experiments. They examined pilot information processing while interacting with the HUDs and HMDs. Hillebrand, Wahrenberg and Manzey (2012) (#140) focused on using a HUD to reduce runway incursions. They noted that participants were more likely to notice centrally located targets, implying attentional tunneling effects. Additionally, Foyle, Andres, McCann, Wenzel, Begault and Battiste (1996) (#131) discuss development of an integrated cockpit display for better situation awareness during taxi

operations. This arguably may reduce runway incursions, particularly during poor weather scenarios. These types of technologies may have positive transfers over to vehicle operations as well.

Alerting systems. Alerting systems have also been investigated in prior research. Cassell, Evers and Yang (2000) (#21) describe a runway incursion advisory and alerting system that provides conflict alerts for all aircraft and ground vehicles on the surface. The authors did not report any results of testing, although they mention that this is being done on a parallel project. Thompson and Eggert (2001) (#115) highlight two types of safety systems: a runway status light system and a tower cab alerting system. While this was an older study, it provided a precursor to many of the later runway safety studies from the early 2000s. Norris (2001) (#28) proposed the use of ultraviolet technology as a tool to reduce runway incursions, particularly in low visibility conditions such as fog or heavy rain. They mention possible benefits to ground vehicle drivers, but do not report any testing of the system.

Incursion prevention technologies. A major area of research in the early 2000s focused on the Runway Incursion Prevention System (RIPS) and variations of this system. Jones, Quach, and Young (2001) (#7) tested RIPS at the Dallas-Fort Worth airport that integrated both ground and airborne components. The goal was to provide both pilots and controllers with enhanced situation awareness, additional guidance cues, real-time display of traffic, and incursion warnings. Green and Jones (2002) (#18) integrated a runway safety monitor (RSM) with the RIPS with the goal of testing how well the RSM detects runway incursions. This system, however, does not prevent the incursions. Jones (2002) (#10) conducted similar research on the RIPS. Using eight commercial airline crews, they conducted a series of test runs to analyze the RIPS airborne incursion detection algorithms. Cassell, Evers, Esche, Sleep and Jones (2002) (#50) reported on a demonstration of the RIPS at the Dallas-Fort Worth airport. Jones (2005) (#11) continued this research by integrating the RIPS with a synthetic visual system at the Reno-Tahoe airport and Wallops Flight Facility. They focused primarily on crossing runway incursions. Jones and Prinzel (2007) (#8) also examined the RIPS, with a similar goal to the previous studies. Their findings are useful for pilot deviations, but do not address vehicle pedestrian deviations. However, it is possible that there could be a positive transfer of improvements to V/PDs.

Surface movement alert technologies. Surface awareness and preventative concepts have also been researched. Eggert, Howes, Kuffner, Wilhelmsen and Bernays (2006) (#46) suggested independent warnings as a backup to the current systems. This warning would alert pilots crossing or departing a runway and warn them of potential conflicts with other traffic on the surface. Vernaleken, Mihalic, Guttler and Klingaug (2006) (#23) define the concepts of preventive and reactive incursion avoidance and discuss the use of a surface movement awareness and alerting system that alerts the flight crew if they are at risk of an incursion.

Electronic flight bags as an alert tool. Ludwig (2007) (#45) examined direct alerts to the cockpit to see how they would help to prevent runway incursions. They discussed how this system would work with ADS-B and outlined the requirements for how this system would be successful. Prinzel and Jones (2007) (#37) proposed that an electronic flight bag may help with detection and avoidance of runway incursions. They used a sample of general aviation pilots to evaluate the system during a simulated flight. Pilots flew numerous, high-complexity and high-workload approaches under different weather and visibility conditions. At some point in the simulation, a rare-occurrence runway incursion was introduced, and pilot

reactions were measured. The authors argue that the results highlight a need for a runway incursion prevention system to be used for general aviation aircraft. Electronic flight bags, which are typically small electronic tablets, could be used and incorporated into vehicle operations, although this was not a focus of this study.

Miscommunications. One commonly identified causal factor of runway incursions is miscommunications. Claudiu (2010) (#101) discussed challenges with verbal communication between air traffic control and pilots. They argue that misunderstandings and breakdowns in communication can cause runway incursions, among other things. They proposed using datalink and textual communication to help with language difficulties. While studies were limited on this topic relating directly to V/PDs, it is likely that communication issues are factors affecting vehicle and pedestrian runway incursions. Chase, Eon and Yeh (2010) (#120) used archival data to review runway incursion reports from 2007 to 2008. They found that about one third of incursions could have been prevented if the aircraft was equipped with a moving map display of the airport surface.

Evaluation existing systems. Schonefeld and Moller (2012) (#3) pointed out that avoiding runway incursions has been a top ten priority for NTSB. They provided an introduction to runway incursions and highlight the threat that they impose. They also reviewed existing systems, provided some technological solutions, and introduced results from a few current runway incursion prevention systems. Schonefeld, Dietmar and Moller (2012) (#126) noted that the wide deployment of the Runway Incursion Prevention and Alerting System (RIPAS) improved safety towards runway incursions in the United States. However, they pointed out that in some of the most dangerous situations, the signal's reach exceeded their limitations. McGarry and Helleberg (2011) (#123) performed a human-in-the-loop simulation in order to evaluate an advanced aircraft dependent surveillance broadcast system. Pilots reported that they preferred a cockpit display of traffic information with runway indication over one without. They also preferred the Track Up view over the North Up view. It is possible that new displays in vehicles could help reduce the chance of runway incursions.

Safety systems and programs. Focus has also been given to the use of safety programs to prevent runway incursions. Rogerson, Lambert and Johns (2013) (#38) presented multi-layered perspectives on the costs and benefits of safety programs that were used to prevent runway incursions. They included both pilots and drivers. The participants felt that the programs were warranted in most situations. Mrazova (2014) (#111) provided a lot of good information about runway incursions and how they pose a serious safety threat. The author emphasized the importance of identifying hot spots, as well as adding runway safety teams to help prevent incursions. She also noted that poor runway and taxiway designs can add to the problem.

Displaying pilot and driver information. Wilke, Majumdar and Ochieng (2015) (#17) assert that runway and taxiway safety is a global challenge for aviation. Their goal was to identify the contributing factors during safety occurrences. They note that much prior research has focused on human factors and operational procedures, but less research has analyzed the impact of the airports involved and their characteristics. They also referenced vehicle pedestrian deviations. Song, Cho, Tessitore and Gurcsik (2018) (#20) offered a data-driven analysis using a generalized additive model (GAM), which can analyze

many variables using modeling distributions. However, while vehicle pedestrian deviations are mentioned, the paper does not focus on their impact on runway incursions.

ACRP project review - general. A review of existing ACRP project reports was completed as part of the literature review. Of all the reports posted on the ACRP website, less than a dozen reports related to peripheral areas dealing with runway incursions, and none directly investigated human factor runway incursion issues.

ACRP safety management projects. Safety management systems and risk assessments have been prior areas of research within the ACRP platform. ACRP Project 01-18 (2012) (#219) examined enterprise risk management for airports. This report serves as a guidebook to for airports to begin developing their safety management systems. Similarly, ACRP Project 04-16 (2015) (#206) provides airports with a guidebook on safety risk management. The study notes the possible benefits to numerous airport employees such as airport directors, managers, maintenance, and operations. Risk assessment could play a role in airports working with their drivers to identify the risk of operating on the airport surface area, and also mitigations to reduce the chance of a V/PD occurrence.

ACRP movement area work practices project. ACRP Project 09-02 (2014) (#210) does provide valuable information to the current study. In this project, the team identified a best practices manual for working in or around movement areas. These areas are active surface areas on the airport, and this increases the risk of a runway incursion. The study provides a best practices database, training tools, and a video for new employees and tenants. The goal was for airports to be able to utilize these tools in their training courses for their personnel.

4. Data Analysis (Task 2)

A key element for meeting the project objectives is to discover the nature of the issues and the underlying causes behind the events that impact airport safety in the airside environment. Specific to Phase I of this project, the goal was to analyze the human factors deemed to cause V/PDs. The Problem Statement called for the research team to perform the following:

> *An analysis of domestic (and, if practical, international) safety statistics related to runway incursions and V/PDs, sorted by size of airport, type of vehicle operator, and other criteria relevant to the objectives of this research.*

The research team was able to gain access to data resident in the FAA Runway Safety Office Runway Incursions (RWS) database. With the assistance of the FAA, the team asked for and received the records for V/PDs for the fiscal years 2017 through 2018. The reason this period of time was chosen was that it mirrored the time period for the latest study of V/PDs done by the Runway Safety Office. The FAA study did not specifically look at the human factors behind the P/PD events, but did add some additional insight as the FAA had access to the raw information received from the airports in the development of their report. The Runway Safety Office shared a PowerPoint Presentation the covered the findings of their study with the research team. Relevant findings from that presentation are included here as well.

The research team attempted to acquire international data similar to that provided by the FAA. Contact was made with the Airports Council International (ACI) and was attempted with the International Civil Aviation Organization (ICAO). ACI informed the team that they did not capture data on runway incursions, and multiple inquiries made to ICAO went unanswered. Thus, as is discussed further in Section 8 of this report, the research team does not intend to continue the search for international data at present.

The data analyzed encompassed 847 events that occurred in the US over the selected two year period. For each of the events, the following information (if available in the database) was reviewed:

- Event Number (FAA generated reference number)
- Date of the Event
- Time of Day
- City and State
- Airport Identifier
- Vehicle Type (Vehicle or Pedestrian)
- Vehicle Code (Car, Aircraft, Baggage Cart, etc.)
- Vehicle Description (Airport Ops Vehicle, FAA Vehicle, Fire Truck, Ambulance, etc.)
- Communications Equipment
- Operator (Airline, Civilian, Military, etc.)
- Training Available (For the Vehicle Operator; Yes or No)
- Training Completed (Yes or No)

- Investigation Narrative
- Airport Region

The data was extracted from an Access database received from the FAA, and the team populated a master Excel spreadsheet for ease of analysis.

While not a specific field in the FAA database, the research team added the following additional field for analysis:

- Airport Size – The research team identified each airport as Large Hub, Medium Hub, Small Hub, Non-Hub, or General Aviation

Methodology

The data fields were all analyzed for trends, however the main focus of the analysis was geared toward the identification of human factors information within the event narratives. To capture usable and actionable human factors information from the investigation narrative, the research team used the Human Factors Analysis and Classification System (HFACS). HFACS uses causal categories or levels that identify the active and latent failures that occur in incidents and accidents. The categories and levels of the HFACS taxonomy are illustrated in Figure 1. A complete explanation of the HFACS framework can be found at the following site: http://www.hfacs.com/hfacs-framework.html.

Of the 847 events in the FAA database during the selected two year period, 786 events (93%) included investigation narratives while 61 of the events had no narrative. Of the 786 events with investigation information, 679 events (86%) had enough information to be coded per the HFACS taxonomy. Thus, in general, 14% of investigations (107 events in this case) do not record enough detailed information to support the analysis of human factors that may be causal. Even for those narratives with enough information for HFACS coding per the taxonomy, the analysis required the research team to default to one unsafe act for the largest percentage of the events; that act being Decision Error. This will be further described during other sections of the report, but highlights the need in the airport industry to improve investigation practices for incidents and accidents in order to tackle safety improvement with more accurate data.

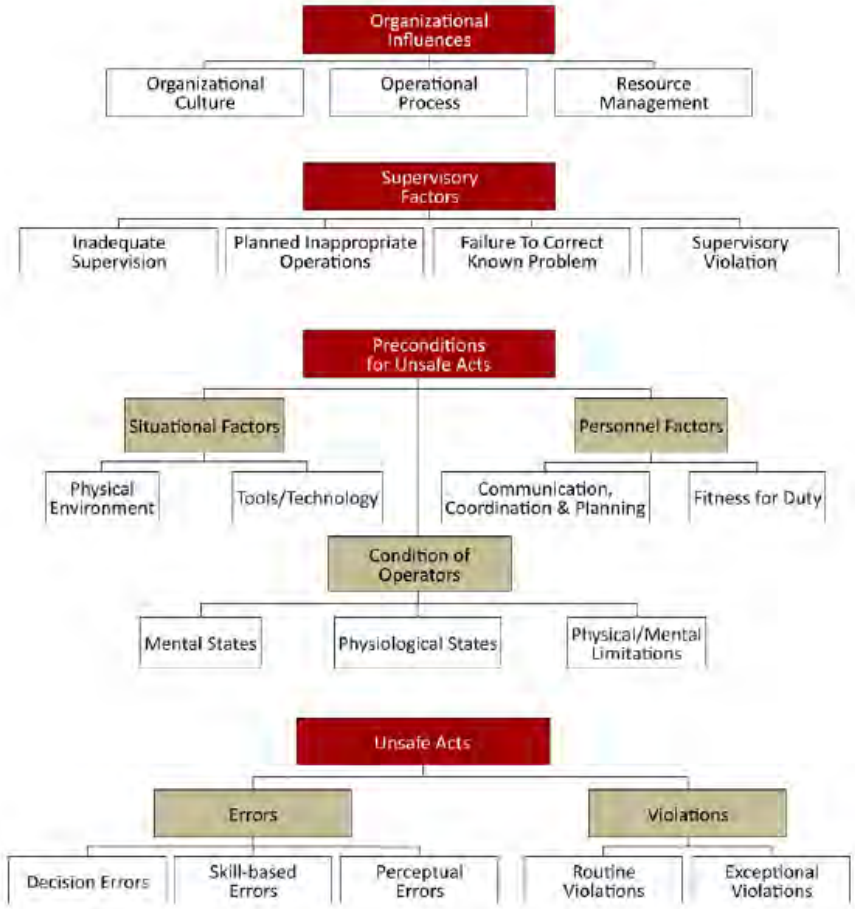

Figure 1. HFACS Taxonomy

Findings from Analysis of the Investigation Narratives – HFACS results

While there were a handful of unsafe acts that were categorized as Skill-Based Errors or Perceptual Errors, the vast majority of unsafe acts were either Violations or Decision Errors. Of the 679 events analyzed via HFACS, 100 were categorized as Violations and 529 as Decision Errors. The HFACS findings focus on these two, to include example excerpts from the investigation narrative write-ups to support the findings.

Violations

In order to code the event as a Violation, evidence in the investigation narrative must exist to indicate the party or parties knowingly performed an action that was contrary to airport rules and regulations. The violations fell into several sub-categories. In many cases, pedestrians or vehicle drivers simply penetrated the airport through fencing or open gates. In some cases, they were drunk or otherwise mentally ill, and in other cases, they were evading police.

- WHILE EVADING POLICE, THE PEDESTRIAN SCALED THE AIRFIELD PERIMETER FENCE, GAINING ACCESS TO THE AIRFIELD.
- THE INDIVIDUAL WAS FLEEING POLICE AND FOUND TO BE MENTALLY INCOMPETENT. HE USED CLOTHING TO SCALE THE AIRPORT FENCE AND INJURED HIMSELF SIGNIFICANTLY ON THE BARBED WIRE AT THE TOP OF THE FENCE.

The other common type of violation involved people simply ignoring the rules and conducting themselves poorly. This included cases where the person knew the rules but did not behave accordingly.

- THE PEDESTRIAN CLAIMED TO BE A PILOT AND A PAST EMPLOYEE WITH THE FAA. HE ALSO CLAIMED TO BE AN AVIATION SAFETY INSTRUCTOR AS WELL. HE STATED THAT HE KNEW THE RUNWAY WAS CLOSED BECAUSE AIRCRAFT WERE OPERATING FROM THE SECONDARY RUNWAY ON THE AIRPORT. WHEN ASKED IF HE CHECKED ANY NOTAMS, TALKED TO THE TOWER OR LISTENED TO THE ATIS HE BECAME IRATE, STATED "THIS CONVERSATION IS OVER", AND HUNG UP THE PHONE.

Decision Errors

In many cases, the narratives did not provide enough information to determine whether the person had knowingly violated a rule which led to the incursion. In these cases, the research team defaulted to assigning a Decision Error code to the scenario. About 80% of the events contained evidence of an error, or lacked evidence of a violation. Many of these decisions errors were influenced by other factors (as described later). However, in some cases, there was not enough information to determine a link between these other factors and the decision error.

- SNOW REMOVAL OPERATIONS WERE ABOUT TO COMMENCE AND PORTABLE 21 AND THE SNOW REMOVAL TEAM WERE GIVEN PERMISSION TO OPERATE ON TWY A & B BUT HOLD SHORT OF RWY 16L. PORTABLE 21 AND SNOW TEAM PROCEEDED AS INSTRUCTED BUT CONTINUED ON TO RWY 16L WITHOUT PERMISSION FROM AIR TRAFFIC CONTROL TOWER (ATCT) ON FREQUENCY 119.9.

In this situation, an incursion ensued, but not enough information was recorded to determine why the person continued on without permission. It could have been due to a variety of reasons, but none of them are listed. In these cases, a Decision Error code is assigned without any amplifying factors. There were many scenarios like this; in such cases, mitigation strategies are nearly impossible to develop as the true cause for the event is not known.

Other Decision Error Influences, Factors or Preconditions

There were many potential influences, factors or preconditions that led to the V/PDs in the database.. The HFACS analysis identified the following frequency of secondary factors behind the errors discovered:

- 214 – Communication, Coordination and Planning
- 140 – Adverse Mental States
- 132 – Inadequate Supervision
- 59 – Tools/Technology
- 26 – Skill Based Errors
- 12 – Physical Environment
- 8 – Failure to Correct Known Problem
- 2 – Supervisory Violation
- 2 – Operational Process

This breakdown shows that the four main reasons appear to be Communication, Coordination and Planning (CCP); Adverse Mental State (AMS); Inadequate Supervision (IS); and Tools and Technology (TT). Each of these are discussed in turn.

Communication, Coordination and Planning

There were 214 narratives examined that contained evidence of CCP errors. This code includes situations where there was poor communication, coordination or planning that contributed to the decision error taking place. Communication was the issue cited in the vast majority of scenarios where this code was assigned. In some cases, the person simply did not communicate at all.

- THE GROUND CONTROLLER (GC) OBSERVED VEHICLES ON TWY "V". THE GC THEN ATTEMPTED TO CONTACT THE VEHICLES VIA RADIO W/O RESPONSE.
- GC NOTICED THAT OPS 1 HAD EXITED RWY 31 BUT DID NOT REPORT OFF THE RUNWAY. A SHORT TIME LATER, GC OBSERVED OPS 1 PROCEED ON RWY 13/31 WITHOUT CALLING FOR APPROVAL.

In some cases, the person was communicating, but did not hear the instructions and falsely assumed there was approval.

- FLAGGER 1 REPORTED NOT HEARING OR ACKNOWLEDGING THESE INSTRUCTIONS AND INCORRECTLY ASSUMING SHE STILL HAD APPROVAL ON 20L, CROSSED THE RUNWAY ONCE MORE.

In other cases, the person was communicating in a less than optimal way.

- LOCAL CONTROL (LC) INSTRUCTED RED2 TO HOLD SHORT. RED2 ACKNOWLEDGED THE INSTRUCTIONS WITHOUT READING THEM BACK. WHEN

THE EMERGENCY AIRCRAFT PASSED THE THRESHOLD, RED2 DROVE ONTO THE RUNWAY BEHIND TANKR14 WITHOUT AUTHORIZATION.

Sometimes, the person heard instructions for someone else and thought it was meant for them.

- OVERHEARD RADIO TRAFFIC APPROVAL FOR ELECTRIC 1 AND MISTAKENLY THOUGHT HE WAS APPROVED TO ENTER THE MOVEMENT AREA.

Other times, the communication was garbled and instructions were not clearly understood.

- AFTER LISTENING TO TOWER RECORDING, FURTHER INVESTIGATION REVEALED THAT AFTER AIRPORT 160 REPORTED OFF OF TAXIWAY A (TO THE SOUTH), THERE WAS A GARBLED MESSAGE THAT WAS BARELY READABLE/COULD NOT BE UNDERSTOOD. THERE WAS NO RESPONSE FROM ATCT. A SHORT TIME LATER IS WHEN AIRPORT 160 WAS OBSERVED ON RWY 18-36.

Adverse Mental State

The research team found that 140 of the investigation narratives included information leading to an AMS code assignment, indicating that there was some issue with situational awareness, distraction, confusion, or external substance (e.g. alcohol/drugs) that negatively affected the person's mental state.

One common reason for AMS incursions was a lack of situational awareness on the part of the offender. In these cases, the person clearly was not intending to cause an incursion, but instead did not realize where she or he was.

- THE DRIVER MOMENTARILY LOST SITUATIONAL AWARENESS WHEN TURNING AROUND ON TAXIWAY; HOWEVER, ONCE HE REALIZED THAT HE CROSSED THE RUNWAY HOLD-SHORT LINE, HE IMMEDIATELY CALLED TEB-99 FOR ASSISTANCE TO CLEAR THE AREA WITHOUT FURTHER INCIDENT.

Another common reason for AMS incursions was distraction or not paying attention on the part of the offender. Again, there was no intent to cause an incursion, but the person should have been more focused on avoiding incursions rather than thinking about other things.

- DRIVER WAS JUST NOT PAYING ATTENTION TO WHAT WAS GOING ON AS SHE WAS CONDUCTING HER DAILY RUNWAY INSPECTION AND GOT COMPLACENT AS SHE USUALLY DOES NOT HAVE TO WAIT FOR TRAFFIC.

A third common reason for AMS incursions was confusion on the part of the offender, or the offender was lost and/or unfamiliar with the airport. This could be due to the person having never been at the airport before, or was not trained on airport procedures.

- AMBULANCE DRIVER WAS UNFAMILIAR WITH THE LAYOUT OF THE AIRPORT AND INADVERTENTLY CROSSED RUNWAY 6 ON TAXIWAY SIERRA AND TAXIWAY BRAVO.

Lastly, there were several cases where the offender was simply not in his or her right mind. There might have been drugs or alcohol involved, or the person had dementia, or another limiting condition.

- FURTHER INVESTIGATION REVEALED THE DRIVER OF THE VEHICLE WAS UNAWARE OF HOW HE ARRIVED AT THE AIRPORT. HE STATED TO POLICE THAT LAST HE REMEMBERED HE WAS ON HIS WAY HOME FROM HIS DAUGHTER'S HOUSE. THE GENTLEMAN ALSO REVEALED THAT HE SUFFERS FROM ALZHEIMER'S DISEASE. AFTER BEING TRANSPORTED TO THE HOSPITAL IT WAS DISCOVERED THAT THE DRIVER WAS REPORTED MISSING EARLIER THAT DAY AND THAT HE HAD DEMENTIA IN ADDITION TO ALZHEIMER.

Inadequate Supervision

There were 132 cases of IS, which can be further broken down into three common situations. In many cases, a supervisor had not trained the employee and mistakes were probably made due to lack of training.

- THE AIRPORT DOES HAVE A MOVEMENT AREA DRIVER'S PROGRAM; HOWEVER, THESE PARTICULAR DRIVERS WERE NOT REQUIRED TO TAKE THE TRAINING.

In other cases, they received training, but it was not adequate or was not the appropriate type of training for the job.

- THE TRAINING PROGRAM IS A COMPUTER BASED PROGRAM AND THA AIRPORT HAD PREVIOUSLY DETERMINED THAT THE COMPUTER BASED TRAINING WAS NOT ADEQUATE FOR DRIVING ON THE NON-MOVEMENT AREA AFTER A V/PD LAST JULY BY A CONSTRUCTION WORKER.

Along a different line, there were several cases where supervisors did not escort the worker when required, left the worker unattended, and/or let one vehicle leave a caravan of vehicles.

- AIRPORT ISSUED STOP WORK-ORDER FOR THE PROJECT UNTIL THE CONTRACTOR DEVELOPED AND IMPLEMENTED A TRAFFIC PLAN REQUIRING ESCORTS & ADDITIONAL TRAINING.
- THE ROOT CAUSE OF THIS INCIDENT WAS CAUSED BY WAS A LACK OF POSITIVE CONTROL OVER PERSONNEL ON THE RAMP AND ESCORT PROCEDURES ON BEHALF OF THE FIXED BASE OPERATOR (FBO).

Tools and Technology

There were 59 cases where a TT code applied. In some cases, airports needed to install cameras to monitor employees and ground crew, or add signs/stenciling and other aids to help crew find their way around.

- AIRPORT CHANGES: 1) INSTALLING CAMERAS; 2) REGULAR VEHICLE/PEDESTRIAN TRAINING; 3) STENCILING ON TXY; 4) ADDED SIGNS TO ACCESS GATES.

There were many instances where a driver or pedestrian entered an open gate. This may have been because the gate was unlocked, or because someone piggy-backed on another driver who did not ensure the gate closed immediately after entering the airport operations area.

- THIS DRIVER ENTERED THE AOA FROM AN OPEN GATE AND AT THE TIME OF ENTRANCE, WAS NOT NOTICED BY ANY OTHER AIRPORT TENANTS OR PERSONNEL.
- THE VEHICLE OPERATOR GAINED ACCESS THROUGH A GATE LEFT OPEN BY AN AIRPORT TENANT.

Lastly, there were a number of cases where fencing was either non-existent or inadequate to stop pedestrians from entering the airport ground.

- IT WAS DETERMINED INADEQUATE FENCING IN THE FORM OF THIS TYPE OF VEHICLE ENTRY/EXIT GATE WAS DEFINITELY A CONTRIBUTING FACTOR TO THE VEHICLE/PEDESTRIAN DEVIATION.

Potential Mitigation Strategies

While recommendations on strategies for mitigating the risks posed by these human factors will developed and presented in the subsequent phases of the project, the findings from the HFACS analysis of the FAA V/PD data led the research team to postulate a number of approaches airports may consider. The following mitigation suggestions are presented here and will be included in the follow-on research phases. These suggestions may guide the areas that receive focus during the remainder of the project.

Violation Mitigation Suggestions: The reasons recorded for violations were fairly straightforward; and the mitigations may be as well. The mitigation will likely reside with individual responsibility and accountability; both of which are influenced by the airport's culture – at least for those employed by or at the airport. In some cases, higher fencing might keep out trespassers who are violating airport rules, but violations may require attention on a case by case basis.

CCP Mitigation Suggestions. The research team discovered that this was a key factor during the three airport visits conducted in Phase I. The site visits will be discussed later in this paper, but airside communication will be an area of continued focus during Phase II and III. Many communication issues might be alleviated by improved training approaches, particularly for temporary personnel. Many of the

ground personnel citied in the CCP events clearly are new on the job, have minimal mandatory training, and not familiar with airports or terminology. Nor were many of them familiar with ground-tower communication protocol, or simply not confident communicating via radio with the controllers in the tower. One potential issue that did not show up in the data but may be ripe for examination was proficiency in English for airport drivers. This subject was mentioned during the airport visits on a couple of occasions and could be explored more thoroughly during subsequent site visits.

With more airports adopting safety management system (SMS) processes, which include safety risk management (SRM) practices, the introduction of easy-to-remember and easy-to-put-into-practice risk management techniques for those working airside could be an effective mitigation strategy that improves communication, coordination and planning. Branches of the US military and airlines include threat and error management techniques and time critical risk management processes to minimize errors while engaged in operations. The research team plans to explore this strategy during future airport and stakeholder interviews.

AMS Mitigation Suggestions. When someone is mentally ill or running from the police, then the only thing stopping them from entering the airport would be a barrier. Fences can only be but so effective, and anything more structurally sound would probably not be cost-effective for smaller airports. On the other hand, training could help to alleviate many of the problems associated with unfamiliarity and loss of situational awareness. As mentioned previously, many of the ground personnel cited were new to the airport, had minimal training, and/or were not familiar with airports in general. Examining the required training and reviewing escort requirements and procedures may help to mitigate these issues.

IS Mitigation Suggestions. Many of the IS cases appear to be solvable through improved training, mentoring, monitoring and evaluation of those in leadership positions or perform duties with heightened responsibility. Other cases can be addressed by ensuring that supervisors understand the escort procedures, and monitor their employees to ensure compliance, and reviewing the procedures to certify effectiveness.

TT Mitigation Suggestions. With regard to issues involving gates, two things came to mind during the analysis. First, cameras could help to ensure that gates have been closed properly by tenants and other personnel. Given the advances in surveillance technologies and the decreasing cost of systems for homes, simple and inexpensive solutions may be suitable for some airport situations. Additionally, understandable markings on the pavement may be more effective for drivers less familiar with markings and signage designed for pilots operating aircraft. An example might be painting a wide, solid red line to mark the where the movement area begins.

V/PD Data Analysis Other Than HFACS

In addition to the HFACS analysis performed on the V/PD database, the research team examined the data outside of the investigation narratives to determine if trends appeared and look for guides to Phase II and III research efforts. The team was looking at the data for evidence fatigue causal factors, weather as an influence on human performance leading to V/PDs, if airport size or complexity of operations leads individuals to make more mistakes, and if the training available and types of equipment used in the field

are indicators of problem areas. As a reminder, the data analyzed was for fiscal years 2017 and 2018. The following figures display the results of this analysis.

Events by Airport Region. Figure 2 shows the distribution of V/PD records for the FAA airport regions. Reports were submitted to the database analyzed came from only five regions: Central (ACE), Western-Pacific (AWP), Eastern (AEA), Great Lakes (AGL), and New England (ANE). The database indicated that 624 (74%) of the events reported occurred in the FAA Central Region. This information is tremendously skewed, and likely unreliable, but may indicate large variations in reporting policy and practices in the US.

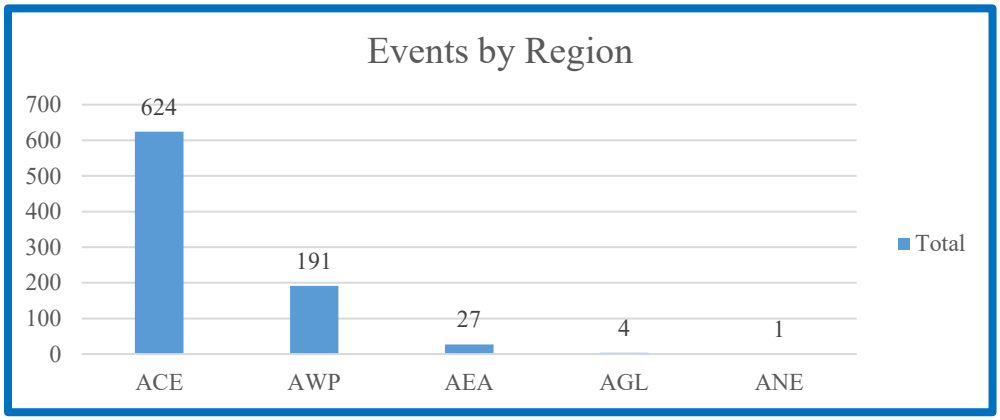

Figure 2. Events by Airport Region. Research Team Analysis.

These results differed from the analysis of V/PDs performed by the FAA Runway Safety Office. The events by region discovered in the FAA analysis is shown in Figure 3. This indicates that V/PDs were reported in all nine airport regions with the fewest occurring in the Central region in 2017.

An increased number of reports occurred in 2018 (highlighted in red) in the Central, Great Lakes, Southern (ASO), Southwest (ASW), and the Western-Pacific regions; while the Alaskan (AAL), Eastern, Northeastern, and Northwest Mountain (ANM) regions showed improvements in 2018 (highlighted in green).

Figure 4 displays the percentage of annual V/PDs occurring in each region as per the FAA Runway Safety Office analysis. The differences in the results between the research team and the FAA will be explored in Phase II if deemed that this is an area where meaningful human factors knowledge might be gained.

Region	FY17	FY18
AAL	14	13
ACE	3	14
AEA	37	32
AGL	41	55
ANE	15	5
ANM	36	22
ASO	41	52
ASW	36	66
AWP	47	65
	270	324

Figure 3. V/PDs per Airport Region in FY-17 and FY-18. FAA Runway Safety Office Analysis. Regions showing improvements in 2018 are highlighted in green.

Region	FY17	FY18
AAL	5%	4%
ACE	1%	4%
AEA	14%	10%
AGL	15%	17%
ANE	6%	2%
ANM	13%	7%
ASO	15%	16%
ASW	13%	20%
AWP	17%	20%
	100%	100%

Figure 4. Percentage of Annual V/PDs per Airport Region in FY-17 and FY-18. FAA Runway Safety Office Analysis.

Events by Quarter. The research team looked at the events per calendar year quarter to see if there was any indication of differences in events per season of the year. Figure 5 shows the results of the analysis, and indicates a relatively flat distribution. The thought was that more incursions might take place during times of the year when snow removal operations take place. This chart would indicate no such trend, even given the large reporting numbers in the data analyzed by the research team in the Central Region which experiences all four seasons.

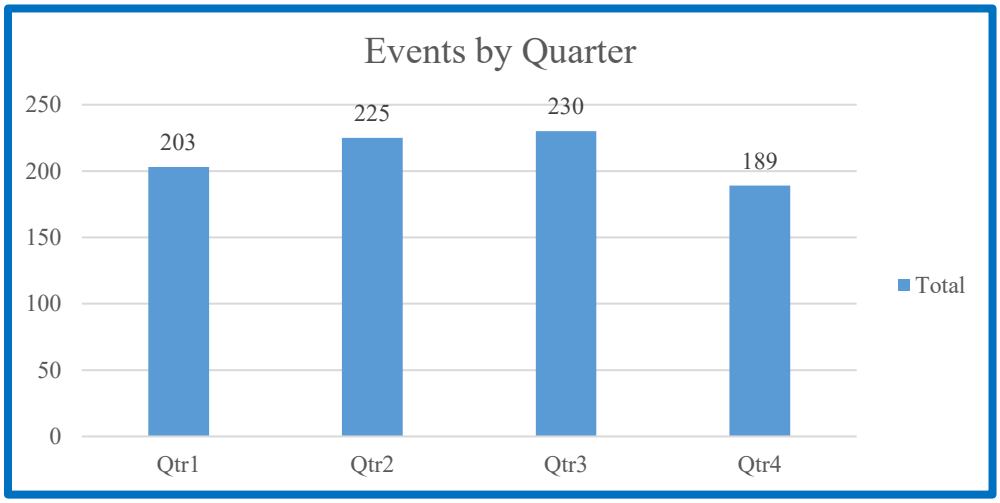

Figure 5. V/PD Events by Calendar Year Quarter. Research Team Analysis.

Events by Time of Day. The research team wanted to evaluate the number of V/PD events as a function of daylight versus darkness. Given that the reports do not record the sunset or sunrise times, sorting the data according to a typical way of breaking up the work day into shifts was determined to be a starting point for such an analysis. The results are shown in Figure 6. This chart indicates that 67% of the events occurred during daylight hours. This is the time when more aircraft operations occur and the activity on the airfield is the highest; thus this data does not seem to show a trend that more V/PDs occur during hours of darkness, and lack of ambient light is a large factor.

This analysis was also seen as a potential indicator of the influence of cognitive fatigue due to sleep restriction. The hypothesis discussed was if a significant percentage of the V/PDs occurred in the late night or early morning hours, fatigue might be a factor in such events. This analysis would not indicate such a relationship, however the data does not contain information on when during shift the event occurred (beginning, middle, or end of shift). An alternate way to investigate the impacts of fatigue or minimized sleep is discussed later in the paper.

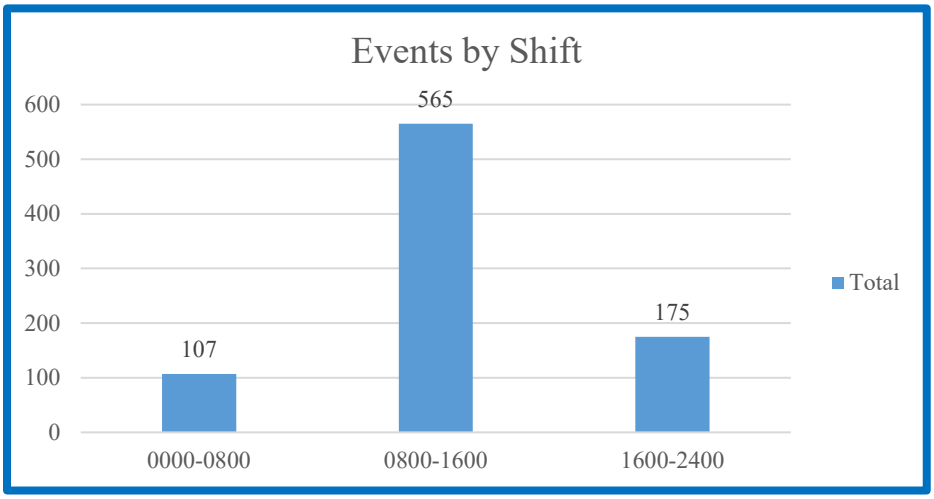

Figure 6. V/PD Events by Time of Day. Research Team Analysis.

Events per Size of Airport. Figure 7 shows the number of incidents according to the size of the airport. The research team used hub size for commercial service to evaluate V/PDs as a function of the airport size. The data shows that 325 events (39%) occurred at General Aviation (GA) Airports; while 168 events (20%) occurred at Non-Hub airports. Thus 59% of the recorded events occurred at the airports with the lowest levels of activity. The level of activity is relative given that some GA airports (such as Teterboro) operate at levels similar to many medium hub airports.

With this information in mind, it is interesting that this data indicates that the focus of V/PD mitigations may need to be on smaller airports versus the busiest. FAA airport records for CY-18 indicated 520 airports have commercial service: 30 Large Hub, 31 Medium Hub, 69 Small Hub, 262 Non-Hub Primary, and 128 Non-Primary Commercial Service airports. Thus the 61 airports carrying the bulk of commercial service flight operations had only 26% of V/PDs. Research during the upcoming phases can dive deeper into the differences between the human factor causes of the V/PDs at the different size airports together with comparing the approaches taken at large airports versus small airports to mitigate the risks.

Some differences to be explored may include:

- Differences in access methods to the AOA
- Frequency of FBO patrons accessing the AOA
- Number of events caused by airport personnel versus non-airport personnel
- Causes of pedestrian deviations versus vehicle deviations
- Differences in communications equipment and methods used

A key reason why this aspect of the analysis may need to be a focus is in the difference in resources and personnel available at large airports versus small airports. The mitigations that are practical for one size airport may be impractical for another.

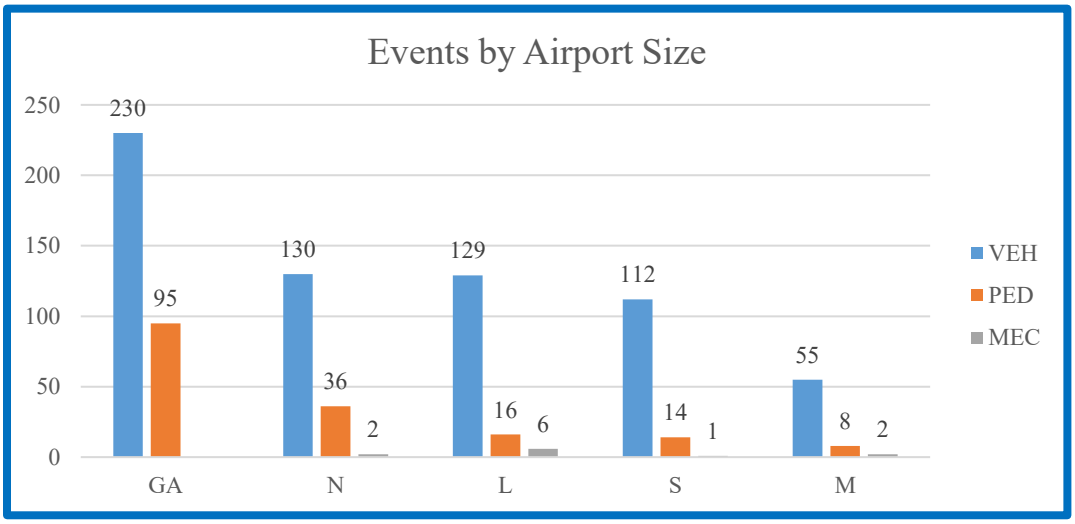

Figure 7. Events as a Function of Airport Size. Research Team Analysis.

Events According to Vehicle Information. The information available for analysis in the database the research team used proved inconclusive. While the data showed that the vast majority of the events involved a vehicle (Figure 9), the information available for Vehicle Code (Figure 10) and Vehicle Description (Figure 11) appears to provide little knowledge with regard to human factors based on this first look.

In the vehicle type field in the database (Figure 9), information was submitted for 839 events. 80% of the events involve a vehicle (11 of those where an aircraft was involved). Thus looking at airside driving and vehicle operations on the airfield would appear to provide the most return on investment.

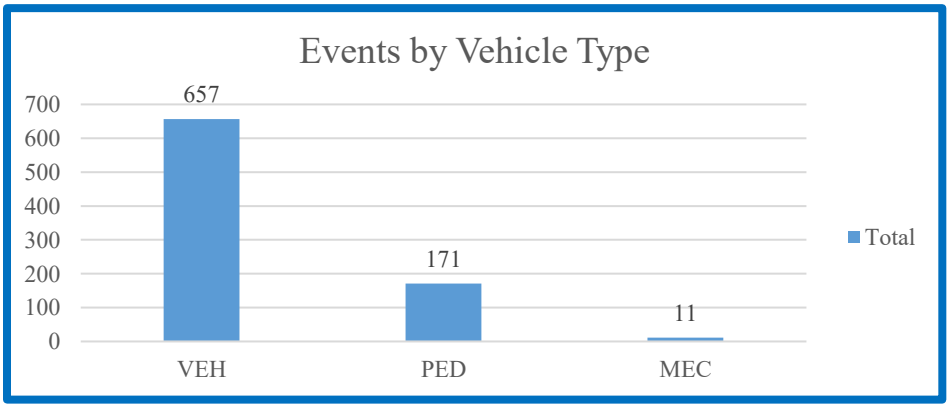

Figure 9. Events as a Function of Vehicle Type. Research Team Analysis.

For the events where a vehicle code was entered (Figure 10), cars were part of 34% of the events. A variety of other vehicles were found to be part of the remainder of the events involving vehicles.

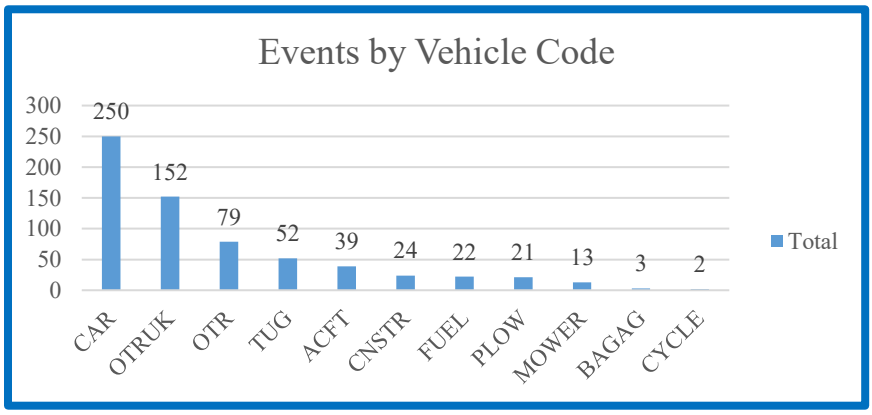

Figure 10. Events as a Function of Vehicle Code. Research Team Analysis.

A more detailed breakdown of the vehicle types is shown in (Figure 11). Tug with Aircraft and Fire Trucks are the two highest in this data field, however the number of vehicles involved in V/PDs is far greater than the number of vehicles described in Figure X. This could be another indicator in the inadequacy in the investigation techniques used for airport incidents and accidents.

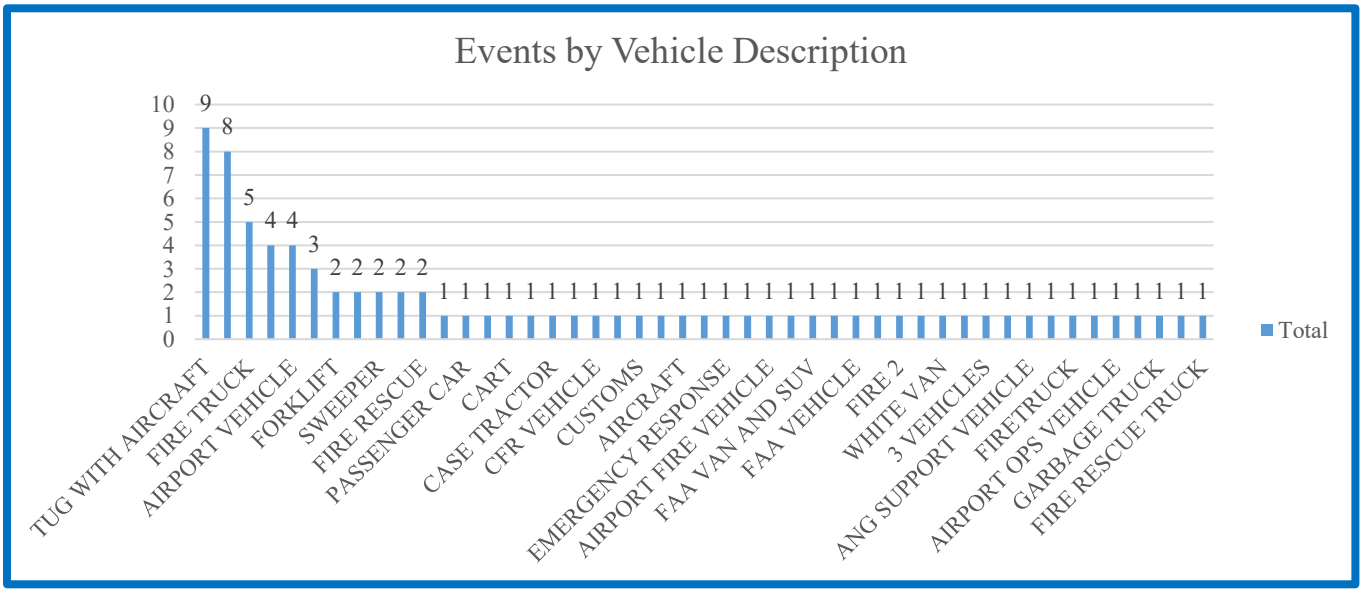

Figure 11. Events as a Function of Vehicle Description. Research Team Analysis.

Events by Operator. Figure 12 provides a breakdown of the information available on those operating the vehicles involved in V/PDs. As with other fields, data was not collected for all events; 584 events (69%)

had an entry in the Operator field. Of those, 58% of the operators were either airport employees or they operator was unknown. The remainder had a variety of airport stakeholders involved.

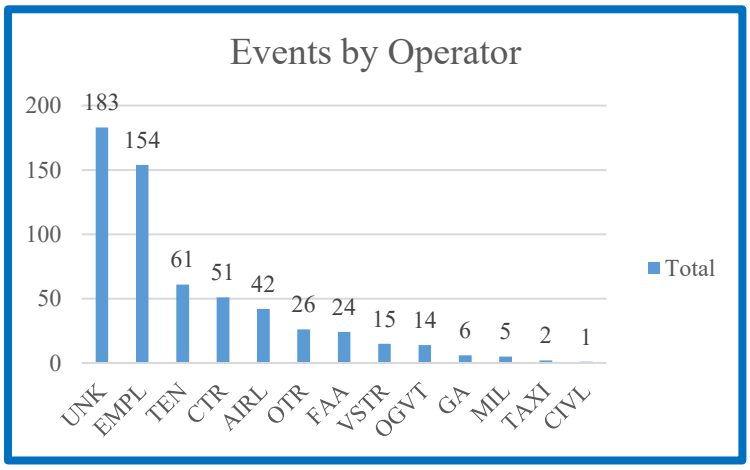

Figure 12. Events as a Function of Vehicle Operator. Research Team Analysis.

Events by Communications. Of the 847 events in the database, 726 had information in the Communications Equipment field (Figure 13). Of those, 53% indicated either no or unknown communications equipment. A radio was available in 43% of the events. Interestingly, only one event indicated a phone was used – given the situation today, it would be expected that nearly everyone working airside has a phone either on their person or readily available. The use of mobile devices as a mitigation strategy will be a focus of research in Phases II and III.

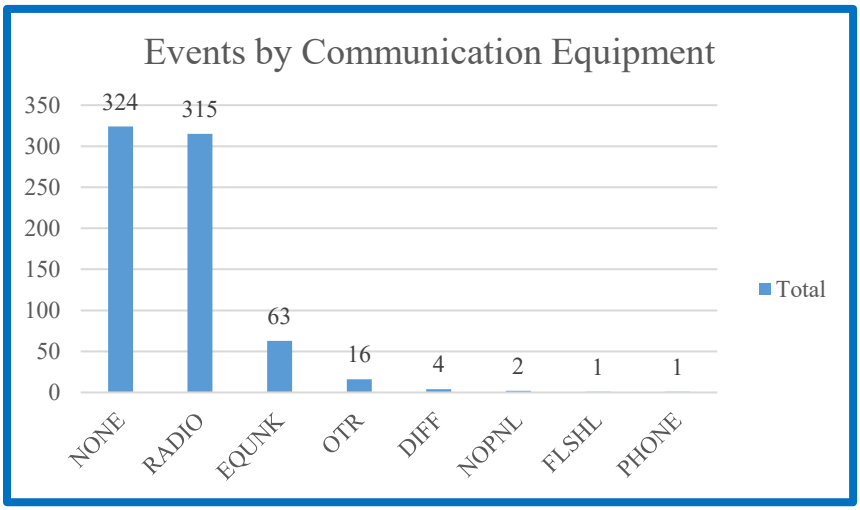

Figure 13. Events as a Function of Communication Equipment. Research Team Analysis.

Events by Training. For 582 events (69%), the Training Availability field was filled in (Figure 14). For 558 of those events (96%), training was available for those involved in the event. What the field does not indicate is the type of training available, nor the content or quality of the training. It is assumed that the

training recorded in this field refers to airside driver training. Reviewing airside driver training is a specific objective of this project and will be a focus in the upcoming project phases.

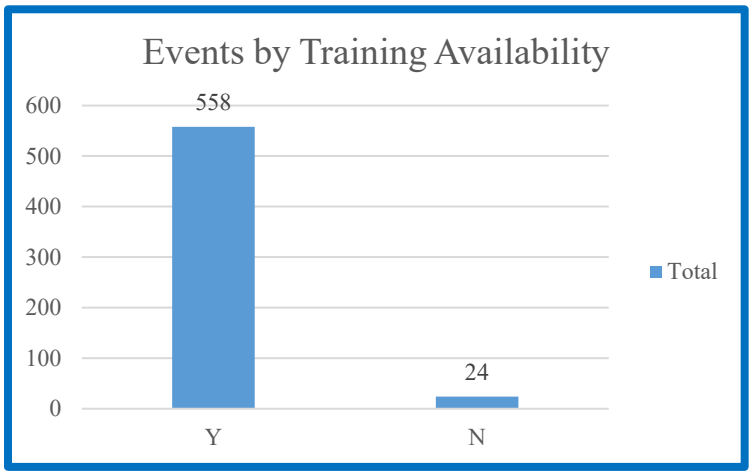

Figure 14. Events as a Function of Training Available. Research Team Analysis.

In 544 of the event investigations, training completion by the person or people involved was examined. The investigations looked into whether or not the training available was completed (Figure 15). For 65% if the events (352 event write-ups) training was completed; therefore it follows that 35% of the events involved untrained personnel or the status of the training completion was unknown. Again, driver training programs and curriculum are subjects marked for examination in the next project phase.

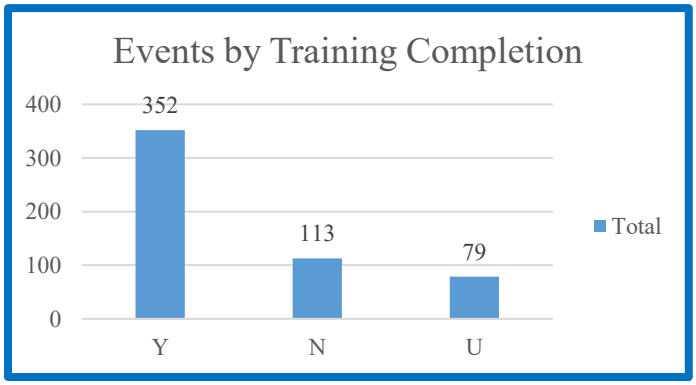

Figure 15. Events as a Function of Training Completion. Research Team Analysis.

FAA Analysis of V/PDs During FY-17 and FY-18

As previously stated, the FAA Runway Safety Office conducts analysis on runway incursions, to include V/PDs. The analysis is performed annually and comparisons are made between the current data and data from past years. From the analysis summary provided in form of a PowerPoint Presentation to the research team, some relevant and interesting information was gleaned that adds insight to the project. What follows are some of the key aspects of the FAA analysis performed on FY17-18 V/PD data.

The FAA found that there was a 20% increase in V/PDs between FY-17 and FY-18. The largest contributor to the increase was airport vehicles. There were also increases in visitor and privately owned vehicles (POV), construction vehicles, and FAA events. The analysis also cited an increase in the number of unknowns reflected in the investigation reports which could reflect the accuracy of the reporting or the thoroughness of the investigations.

The Runway Safety Office has access to additional information provided by the airports conducting the investigations of the events. This additional information is primarily in the form of expanded narratives of the events and responses to questions posed by the FAA regarding the investigation letters and forms submitted by the airports. This amplifying data was not included in the FAA database provided to the research team.

While the FAA Runway Safety Office analysis does not focus on the human factors underlying the event findings, the findings do provide additional insight regarding specific airport activities and their contributions to V/PDs. Key parts of the FAA analysis are described here.

ARFF Vehicle Issues. One class of airport vehicles examined that contributed to the increase in V/PDs were Aircraft Rescue and Fire Fighting (ARFF) vehicles. ARFF incidents were not frequent in the data but some of the underlying causes for the events add validity to the findings of the research team.

The Runway Safety Office looked at the reasons the ARFF vehicles were on the airfield and found the following:

- Ongoing airfield emergency (3)
- Participating in a drill (1)
- Participating in Training/Airfield Orientation (2)
- FOD Inspection (1)
- Unknown (1)

The causes of these events were determined to include the following:

- Route assigned by Air Traffic Control (ATC) was different than the usual route when traveling to emergency location
- ATC Replied Roger
- Driver talking to trainee
- Did not follow ATC instructions
- Both ATC Trainee and Driver used non-standard phraseology
- Unknown

Without amplifying information on the events, coding of the human factors per the HFACS taxonomy is not possible. That said, these event causes show indications of communications, coordination and planning errors.

Construction Vehicle Issues. The Runway Safety Office examined eight events involving vehicles participating in airport construction projects. In one of the events, the driver parked a vehicle in movement area. Although had received driver training, the investigation found that the driver was unfamiliar with parking procedures; and the airport inspections failed to detect the vehicle during the night. In two incidents, drivers became disoriented while on the airfield on two occasions; while in another incident, the driver was not cognizant of the runway safety areas boundaries due to differences in the markings and signage on different ends of the runway.

As with the ARFF incidents, HFACS coding is not possible given the limited information in the FAA presentation. However, the summary of causes does tend to indicate decision errors, with the potential for tools and technologies (in the form of airport markings and signage contributing to the incidents.

Snow Removal Operations Issues. Ten events related to snow removal operations were examined. While there is limited information in the summary to add to the human factors discussion, it was determined that inexperienced personnel, poor visibility, and the use of non-standard phraseology by ATC were contributing causal factors. The research team does intend to explore snow removal operations during future airport interviews during the upcoming phases. The research team hypothesizes that fatigue can be a key contributor to decision and human performance degradation during snow removal operations.

Other Airport Vehicle Issues. The Runway Safety Office looked at an additional 77 incidents where airport vehicles other than ARFF and snow removal vehicles were involved, and information relating to the reasons the vehicles were on the airfield and the incident causes was available.

As to why the vehicles were on the airfield, the following determinations were made:

- Conducting airfield/runway inspections (30%)
- Performing maintenance (14%)
- Escorting aircraft or other vehicles (11%)
- Mowing operations (8%)
- Responding to an emergency (6%)
- Driver training (1%)

Information relating to the causes of the incidents other than the nature of the vehicle operation was not available. These types of daily airport vehicle operations will aid in directing the discussions during airport interviews in Phases II and III of the project.

Visitors and POV. When examining incursions were airport visitors and POVs were involved, the Runway Safety Office analysis found the following potential causes:

- Driver did not follow instructions
- Lack of driver training
- Lack of adequate fencing
- “Piggy-Backing” through the gate

- Tenant let visitor onto the airport
- Lost trying to exit the airport
- Tenant failed to escort the visitor
- Disregard for airport signs

This analysis follows closely with that of the research team in the HFACS analysis. Additionally, if the assumption is made that the majority of the visitor and POV events happen at smaller airports, it makes sense that additional exploration of small airport access procedures, as well as FBO policies and procedures should be examined further during the remaining project phases.

5. Technologies and Processes

Potential mitigation strategies to reduce human performance risks for the purpose of improving airside safety and reducing V/PDs include introducing new technologies and adjusting airport processes. Both of these approaches require resources; with some technology solutions, the monetary resource requirements may be beyond the airports ability to manage. Thus, researching approaches that can help improve situational awareness and decision making while ensuring benefits of such changes outweigh the costs are key elements of the research.

In the Problem Statement for the project, the research team is required to explore and then address in the report the following:

- How technologies and processes potentially could be used to reduce or mitigate risks from reduced human performance.
- Effective technologies and processes exist that affect and could potentially improve situational awareness for airport employees and others working on the airside.
- Estimates of resource requirements, including cost, of these technologies and processes.
- Limitations and complications these technologies and processes may add to the demands of people working in the airside environment.

This effort began in Phase I of the project and will continue in the subsequent phases. During Task 3, the research team researched available technologies and began the exploration of airport policies in use to improve situational awareness and decision making, thus reducing V/PDs. The team looked at technologies and policies in three areas:

- FAA Sponsored V/PD Prevention
- Vehicle Tracking and Situational Awareness Enhancement
- Fatigue Monitoring

During the upcoming project phases, the potential impacts of implementing such changes, and the costs and resource requirements associated with the changes, will be examined.

Before discussing potential technology advances that could be used, and in some cases are being used, in the airport environment, current efforts to improve surface movement awareness by the FAA are discussed.

FAA Sponsored V/PD Prevention

There are several technological solutions being implemented by the Federal Aviation Administration to attempt and reduce the number of runway incursions. These solutions can apply to aircraft, vehicles, and pedestrians. The main systems currently being used are: Runway Status Lights (RWSL) technology; Airport Surface Detection Equipment Model 3 (ASDE-3) and Airport Movements Area Safety System (AMASS); Airport Surface Detection Equipment Model X (ASDE-X); and electronic flight bags (EFB).

One of the most notable advancements has been the implementation of RWSL technology. This system has been implemented at 20 major airports across the United States. As part of this program, operators see in-pavement lighting which indicates whether or not the runway is occupied. These lights serve as a backup to voice communications and clearances. There is also information provided on RWSL in an associated technical report from the FAA published in 2019 (FAA, 2019a).

The ASDE-3 and the AMASS uses radar to track airport ground movements (FAA, 2018). The system provides air traffic controllers with visual and audio alerts if potential collisions are detected on airport runways. ASDE-3 provides the radar for the system while AMASS is the software and hardware components of the system.

An additional system related to ASDE-3/AMASS is ASDE-X. While ASDE-3/AMASS uses non-integrated signals, ASDE-X incorporates multiple data sources such as radar, transponders, and automatic dependent surveillance broadcast (ADS-B) to provide more accurate position locations of airport movements. ASDE-X is be supplemented with the new system Airport Surface Surveillance Capability (ASSC). ASSC is similar to ASDE-X, and it allows aircraft and ground vehicles to be seen by air traffic controllers on the airport surface and within a few miles of the airport, (FAA, 2019c).

Lastly, the use and implementation of EFBs has helped increase situational awareness for users, namely pilots (FAA, 2018). These tablets consist of airport maps along with georeferenced positioning so operators can identify their location on the airport surface. These electronic devices can be deployed in either aircraft or vehicles at relatively minor costs. In conjunction with the use of electronic flight bags, the FAA technical report discusses the implementation of Geographic Information Systems (GIS) to create detailed mapping of airport surface areas. These advanced maps could be used along with EFBs to provide detailed location information for airport surface operators.

There were four references found during the Literature Review (Task 2) that may prove valuable during the remaining technology exploration. The technologies cited are related to the FAA technology programs just discussed.

Ali, Ochieng, Majumdar, Schuster and Chiew (2014) (#98) identify the use of ADS-B as a way to provide better air-to-ground location information. The purpose of their study was to evaluate failure modes of ADS-B, but the use of ADS-B could be implemented and used within vehicles as well. ADS-B is highlighted in the tech report with the L3Harris Vehicle Movement Area Transponder (VMAT). This system uses ADS-B for real-time tracking of surface vehicles on the airport. Similarly, Logistimatics Inc. is discussed in the tech report as providing vehicle GPS tracking.

Stubbotin (2011) (#103) conducted a report for the FAA implementing Global Positioning System (GPS) locators on vehicles to help provide situational awareness as part of an airport ground vehicle warning system. The study found that the systems could be implemented for approximately $1,500 to $4,000 for independent devices and the system implementation would be around $100,000. The minimum performance specifications were vehicle location, location receiver placement, proximity warnings, holding position marking alert areas, runway safety area alerts, audible signal, and visual signals. This

study could be linked to the idea of incorporating GPS with geofencing. Other related areas highlighted in the tech report include the use of GPS, cell phone/GPS technology, and Bluetooth.

Colone, Martelli, Bongioanni, Pastina and Lombardo (2017) (#124) examined the use of a Wi-Fi based passive radar system which could be used primarily at smaller airfields for aircraft and ground vehicles. The results indicated fairly good tracking of aircraft, vehicle, and pedestrian targets. The findings from this study could be linked with the idea from the FAA technical report of creating GPS tags which work with the Internet of Things (IoT) to provide location information for specific vehicles.

Kopald and Chen (2014) (#194) completed a paper on the development of a closed runway operation prevention device (CROPD). The goal was to combine the runway status with speech recognition. The system would work by recognizing a controller's verbal clearance for operations such as takeoff or landing on a closed runway, and then would issue an alert.

The research team intends to go back to these references as options for airports are explored in Phase II. With the exception of the study by Colone et al (2017), on the use of a WiFi system, the approaches studied involve complex systems that may include large price tags. These solutions may work well at large airports, but not practical at smaller airports.

Vehicle Tracking and Situational Awareness Enhancement

There are technologies being used or being developed in other industries to track vehicles and improve situational awareness that could find application to airport operations. Some interesting possibilities are discussed here.

Law enforcement is exploring the possible benefits using GPS in conjunction with geofencing in areas of cities patrolled by police. Geofencing is the practice of setting up "virtual walls" using GPS coordinates that can interact with equipment. Geofencing a taxiway or entrance to a runway could send an automatic alert to the ground controller, or it could alert the driver to stop and ensure they have clearance before proceeding. It would also be possible to tag people/equipment on or off the movement areas and even automatically switch their radios to the ground control frequency.

Expanding on the IoT, it is not just a technology itself but rather a technology architecture made up of several different items that can interact (talk with) one another. GPS tags affixed to the equipment function as sensors to create a thread of digital information about the location of a specific piece of the equipment. While not discussed in the article, it would follow that two vehicles (e.g. a maintenance truck and an aircraft; or a luggage cart and a catering vehicle) connected in the IoT framework could warn each other of impending conflicts when they get too close, or approach the boundary of a restricted area on the airfield – such as the hold short line.

Edge Computing is a distributed computing paradigm which brings computation and data storage closer to the location where it is needed, to improve response times and save bandwidth. Employing this technology on an airfield could allow data to be seen in real time without the lag of sensor/GPS data traveling to an offsite cloud server. GIS data could be used within the concept, providing a dynamically

updated geographical context for data vehicle and equipment locations. Digital maps can thus enable an aggregate and spatially contextualized viewpoint of data on potential threats, specific hazards, target objectives, or critical resources — in other words, enhanced spatial awareness.

Lastly, Situational Awareness Platform software is the foundation on which the above technologies must function. It is the user interface that brings all the data together. In ground control, for example, it could give all information available tailored on the current issue. Directing normal operations in and out of the movement areas and keeping an eye out for possible hazards are potential benefits. In an emergency situation, the software could tailor data needed to direct emergency crews. Ground operators could have a much smaller data set available in their vehicles on a tablet of some sort.

From the military services, BattleView 360 is a user interface developed for ground troops. It uses external optical sensors (normal vision/infrared) to feed imagery to a helmet-mounted display that synchronizes with head movements and stiches together a complete picture of the battlespace (which in the case of this project would be the airfield). A tablet display can be used to digitally collate, map, and classify various features on the battlefield (airfield) to track their environment. This technology might be most usable for emergency responders and flight crews, but these head-mounted displays could be adapted to headgear for ground crew supervisors and airfield drivers to improve situational awareness in daylight, nighttime, and in low-visibility situations.

Telematics is an interdisciplinary field that encompasses telecommunications, vehicular technologies, electrical engineering (sensors, instrumentation, wireless communications, etc.), and computer science (multimedia, Internet, etc.). An interesting advance for municipalities using telematics is called V2X, or rather Vehicle-to-Everything. V2X is comprised of V2I (vehicle-to-infrastructure), V2N (vehicle-to-network), V2V (vehicle-to-vehicle), V2P (vehicle-to-pedestrian), V2D (vehicle-to-device), and V2G (vehicle-to-grid) communications. V2V devices “talk” to each other and alert occupants with forward collision warnings, lane change warning/blind spot warnings, emergency vehicles approaching alerts, and roadwork warnings. They can take over emergency braking, assist with intersection movement, and organizing vehicle platooning (multiple vehicles moving together as one like a train). V2P and V2D can alert drivers and pedestrians of potential dangers.

In 2016, Toyota became the first automaker globally to introduce automobiles equipped with V2X. These vehicles use DSRC (dedicated short-range communications) technology and are only for sale in Japan. In 2017, GM became the second automaker to introduce V2X. GM sells a Cadillac model in the United States that also is equipped with DSRC V2X. Industry analysts suggest that there will be 6 million V2X-equipped vehicles by 2022.

L3-Harris offers a Vehicle Movement Area Transponder (VMAT) ADS-B Vehicle Tracking Unit. Using ADS-B, VMAT provides accurate, real-time tracking of surface vehicles in the airport movement area to provide complete surface situation. This improves collaboration, safety, efficiency and can reduce runway incursions. The VMAT is able to integrate into the Symphony, OpsVue, and MobileVue products providing operations management and vehicle operators complete airport-wide situational awareness.

The GO9 by Geotab is a plug and play device that plugs into a vehicle's electronics port. This technology offers highly accurate GPS vehicle tracking, engine and battery health assessments, advanced vehicle data capture, collision detection & notification via a built-in accelerometer. An IOX expansion port allows for additional services such as satellite tracking, driver ID, hours-of-service, temperature tracking, camera systems, and more. This may be a less expensive option for small hub and GA airports to keep track of their vehicles. Historical data can be used for investigating a mishap or reviewing a particular driver's unsafe habits.

Logistimatics is a company that offers several vehicle and personal tracking devices at cost more suited for small airports. The Qbit GPS Tracker (currently $44.95) is smaller than a cookie and has a three-day battery life. Their Mobile-200 GPS Tracker (currently $49.95) has a battery life of 2 to 3 weeks. The Auto-325 GPS Car Tracker (currently $59) plugs into the vehicle's electronics port to provide tracking information. These systems are capable of 2-way communication, and have geofencing capabilities.

Foreflight is a company that produces aviation applications for mobile devices. They have developed a Runway Proximity Advisor that has been built into their aviation app. It can provide visual and audible alerts when it is getting close to a runway. Even though the app is primarily used by pilots, it appears to could easily be developed for airport vehicle operators.

A company called Team Eagle (based in Canada) makes a product called Asset Tracking and Incursion Management System (ATIMS). This solution uses equipment that can be installed in a vehicle to alert the driver if they are approaching a restricted area. It can also be set-up for areas other than runways (e.g. construction sites, etc.).

Fatigue Monitoring

The final technology topic area for this discussion is fatigue monitoring. There are a number of companies that provide methods to monitor sleep activity, as well as provide information during normal activities to assess levels of fatigue in humans.

SmartCap is a device originally designed for the Australian mining industry but has found to be useful in other industries as well. It is being tested to monitor the fatigue levels of long-haul truckers. SmartCap is wearable technology that measures changes in a person's electrical activity in the brain (EEG), a widely accepted indicator of a person's alertness. Rather than reacting to microsleep episodes, SmartCap is proactive and can detect fatigue levels before microsleep occurs.

SeeingMachines Guardian is another automated fatigue measuring system. Instead of EEG monitoring, SeeingMachines Guardian uses a camera that measures eye and face movements to measure fatigue levels. The advantage to this system is that in addition to fatigue, Guardian can measure how distracted a driver is as well. A downside to the system is that it can only measure fatigue levels while driving. If a maintenance worker leaves the truck to fix a taxiway light, it wouldn't be able to keep track of fatigue or distraction levels.

Optalert is another company producing wearable technology that proactively measures fatigue levels. Their system, BlinQ, uses infrared light to measure eyelid movements. The sensor technology is mounted inside glasses frames where sunglasses or prescription lenses can be fitted to the wearer. Optalert has data collection and reporting software that allows managers to monitor fatigue levels of individual workers that could aid in make schedule changes as needed to keep employees safe.

Fatigue Science's Readiband actigraph is a wrist band that monitors a person's sleep score and the quality of sleep to give a person information on their sleep patterns – the only true remedy to the effects of fatigue. It takes sleep and awake patterns, along with the quality of sleep into account to make suggestions to improve a person's sleep score. The device has been tested by military aviation organizations.

CurAegis Technologies has a system called CURA (Circadian User Risk Assessment). This is used with the myCadian fatigue model and Z-Coach training program to teach the wearer how to increase their sleep scores, thus decreasing sleepiness and fatigue. A watch worn by the person has sensors that monitor circadian rhythm, sleep patterns, and other biological metrics to display a CURA score. Computer lessons and data are then tailored for the individual to help increase average scores.

Maven Machines' Co-Pilot is a headset worn by a driver. It can detect if the driver is looking straight through the windshield, checking mirrors, or distracted in another way. It can also detect head bobs and head jerks, both signs of microsleep. The headset has a dual microphone and headphones to enable hands-free communication as well. The Smartsense IoT program analyzes movement to offer a "Maven Score", how often mirrors are checked, and a distraction level.

Bosch Mobility Solutions has created a system that using steering wheel movements and other factors to detect driver drowsiness. Their website states that the system uses an algorithm that utilizes 70 different signals to access a driver's level of drowsiness.

Summary and Follow-On Project Efforts

The technologies described in this section provide a number of potential solutions that could help address the risks associated with human errors in decision making, distraction, confusion and fatigue. Each will carry a price tag (some more affordable than others) and require varying levels of integration complexity to fit within an airport's operating policies and processes.

In Phases II and III of the project, the research team will examine a select number of these technology solutions for further exploration; examining the scope of the systems, the costs involved, training requirements, infrastructure requirements, and the projected service life of the technologies given the rapid advance of electronic and autonomous vehicle technologies in today's world.

One area of focus for the team will be on those technologies that can be used in conjunction with the mobile devices that airport personnel carry on their person. This would appear to offer solutions easiest to implement and be acceptable for use by employees.

6. Airport Site Visits

The research team conducted three site visits to airports during Phase I. The purpose of these site visits was to: 1) gain initial validation of the research findings from Task 2 (Literature Review and the Data Analysis); 2) examine the technologies and processes being used to mitigate human factors risks at these airports; and 3) to interview airport leadership, supervisors and airside employees to explore their insights into the subjects of greatest interest and concern to them.

The airports visited, along with the dates of the site visits and characteristic information about the airport, were as follows:

- Orlando Melbourne International Airport (MLB); Melbourne, FL; January 29-30, 2020
  - Non-Hub Airport
  - Home to numerous aerospace contractors supporting NASA
  - Home to FIT Aviation, the university aviation operations of Florida Tech University
- San Antonio International Airport (SAT); San Antonio, TX; February 26, 2020
  - Medium Hub Airport
  - Early SMS adopter
  - Mature safety processes
- Daytona Beach International Airport (DAB); Daytona Beach, FL; March 4, 2020
  - Non-Hub Airport
  - Home to Embry Riddle Aeronautical University
  - Home to the NextGen Test Bed supporting FAA air traffic management advances

The research team sent four team members to the first site visit at MLB which lasted two days. This was to establish the process and areas of focus for the follow-on site visits. The follow-on visits were conducted by two team members, one of which had participated in the MLB site visit, and were limited to one day on site. The planned agenda for the MLB visit along with the prepared questions used by the team to guide the interviews and discussions with airport personnel is included as Appendix 3.

Key Findings from the Site Visits

There were a number of findings from the site visits that were in line with the analysis of the V/PD data. These findings were consistent at the three airports. Additionally, there were variations on the views of certain issues between the three airports that also shed light on the challenges airport face in mitigating human factors risks.

Common Issues. The following were common issues expressed by airport personnel or observed by research team members during the site visits. These issues are worthy of additional examination during Phases II and III.

Communications. Communications between drivers operating in the airside environment, particularly between drivers and ATC when access to the movement areas is required, was a common issue at all three

airports. This is in line with a key finding from the Data Analysis. Communications challenges can lead to confusion for drivers, which in turn can result in vehicle operations contrary to that approved by ATC or in conflict with airport procedures. Some of the aspects impacting effective communication include:

- Non-standard terminology or phraseology
- Expectation bias (driver expects to hear one thing and ATC says something different)
- Inexperience drivers uncomfortable or intimidated to speak on the radio

Airport Access and Escorting Procedures. Two of the three airports visited (DAB and MLB) were small airports where a significant percentage of the operations result from with flight school activity or general aviation flight supported by FBOs. As a result of the airport size and the staffing, as well as the number of personnel that access the airport who are not airport employees, there are challenges in ensuring that those on the airfield adhere to surface movement procedures.

One issue faced is limiting access inside the fence line at FBOs. Each FBO utilizes its own procedures for gate access and escort once on the airfield, and each airport has it unique boundary security challenges and practices. This is an area that contributes to a large number of V/PDs at small airports and may warrant examination from a human factors standpoint, mainly in managing violations.

Escorting procedures is not limited to small airports and their control of access. SAT expressed concern about the number of drivers authorized to operate on the airfield and the escort procedures needed to manage access and compliance on the movement areas given limited staffing available to maintain continuous escorts.

Investigation Processes. It was acknowledged at all three airports that the requirements for and training received to conduct investigations of incidents was lacking and does not adequately address the examination of human factors behind the causes.

Individual Airport Issues. In addition to the three common issues, each of the airports expressed individual issues that impact operations at their facilities. While these were expressed by one of the three airports, the research team anticipates that they are not unique in the industry as there was knowledge gained from the V/PD data analysis that supports further examination.

ATC – Airport Relationships. At one of the airports, the research team observed a somewhat adversarial relationship with the airport. This relationship has resulted in confusion by drivers regarding the instructions they receive, reluctance of drivers to ask for clarification, impatience with driver requests exhibited by tower controllers focused on controlling aircraft during times of high tempo operations.

Fatigue during Snow Removal Operations. While none of the airports visited deals with snow removal, one senior manager at SAT had worked previously at an airport on Canada. He expressed his belief that the practices the airport used in scheduling their personnel during snow removal operations resulted in fatigued drivers who were more prone to errors and incursions.

Driver Training. Only one airport expressed concern with the content and quality of their driver training program, and was planning to review and revise their practices. The main concern expressed was that the training was conducted online by completing courses provided by a third party vendor. Any training specific to the airport needed to be conducted on the job, and the content and quality was dependent on the trainer. The research team plans on examining airside driver training in depth during Phase II, and this is believed to be an area where improvements can be made industry wide that will positively mitigate human factors.

Airport Culture. An airport has multiple stakeholder operating vehicles and with varying numbers of drivers having access to the airside environment. Each stakeholder has its own culture that influences their activities, some of which may not be in line with the overarching culture fostered by the airport. Thus some drivers may be more susceptible to decision errors or violating airport procedures than others. The ability of the airport to drive the cultural impacts on human performance by all working airside, and the techniques an airport might employ to influence the performance of tenant and other stakeholder personnel could be a subject for project exploration or follow-on research.

Unintended Outcomes of Technology Introduction. The only airport visited that employed vehicle technologies other than radios as a standard practice was SAT. The operations supervises at SAT often operate their vehicles with laptops, multiple phones, and multiple radios available for use. SAT Operations leaders expressed concerns that the introduction of more technology solutions could have unintended outcomes and perhaps lead to more incidents due to distracted drivers.

Higher Risk Operations as a Function of Time of Day. An interesting observation made by the ARFF personnel at SAT was the drivers seem to be more susceptible to errors close to dawn and dusk as a result of the position of the sun adversely impacting their vision. The research team was not able to examine time of sunrise and sunset during the data analysis. This level of analysis could taek considerable time and not produce actionable knowledge. However, this could be a topic explored during future airport interviews.

7. Executive Summary Topic Outline

As part of Task 5, the research team planned to develop an early outline upon which to build the Executive Summary Content project deliverable. The Task 5 description in the AWP includes the following:

> *"The research team will use the findings of the first four Phase I tasks to create an outline for the Executive Summary on Airport Human Factors planned for Phase II. The purpose of the outline is to present an initial set of ideas to the Project Panel on the key information areas upon which airport decision makers might focus resources and enhance risk-based decision making. By presenting these initial thoughts early, the research team looks to solidify a common understanding of the approach to this important project deliverable."*

The ultimate project objective as put forth in the Problem Statement reads as follows (different parts of the Problem Statement are combined here to cover the entirety of the project requirement:

- **Supporting Project Objective:** Inform airport decision makers of the human factors related to airside operations and make a justifiable case for allocating resources to mitigate the risks from human elements operating in the airside environment. *(Develop a report that)* includes unformatted content for a stand-alone executive summary for decision makers to help develop strategies for identifying and implementing strategies for their unique situation. (*Special Note*) The stand-alone executive summary should be concise and focus on the most compelling information needed for decision makers responsible for allocating funds to airside safety programs.

In order to meet this objective, the research team planned for the following as elements of Task 11 in Phase II (summarized from AWP):

- **Task 11 – Develop Executive Summary:** Develop the recommended content for the planned executive summary that will inform airport decision makers during the decision-making process for the allocation of resources and funds for airside safety programs.
    - Present key information areas upon which airport decision makers might focus resources and enhance risk-based decision making.
    - The content will focus on the areas and approaches that will have the greatest risk reduction impact related to runway incursions and V/PDs. The content will address the costs and levels of effort required for implementation of the mitigations so that airport leaders for airports of all sizes can use the information in their decision making and budget development processes.

Important knowledge was gained during Phase I that has led the team to develop the following topics as potential content for the Executive Summary. This is a starting point and the research team expects additional areas of interest to be discovered during Tasks 8 and 9, as well as during the discussions with the Project Panel at the Interim Meeting.

Executive Summary Content Outline (Phase I Input)

Based upon the research results and research team consultation during Phase I, the following are considered Key Points to consider for inclusion in the Executive Summary Content Deliverable to be developed in Phase II of the project.

- Airside Communication Effectiveness
    - Standard terminology development for movement area driving
    - Training for radio communication
        - Improve understanding
        - Enhance driver confidence on the radio
    - Stakeholder engagement in improved communications
        - Air Traffic Control Tower
        - Airport Operations and Maintenance
        - Emergency Response
        - Airlines and FBOs
- Airside Driving Signage and Markings
    - Markings for common driver understanding vice solely pilot understanding
    - Common street signage, markings, and driving lanes
- Airfield Access Control (primarily at small airports)
    - Techniques for preventing civilians from accessing airside
    - Physical constraints
    - Awareness
    - Escorting practices
- Technologies to Enhance Situational Awareness (Phase II research topic)
    - Vehicle tracking
    - Communication modes to include mobile device use
    - Moving Maps
    - Costs and benefits
- Fatigue Risk Management (Anticipated shift in research during Phase II)
    - Fatigue knowledge for employees
    - Airport policies and practices to manage fatigue risk
    - Sleep monitoring technologies available
    - Management responsibilities
    - Individual employee responsibilities
- Investigation of Incidents and Accidents
    - Human factor considerations
    - Personnel history for past 24 to 48 hours
    - Communications systems
    - Training received
    - Supervision

8. Proposed Revisions to the Amplified Work Plan

During the course of Phase 1, the research proceed as per the Amplified Work Plan (AWP) with very little variation. As stated in the earlier sections, there were two areas where the research project had limited results. These areas were:

- Accessing and analyzing international data on V/PDs
- Exploration of the impacts of fatigue as a causal factor in airport incidents

International Data

The research team recommends that efforts to gather and analyze international V/PD data be suspended. The time dedicated to contacting the right people at ICAO who may have the desired data have proven unsuccessful. The research team believes that the information made available by the FAA provided significant insight into the documented causes of V/PD events at domestic airports fully supports the project objectives. The team feels the likelihood of discovering anything new or significant in the analysis of international data is low, thus the cost in time of acquiring and analyzing such data would outweigh the benefits.

Fatigue

A specific objective of the research defined in the Problem Statement is to ensure the project report, "Identifies risks associated with reduced cognitive ability and situational awareness caused by fatigue or overload." The findings in Phase I reveal that meeting this objective as written will be very difficult. In fact, this objective could be the subject of its own research project. The reason for the difficulty is the lack of data on fatigue as an accepted causal factor in airside incidents. As stated in the Phase I findings, current investigative techniques employed at airports, and the reports authored using these techniques, generally do not adequately address human factors – particularly fatigue impacts.

The research team recommends modifying the fatigue objective in a way that can produce actionable results for airports. Given that the analysis of the FAA V/PD data revealed that nearly 80% of the events involved decision errors, it is not unrealistic to assume that a percentage (perhaps a sizable percentage) of these errors can be traced to cognitive fatigue. Flying organizations have accepted this conclusion based on a number of studies and produced guidance on aircrew fatigue management (IATA, ICAO, FAA, Transport Canada, various airlines) so it follows that fatigue impacts other aspects of fight operations support. The literature review for this project did not explore fatigue risk management guidance or programs outside of those relating to the airport industry. This is a gap in the research that can be addressed in Phase II.

The research team recommends that additional exploration of fatigue focus on the fatigue risk management programs currently operating in the aviation industry and select other high risk industries (rail, trucking, medicine are potential options) and determine the aspects of these initiatives that could

directly translate or be modified to fit the airport airside environment. The majority of this effort would fall under Task 8.

Apart from these two modifications, the research team holds that significant changes to the tasks proposed for Phase II of the project are not necessary.

Planned Phase II Tasks

Phase II of the research project is comprised of seven tasks; the first four tasks (Tasks 8 – 11) providing the research and material to be included in the development and delivery of the Interim Report (Tasks 12 and 13), followed by the gathering of the project principals for the Interim Meeting (Task 14). Tasks 8 – 11 of Phase II will be discussed here to refresh the Project Panel on the planned approach, and propose specific changes to the plan in order to best meet the research objectives.

Task 8 – Research Human Factors Impacts, Required Cognitive Tasks and Airside Abilities

Task 8 is defined in the AWP as follows:

> Continue and advance the in-depth analysis on the impacts of human factors on airside safety, to include the identification and prioritization of the cognitive tasks and airside abilities necessary to improve airport safety performance.

The task is further detailed in the AWP as follows:

> *"The research team will continue the research performed during Phase I but in a more in-depth and focused manner. Specifically, the Futron Team will further analyze key literature review findings and the human factors causal factors identified during the safety data analysis to specifically accomplish the following:*
>
> - *Outline the airside demands and conditions that limit or reduce situational awareness.*
> - *Analyze the risks of fatigue and task saturation (or overload) to airside operations.*
> - *Identify and prioritize the cognitive tasks demanded when working airside and the abilities required of airport personnel to effectively perform their assigned duties.*
> - *Collate the technologies and processes that can enhance situational awareness and reduce human factors risks with the identified airside tasks and abilities.*
>
> *"The work in this task will add focus to how changes in these specific human performance areas, and the mitigations in use and to be developed that better manage the associated risks, can reduce the number of runway incursions and V/PDs and just as importantly, translate to improved safety performance in the ramp and*

non-movement areas. The results of this task will inform the work performed in the other phase tasks and the development of the Phase III research recommendations."

This Task as proposed will meet project objectives by diving deeper into the findings in Phase I toward the development of mitigation strategies. In particular, the team will add to the subtasks listed in the AWP in the following ways:

- *Outline the airside demands and conditions that limit or reduce situational awareness* – Additional examination of airside communications procedures and training, the use of mobile devices for situational awareness enhancement, and driver training techniques will be conducted.
- *Analyze the risks of fatigue and task saturation (or overload) to airside operations* – As described above.
- *Identify and prioritize the cognitive tasks demanded when working airside and the abilities required of airport personnel to effectively perform their assigned duties* – This will be explored more in depth through interviews and added airport visits, especially to larger airports. Key information will likely come from the specific questioning on this subject with airport managers and supervisors.
- *Collate the technologies and processes that can enhance situational awareness and reduce human factors risks with the identified airside tasks and abilities* - The team will more completely link the technologies and processes explored in Phase I with the human factors outlined in the HFACS analysis of the V/PD database to develop recommendations and mitigations airport leadership can implement.

Task 9 – Research Impacts on Airside Situational Awareness and Incursion – V/PD Risks.

Task 9 is defined in the AWP as follows:

Expand upon the outcomes of the Task 8 work to examine how the cognitive tasks and airside abilities, as well technology and process changes, impact airside situational awareness and incursion - V/PD risks.

The task is further detailed in the AWP as follows:

"In the second task of this phase, a risk-based approach will be used to examine the potential impacts of the technological and process changes or mitigations on the hazards resulting in runway incursions, V/PDs and decreased situational awareness. By applying a risk management process that takes the known hazards present airside and result in the focus undesired outcomes, further analyzes their risks and prioritizes the risk mitigations, the research team intends to identify and <u>create a list of effective technologies and airport processes to reduce risks.</u>

> *"Based upon the developed, prioritized risk mitigations list, the Team will lay the foundation for the estimation of resource requirements and costing considerations airport leadership will need to make important risk-based decisions on the implementation of the mitigations. The work in this task will include an examination of the limitations and complications the introduction of these changes may present and add to the demands of those working airside; in other words, this task will address the residual and additional risks these advances will introduce."*

The research team does not intend to modify this task. No changes are deemed necessary and the approach will support project objectives. The underscored parts of the task description identify the key aspects and output of this task upon which the team will focus.

Task 10 – Develop Phase III Research Recommendations

Task 10 is defined in the AWP as follows:

Develop a recommended plan for the research to be conducted during Phase III of the project and recommendations for follow-on research after project completion that can build upon the accomplished research results.

The task is further detailed in the AWP as follows:

> *"The work in Phases I and II will allow the research team to craft recommendations for the topics that can and should be addressed in the final phase of the project, as well as what further research could benefit the airport industry and better manage airside risks. Given the depth and breadth of the human factors research field, as well as the time, scope and budget associated with ACRP 06-08, the work in this task will focus on creating a baseline for addressing human performance improvement in the airport industry and determining what can be accomplished with the remaining project resources."*

The research team does not intend to modify this task; however, based upon the findings of Phase I, it is unclear whether or not the anticipated topics outlined in the proposed research plan will be included in the recommendations. The topics presented in the proposal included:

- Driving training curricula
- Initial and recurrent airside personnel training for personnel with access to the airside environment.
- Impacts of fatigue on airport stakeholder personnel and their effects on airport safety
- Safety performance and human factors in the non-movement and ramp areas that result in airport property damage
- Human factors monitoring during Part 139 self-inspections
- Personnel turnover rates for airside workers and the associated human factors

Apart from the topic of fatigue (which was addressed previously) these topics and others developed during Phase II will be examined and prioritized during this task.

Task 11 – Develop Executive Summary Content

Task 11 is defined in the AWP as follows:

Develop the recommended content for the planned executive summary that will inform airport decision makers during the decision-making process for the allocation of resources and funds for airside safety programs.

The task is further detailed in the AWP as follows:

> *"During this task, the research team will develop the unformatted recommended content for the stand-alone executive summary of project findings the ACRP intends to publish for the airport industry. The content will focus on the areas and approaches that will have the greatest risk reduction impact related to runway incursions and V/PDs. The content will address the costs and levels of effort required for implementation of the mitigations so that airport leaders for airports of all sizes can use the information in their decision making and budget development processes."*

The research team does not intend to modify this task. The research will build upon the outline developed in Phase I and included in this White Paper. With the approval of the Project Panel during the Interim Meeting, the results of this task may satisfy the requirements of the final project deliverable, thus completing this project objective prior to Phase III.

9. Conclusions

The research performed during Phase I establishes a solid foundation for accomplishing the objectives for the project. An overarching goal of the research, as stated in the Problem Statement, is ". . . to improve airside operations safety through better understanding of human factors as well as improve each individual's situational awareness within the airside environment." By performing an extensive search of the literature, analyzing FAA data on V/PDs using the HFACS taxonomy and methodology, and exploring technologies that are currently available or in testing, the research team laid the groundwork for the planned efforts beginning in Phase II.

While the literature review revealed that the significant work done on aviation human factors focusses on flight operations and air crew performance (this highlighting the need for this research), there are key references that will guide the efforts during the remaining phases. One reference in particular supported the findings of Phase I and indicated that the research team was travelling a path toward providing meaning information to airport industry decision makers. In 2009, Young and Vkek concluded that there are four main causes for ground vehicle incursions: 1) driver distraction, 2) insufficient training, 3) poor situation awareness, and 4) failure to communicate effectively. (Young and Vlek, 2009) Findings from the data analysis, along with the results of the airport site visits, indicated that two key areas of focus during the remainder of the project will be driver training and airside communications.

With little data available on the impacts of fatigue on errors leading to incursions, the research team recommends that the fatigue focus change from accomplishing the objective of identifying the risks associated with reduced cognitive ability and situational awareness caused by fatigue or overload (as outlined in the Problem Statement), to assuming fatigue is a significant cause of increased risk of human decision making errors and shifting the research effort to identifying fatigue management practices and techniques that fit the airport airside environment.

An additional focus during Phase II will be to further examine the technologies that can improve situational awareness for those working and driving airside; limiting the focus to those that could be affordable for airports or various sizes with varying levels of resources. While not specifically outlined in Section 5 of this report as being a focus of new technologies for airport operations, the airport visits along with the acceptance of mobile device use by a great percentage of society begs the research team to focus on how mobile devices are and/or can be used to improve situational awareness.

The approach for Phase II outlined in Sections 7 and 8 of the report is offered from review by the Oversight Panel. The research team believes the tasks described as revised from the AWP will continue to pave the way to ensuring (as the Problem Statement directs) the final project results will, 1) inform airport decision makers of the human factors related to airside operations, and 2) make a justifiable case for allocating resources to mitigate the risks from human elements operating in the airside environment.

The research team looks forward to receiving the comments of the Oversight Panel and discussion the way forward during the upcoming Web Meeting.

Appendix 1 – Literature Review Resources

References

Adam, G. L., Lentz, R. H., & Bair, R. W. (1992, September). Study of the causes of runway incursions and related incidents. In [Proceedings 1992] The First IEEE Conference on Control Applications (pp. 539-543). IEEE.

Barnett, A., Paull, G., & Iadeluca, J. (2000). Fatal US runway collisions over the next two decades. Air Traffic Control Quarterly, 8(4), 253-276.

Cardosi, K., Chase, S., & Eon, D. (2010). Runway safety. Air Traffic Control Quarterly, 18(3), 303-328.

Cassell, R., Evers, C., & Yang, Y. E. (2000, October). PathProx-a runway incursion alerting system. In 19th DASC. 19th Digital Avionics Systems Conference. Proceedings (Cat. No. 00CH37126) (Vol. 2, pp. 7D3-1). IEEE.

Cassell, R., Evers, C., Esche, J., Sleep, B., & Jones, D. R. (2002). NASA runway incursion prevention system (RIPS) Dallas-Fort Worth demonstration performance analysis. [NASA/CR-2002-211677]. National Aeronautics and Space Administration.

Chase, S., Eon, D., & Yeh, M. (2010). Mitigating runway incursions: A safety benefits assessment of airport surface moving map displays. Presented at the 2010 International Conference on Human-Computer Interaction in Aeronautics (pp.1-8).

Claudiu-Mihai, G. (2010). Reducing pilot/ATC communication errors using voice recognition. In Proceedings of ICAS (Vol. 2010).

Eggert, J. R., Howes, B. R., Kuffner, M. P., Wilhelmsen, H., & Bernays, D. J. (2006). Operational evaluation of runway status lights. lincoln laboratory journal, 16(1), 123.

Foyle, D. C., Andre, A. D., McCann, R. S., Wenzel, E. M., Begault, D. R., & Battiste, V. (1996). Taxiway Navigation and Situation Awareness (T-NASA) system: Problem, design philosophy, and description of an integrated display suite for low-visibility airport surface operations (No. 965551). SAE Technical Paper.

Green Jr, D. F., & Jones, D. R. (2002). Runway safety monitor algorithm for runway incursion detection and alerting. [NASA/CR-2002-211416]. National Aeronautics and Space Administration.

Hillebrand, A., Wahrenberg, E., & Manzey, D. (2012). A new method to assess pilots' allocation of visual attention using a head-up display. In Human Factors: a view from an integrative perspective. Proceedings HFES Europe Chapter Conference Toulouse (pp. 235-275).

Jones, D. R. (2002, October). Runway incursion prevention system simulation evaluation. In Proceedings. The 21st Digital Avionics Systems Conference (Vol. 2, pp. 11B4-11B4). IEEE.

Jones, D. R. (2005, May). Runway incursion prevention system testing at the Wallops Flight Facility. In Enhanced and Synthetic Vision 2005 (Vol. 5802, pp. 47-58). International Society for Optics and Photonics.

Jones, D. R., & Prinzel, L. J. (2006, October). Runway incursion prevention for general aviation operations. In 2006 ieee/aiaa 25TH Digital Avionics Systems Conference (pp. 1-12). IEEE.

Jones, D. R., Quach, C. C., & Young, S. D. (2001, October). Runway incursion prevention system-demonstration and testing at the dallas/fort worth international airport. In 20th DASC. 20th Digital Avionics Systems Conference (Cat. No. 01CH37219) (Vol. 1, pp. 2D2-1). IEEE.

Ludwig, D. (2007, October). Direct alerting to the cockpit for runway incursions. In 2007 IEEE/AIAA 26th Digital Avionics Systems Conference (pp. 5-A). IEEE.

Mathew, J. K., Major, W. L., Hubbard, S. M., & Bullock, D. M. (2017). Statistical modelling of runway incursion occurences in the united states. Journal of Air Transport Management, 65, 54-62. doi:10.1016/j.jairtraman.2017.09.003

McCann, R. S., & Foyle, D. C. (1996, January). Scene-linked symbology to improve situation awareness. In Agard Conference Proceedings Agard Cp (pp. 16-16). AGARD.

McGarry, K., & Helleberg, J. (2011). Using a cdti with indications to prevent runway incursions. In 16th International Symposium on Aviation Psychology (p. 257).

McLean, D., & Monro, I. (2004). Runway incursions and prevention systems. Aircraft Engineering and Aerospace Technology, 76(5), 472-478. doi:10.1108/00022660410555149

Mrazova, M. (2014). Runway incursions-clear and constant danger. Incas Bulletin, 6(3), 71.

National Academies of Sciences, Engineering, and Medicine. (2011). Improved models for risk assessment of runway safety areas. (No. Project 04-08). Washington, DC: The National Academies Press. https://doi.org/10.17226/13635.

National Academies of Sciences, Engineering, and Medicine. (2012). Airport apron management and control programs. (No. Project 04-07). Washington, DC: The National Academies Press. https://doi.org/10.17226/22794.

National Academies of Sciences, Engineering, and Medicine. (2012). Application of enterprise risk management at airports. (No. Project 01-18). Washington, DC: The National Academies Press. https://doi.org/10.17226/22744.

National Academies of Sciences, Engineering, and Medicine. (2013). Apron planning and design guidebook. (No. Project 07-09). Washington, DC: The National Academies Press. https://doi.org/10.17226/22460.

National Academies of Sciences, Engineering, and Medicine. (2014). Best practices manual for working in or near airport movement areas. (No. Project 09-02). Washington, DC: The National Academies Press. https://doi.org/10.17226/22380.

National Academies of Sciences, Engineering, and Medicine. (2015). A guidebook for safety risk management for airports. (No. Project 04-16). Washington, DC: The National Academies Press. https://doi.org/10.17226/22138.

National Academies of Sciences, Engineering, and Medicine. (2017). Guidebook for developing ramp control facilities. (No. Project10-24). Washington, DC: The National Academies Press. https://doi.org/10.17226/24668.

Norris Jr, V. J. (2001, August). Autonomous UV-enhanced-vision system that prevents runway incursions at medium-size airports. In Enhanced and Synthetic Vision 2001 (Vol. 4363, pp. 67-75). International Society for Optics and Photonics.

Prinzel III, L. J., & Jones, D. R. (2007). Cockpit Technology for the Prevention of General Aviation Runway Incursions. In 2007 International Symposium on Aviation Psychology (p. 546).

Quilty, S. M. (2008). Preventing vehicle–aircraft incidents during winter operations and periods of low visibility (No. Project 11-03, Topic S04-02).

Rankin, W. B. (2008). Runway incursions: An industry examination of FAA initiatives and objectives. International Journal of Applied Aviation Studies, 8(2), 225-240.

Rankin II, W., & Cokley, J. (2009). Runway incursions: Airport movement area driver training demographics suggests revisions to airport driver training methods. Journal of Management and Marketing Research, 2, 1.

Rogerson, E. C., Lambert, J. H., & Johns, A. F. (2013). Runway safety program evaluation with uncertainties of benefits and costs. Journal of Risk Research, 16(5), 523-539. doi:10.1080/13669877.2012.725674

Schönefeld, J., & Möller, D. P. (2012, September). Fast and robust detection of runway incursions using localized sensors. In 2012 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI) (pp. 33-39). IEEE.

Schönefeld, J., & Möller, D. P. F. (2012). Runway incursion prevention systems: A review of runway incursion avoidance and alerting system approaches. Progress in Aerospace Sciences, 51, 31-49. doi:10.1016/j.paerosci.2012.02.002

Song, I., Cho, I., Tessitore, T., Gurcsik, T., & Ceylan, H. (2018). Data-driven prediction of runway incursions with uncertainty quantification. Journal of Computing in Civil Engineering, 32(2), 4018004. doi:10.1061/(ASCE)CP.1943-5487.0000733

Sridhar, B., & Chatterji, G. B. (1994, July). Computer-aided system for detecting runway incursions. In Sensing, Imaging, and Vision for Control and Guidance of Aerospace Vehicles (Vol. 2220, pp. 328-337). International Society for Optics and Photonics.

Subbotin, N. (2011). Development of an Airport Ground Vehicle Runway Incursion Warning System. FAA report, DOT/FAA/AR-11/26.

Thompson, S. D., & Eggert, J. R. (2001). Surveillance performance requirements for runway incursion prevention systems (No. ATC-301). Massachusetts Inst of Tech Lexington Lincoln Lab.

Vernaleken, C., Mihalic, L., Güttler, M., & Klingauf, U. (2006, May). A fresh look at runway incursions: onboard surface movement awareness and alerting system based on SVS. In Enhanced and Synthetic Vision 2006 (Vol. 6226, p. 62260J). International Society for Optics and Photonics.

Wilke, S., Majumdar, A., & Ochieng, W. Y. (2015). The impact of airport characteristics on airport surface accidents and incidents. Journal of Safety Research, 53, 63-75. doi:10.1016/j.jsr.2015.03.006

Young, S., & Vlek, J. (2009). An analysis of the causes of airfield incursions attributed to ground vehicles. Journal of Airport Management, 3(3), 299-308.

Zhang, X. Q., & Yang, W. T. (2010). Reason analysis of runway incursions based on grey theory. Journal of Safety and Environment, 10(5), 160-162.

Appendix 2 – Literature Review Citations

Reference #	1	**General Area**	Airside Driving	**Specific Area**	Runway Incursions
Title	*Preventing Runway Incursions and Conflicts*				
Source/Agency	*Aerospace Science and Technology*				
Authors	G.K.Singh; ChristophMeier			**Year**	2004
Abstract	Preventing runway incursions and conflicts is amongst the most critical problems in airport ground movement operations. Despite being on the NTSB's 'MOST WANTED' list of desired safety improvements for over a decade now, it remains a persistent issue. The paper looks at some system architectures that may be used to prevent/reduce runway incursions. The existing approaches to the problem are looked into. We propose a new pseudo-series system architecture that not only provides the pilot/driver with an independent source of direct information for operations on/across the runway, but also keeps the controller in the loop so as to significantly reduce the chances of an operational error. It also addresses some of the shortcomings of the earlier approaches. The system 'secures' the runway before any takeoff /landing/crossing operations are to be cleared by the controller. The 'securing' of the runway is done based on an evaluation of the current traffic scenario and uses a simple logic. The concept may be easily extended for more realistic runway-taxiway configurations.				
Comments	*Propose new system architecture to provide direct information to pilot/driver and keeps controller in the loop; addresses shortcomings of earlier approaches.*				
Potential Gaps	*Conceptual presentation of ground-based guidance systems (GBGS), runway automated guidance systems (RAGS), and controller working position (CWP), but lacks any data, experimental or field testing to measure program's success at reducing runway incursions or increased performance/awareness.*				
Link	https://www.sciencedirect.com/science/article/pii/S1270963804000926				

Reference #	2	**General Area**	RSA and RPZ	**Specific Area**	Runway Incursions
Title	*Statistical Modelling of Runway Incursion Occurrences in the United States*				
Source/Agency	*Journal of Air Transport Management*				
Authors	Jijo K.Mathew; Wesley L.Major; Sarah M.Hubbard; Darcy M.Bullock			**Year**	2017
Abstract	Runway incursions are an important aviation safety concern; between 2002 and 2015 there were 16,785 runway incursions at United States airports ranging in size from small general aviation (GA) to large commercial airline hubs. When examining airports with the 50 highest incursion count over the past 5 years, the predominant categories were large hubs, which accounted for 21 airports and general aviation (GA) airports which accounted for 16 airports. In June 2015, the Federal Aviation Administration (FAA) announced the Runway Incursion Mitigation (RIM) program to identify airport risk factors that might contribute to a runway incursion and develop strategiesto help airport stakeholders mitigate those risks. Different size airports serve differentaircraftfleets, serve different operating volumes, and have different resources available (both funds and technologies) for incursion mitigation. Therefore, it is valuable to determine the correlating factors that affect incursions at different size airports. This paper uses econometrics-based modelling techniques to identify statistically significant factors in data provided by the (FAA) publicweb siteson runway incursions. The model identified statistically significant variables that correlate with incursions, based on severity, for airports categories defined by theNational Planof Integrated Airport Systems (NPIAS). The model results indicate that operational incidents (OI) are more likely at large hub airports. In contrast, at GA/non-hub airports, pilot deviations (PD) were significant for less severe incursions (severity C and D). Only one variable, "number of years since 2002", was found to be significant for all the three airport categories; this variable was correlated with severity A incursions and indicated a statistically significant reduction in severity A incursions, despite an overall 80% increase in incursions between 2002 and 2015.				
Comments	*Conducted a statistical model which indicates that operational incidents (OI) are more likely at large hub airports; for general aviation/non0hub airports, pilot deviations (PD) were significant for less severe incursions (C and D). V/PD's most likely at GA/non-hub airports, and severity level D. Possibly due to fewer separate access roads at smaller airports.*				
Potential Gaps	*V/PD's accounted for approximately 15-20% of reports. Conducted modeling on existing data, no type of experimental analysis.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0969699717300522				

Reference #	3	**General Area**	RSA and RPZ	**Specific Area**	RI Technology
Title	*Runway Incursion Prevention Systems: A Review of Runway Incursion Avoidance and Alerting System Approaches*				
Source/Agency	*Progress in Aerospace Sciences*				
Authors	J.Schönefeld; D.P.F.Möller			**Year**	2012
Abstract	Runway incursions are events where two or more vehicles use the same runway, resulting in a conflicting situation. Avoiding runway incursions has been a top ten priority for the National Transportation Safety Board (NTSB) for over a decade. Therefore, this article provides a review of currently deployed technological responses and those currently under development. The outline is as follows: InSection 1, an introduction to runway incursions and the increasing significance of the threat is given, followed by a brief description of possible technological solutions inSection 2.Section 3introduces the results of currently developed runway incursion prevention systems, whileSection 4is a description of the performance of the systems. The review concludes with a brief discussion and an outlook on essential future work.				
Comments	*Provides a review of currently deployed technological systems to prevent runway incursions.*				
Potential Gaps	*Provides reviews of existing systems and a framework for future systems, limited data forecasting and performance assessments.*				
Link	https://www.sciencedirect.com/science/article/pii/S0376042112000152				

Reference #	4	**General Area**	RSA and RPZ	**Specific Area**	RI Modeling
Title	*Modelling Runway Incursion Severity*				
Source/Agency	*Accident Analysis & Prevention*				
Authors	SabineWilke; ArnabMajumdar; Washington Y. Ochieng			**Year**	2015
Abstract	Analysis of the causes underlying runway incursions is fundamental for the development of effective mitigation measures. However, there are significant weaknesses in the current methods to model these factors. This paper proposes a structured framework for modelling causal factors and their relationship to severity, which includes a description of the airport surface system architecture, establishment of terminological definitions, the determination and collection of appropriate data, the analysis of occurrences for severity and causes, and the execution of a statistical analysis framework. It is implemented in the context of U.S. airports, enabling the identification of a number of priority interventions, including the need for better investigation and causal factor capture, recommendations for airfield design, operating scenarios and technologies, and better training for human operators in the system. The framework is recommended for the analysis of runway incursions to support safety improvements and the methodology is transferable to other areas of aviation safety risk analysis.				
Comments	*Creates framework to provide statistical modeling of runway incursions. Identifies communication breakdowns between pilots and ATC.*				
Potential Gaps	*Limited investigation without much related to V/PDs; framework unable to provide prediction for category A and B occurrences along (A-C as one group), due to limited sample size.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0001457515000901				

Reference #	5	**General Area**	Terminal Incidents	**Specific Area**	RI Categorization
Title	*Human Risk Factors Associated with Runway Incursions*				
Source/Agency	*Journal of Air Transport Management*				
Authors	Yu-Hern Chang; Kin-Meng Wong			**Year**	2012
Abstract	This study examines the human risk factors associated with pilots in runway incursions. We applied a human factors model to categorize the risk factors based on the opinions of 112 airline pilots. We focus on Taiwan's airlines and civil aviation authority and integrates expert opinions about the relative improvement potential of four strategies for airline pilots to reduce runway incursions. Experts weighed 37 preliminary and 25 primary pilot risk factors.				
Comments	*Opinions of 112 airline pilots from Taiwan's airlines. Use of SHELLO model and human factors techniques to categorize incidents/factors. Identify 4 zones to reduce pilot errors.*				
Potential Gaps	*Limited to pilots, did not consider V/PDs.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0969699712000890				

Reference #	6	**General Area**	RSA and RPZ	**Specific Area**	RI Hazards
Title	*Evaluation of the Risk Frequency for Hazards of Runway Incursion in Korea*				
Source/Agency	*Journal of Air Transport Management*				
Authors	DohyunKim; HanmoYang			**Year**	2012
Abstract	This paper evaluates the risk frequency of hazards related to airport runway incursion. Gimpo International Airport, which has a record of two runway incursions, was selected for study. We verified 15 hazards causing runway incursion and derived the weights for each hazard through an analytic hierarchy process. Then, fault tree analysis was conducted by applying the statistics of runway incursion and the estimated weights to evaluate the risk frequency of each hazard. The analysis results verified the close relation of runway incursion with human error.				
Comments	*Used analytic hierarchy process and fault tree analysis to evaluate risk frequency of hazards at Gimpo Airport in South Korea; key areas were communication breakdowns between pilots and ATC and failure to comply with ATC instructions.*				
Potential Gaps	*Did include V/PDs with pilots; limited to one airport in South Korea.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0969699712000129				

Reference #	7	**General Area**	Airport Losses	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention System-Demonstration and Testing at the Dallas/Fort Worth International Airport*				
Source/Agency	20th DASC. 20th Digital Avionics Systems Conference				
Authors	D.R. Jones; C.C. Quach, S.D. Young			**Year**	2001
Abstract	A Runway Incursion Prevention System (RIPS) was tested at the Dallas-Fort Worth International Airport (DFW) in October 2000. The system integrated airborne and ground components to provide both pilots and controllers with enhanced situational awareness, supplemental guidance cues, a real-time display of traffic information, and warning of runway incursions in order to prevent runway incidents while also improving operational capability. A series of test runs was conducted using NASA's Boeing 757 research aircraft and a test van equipped to emulate an incurring aircraft. The system was also demonstrated to over 100 visitors from the aviation community. This paper gives an overview of the RIPS, DFW flight test activities, and quantitative and qualitative results of the testing.				
Comments	*Examines Runway Incursion Prevention System (RIPS); demonstrates the need for timely, reliable, and accurate traffic data to avoid incursions.*				
Potential Gaps	*Not really focused on V/PDs; testing of prototype software/equipment and at Dallas/Fort Worth (DFW) airport only.*				
Link	https://ieeexplore.ieee.org/abstract/document/963333				

Reference #	8	**General Area**	Airport Losses	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention for General Aviation Operations*				
Source/Agency	2006 IEEE/AIAA 25TH Digital Avionics Systems Conference				
Authors	Denise R. Jones; Lawrence J. Prinzel			**Year**	2007
Abstract	A runway incursion prevention system (RIPS) and additional incursion detection algorithm were adapted for general aviation operations and evaluated in a simulation study. RIPS has been designed to enhance surface situation awareness and provide cockpit alerts of potential runway conflicts in order to prevent runway incidents while also improving operational capability.				
Comments	*Analysis of same software from Article #7 but adapted for general aviation operations and included simulator study with pilots.*				
Potential Gaps	*No examination of the effects of these tools for V/PDs.*				
Link	https://ieeexplore.ieee.org/abstract/document/4106289				

Reference #	9	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention: A Technology Solution*				
Source/Agency	Joint Meeting of the Flight Safety Foundation 54th Annual International Air Safety Seminar				
Authors	Steven Young; Denise Jones			**Year**	2001
Abstract	A runway incursion occurs any time an airplane, vehicle, person or object on the ground creates a collision hazard with an airplane that is taking off or landing at an airport under the supervision of Air Traffic Control (ATC). Despite the best efforts of the Federal Aviation Administration (FAA), runway incursions continue to occur more frequently. The number of incursions reported in the U.S. rose from 186 in 1993 to 431 in 2000, an increase of 132 percent. Recently, the National Transportation Safety Board (NTSB) has made specific recommendations for reducing runway incursions including a recommendation that the FAA require, at all airports with scheduled passenger service, a ground movement safety system that will prevent runway incursions; the system should provide a direct warning capability to flight crews. To this end, NASA and its industry partners have developed an advanced surface movement guidance and control system (A-SMGCS) architecture and operational concept that are designed to prevent runway incursions while also improving operational capability. This operational concept and system design have been tested in both full-mission simulation and operational flight test experiments at major airport facilities. Anecdotal, qualitative, and specific quantitative results will be presented along with an assessment of technology readiness with respect to equipage.				
Comments	*Assessment of advanced surface movement guidance and control system (A-SMGCS).*				
Potential Gaps	*Focus on pilots and controllers, not examined using V/PDs.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20070030080				

Reference #	10	**General Area**	Airport Losses	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention System Simulation Evaluation*				
Source/Agency	21st Digital Avionics Systems Conference				
Authors	Denise Jones			**Year**	2002
Abstract	A runway incursion prevention system (RIPS) was evaluated in a full mission simulation study at the NASA Langley Research center in March 2002. RIPS integrate airborne and ground-based technologies to provide (1) enhanced surface situational awareness to avoid blunders and (2) alerts of runway conflicts in order to prevent runway incidents while also improving operational capability. A series of test runs was conducted in a high-fidelity simulator. The purpose of the study was to evaluate the RIPS airborne incursion detection algorithms and associated alerting and airport surface display concepts. Eight commercial airline crews participated as test subjects completing 467 test runs. This paper gives an overview of the RIPS, simulation study, and test results.				
Comments	*Related to earlier studies on RIPs. Used eight commercial airline crews.*				
Potential Gaps	*Nothing related to V/PDs*				
Link	https://ieeexplore.ieee.org/abstract/document/1052974				

Reference #	11	**General Area**	Airport Losses	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention System Testing at the Wallops Flight Facility*				
Source/Agency	*Society of Photo-Optical Instrumentation Engineers*				
Authors	Denise Jones			**Year**	2005
Abstract	A Runway Incursion Prevention System (RIPS) integrated with a Synthetic Vision System concept (SVS) was tested at the Reno/Tahoe International Airport (RNO) and Wallops Flight Facility (WAL) in the summer of 2004. RIPS provides enhanced surface situational awareness and alerts of runway conflicts in order to prevent runway incidents while also improving operational capability. A series of test runs was conducted using a Gulfstream-V (G-V) aircraft as the test platform and a NASA test aircraft and a NASA test van as incurring traffic.				
Comments	*Further examination of RIPs along with synthetic vision system; pilots indicated greater situation awareness.*				
Potential Gaps	*Focus again on usage with pilots, not V/PDs.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5802/0000/Runway-incursion-prevention-system-testing-at-the-Wallops-Flight-Facility/10.1117/12.602327.short?SSO=1				

Reference #	12	**General Area**	Airport Losses	**Specific Area**	Statistical Models
Title	*Statistical Models of Runway Incursions Based on Runway Intersections and Taxiways*				
Source/Agency	*Journal of Aviation Technology and Engineering*				
Authors	**Mary E. Johnson; Xun Zhao; Brian Faulkner; John P. Young**			**Year**	2016
Abstract	According to the Federal Aviation Administration (FAA), the number of runway incursions are rising. The configuration of runways and taxiways at airports has been identified by the FAA as possibly being related to the number of incursions. In this paper, the relationship between airport geometry factors and the number of runway incursions at specific United States airports is explored using statistical analyses. Airport operations data from the FAA Air Traffic Activity System, runway incursion data from the FAA Aviation Safety Information Analysis and Sharing System from 2009 through 2013, and airport geometry data created using airport geometry features from the FAA airport diagrams were collected. The 30 busiest airports with intersecting runways and the 30 busiest airports without intersecting runways were compared. As expected, the analysis of the data show that at alpha = 0.05 level, runway incursions occur at a more frequent rate for airports with intersecting runways compared to airports with no intersecting runways. In the second phase of statistical analysis, the number of incursions per 100,000 operations at the 63 busiest United States airports was analyzed using four airport geometry factors as independent variables in regression analysis. The resulting regression equation was significant at the alpha = 0.05 level and contained two independent variables: the number of crossing taxiways per runway and the number of runway intersections per runway. The equation and each variable in the equation are statistically significant and the equation explains 17.3% of the variation in incursions per 100,000 operations.				
Comments	*Analysis of airports with crossing runways and without – more RIs at airports with crossing runways. Using statistical models, number of crossing taxiways/runway and number of runway intersections/runway predicted the chance of an RI.*				
Potential Gaps	*Did not distinguish between types of runway incursions or levels of severity.*				
Link	https://docs.lib.purdue.edu/jate/vol5/iss2/3/				

Reference #	13	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Safety Benefits of Pathprox-A Runway Incursion Alerting System*				
Source/Agency	Digital Avionics Systems Conference				
Authors	R. Cassell; C. Evers; J. Esche			**Year**	2003
Abstract	This paper analyzes the safety benefits of the implementation of PathProx, a runway incursion alerting system. Airport surface incursions have been identified by the National Transportation Safety Board (NTSB) as one of the most significant safety hazards in civil aviation. PathProx is a system development by Rannoch Corporation to help address this problem. It is an aircraft-based runway incursion alerting system, providing runway incursion alerts directly to the pilot(s) in the cockpit. PathProx has undergone a series of simulator and flight tests conducted by NASA over the last 3 years. It is part of the NASA Runway Incursion Prevention System (RIPS). These tests have validated the basic concept and design of PathProx. Several analyses have been performed related to the safety benefits of PathProx implementation. These include analyses of critical runway incursion scenarios and Monte Carlo simulation. The Monte Carlo simulation results indicated that the risk of collisions due to runway incursions could be nearly eliminated through aircraft equipage with PathProx. The simulations and analyses also found that PathProx provides significant improvement in runway safety even without full fleet equipage-where only of the two aircraft involved in a conflict is equipped. Analyses have also been done to compare the safety improvements provided by PathProx with that provided by ground system surveillance and alerting. PathProx provides more timely alerting than provided by ground-based systems, primarily by eliminating the delays associated with having the controller in the loop and associated communications delay.				
Comments	*Examines PathProx aircraft-based alerting system for runway incursions.*				
Potential Gaps	*Focus on conflicts between aircraft, not V/PDs.*				
Link	https://ieeexplore.ieee.org/abstract/document/5731154				

Reference #	14	**General Area**	RSA and RPZ	**Specific Area**	Statistical Models
Title	*Runway Incursions: A Case Study Analysis*				
Source/Agency	Purdue University				
Authors	Bradley G. Cozza, John P. Young			**Year**	2013
Abstract	Utilizing publicly-available information gathered from government resources, a case study analysis of runway incursion data endeavored to determine the correlation between the reported incursions that occurred at American airports between fiscal years 2009 and 2011 and the meteorological conditions, times of day, and presence of an air traffic control tower. With runway incursions long-plaguing the safety of United States aviators, their passengers, and aviation personnel, continued research aimed at refining the body of knowledge underpinning incursions coupled with ongoing prevention efforts aspire to diminish the annual incidence of incursions, increase safety, and save lives. In accordance with this mission, mining the National Transportation Safety Board's (NTSB) and National Aeronautics and Space Administration's (NASA) runway incursion databases and analyzing the resulting data with the Pearson correlation indicated a higher likelihood of incursions amid clear weather, during the daylight hours, and at airports with an air traffic control tower.				
Comments	*Graduate project looking for statistical relationships related to runway incursions.*				
Potential Gaps	*Limited to an analysis of a few correlations, no information regarding causal aspects of runway incursions.*				
Link	https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1020&context=atgrads				

Reference #	15	**General Area**	RSA and RPZ	**Specific Area**	Runway Safety
Title	*Runway Safety Report 2011 – 2012*				
Source/Agency	FAA				
Authors	*FAA*			**Year**	2012
Abstract	N/A				
Comments	*2011-2012 FAA Runway Safety Report detailing FY 2011 and FY2012; provides good analysis by State in Appendix B.*				
Potential Gaps	*Summative report published by the FAA only using archival data.*				
Link	https://www.faa.gov/airports/runway_safety/publications/media/2012-AJS-475-FY2011-Runway-Safety-Annual-Report.pdf				

Reference #	16	**General Area**	RSA and RPZ	**Specific Area**	Taxiway Mgt.
Title	*Los Angeles International Airport Runway Incursion Studies: Phase III—Center-Taxiway Simulation*				
Source/Agency	NASA				
Authors	Michael D. Madson			**Year**	2004
Abstract	Phase III of the Los Angeles International Airport (LAX) Runway Incursion Studies was conducted, under an agreement with HNTB Corporation, at the NASA Ames FutureFlight Central (FFC) facility in June 2003. The objective of the study was to evaluate a new center taxiway on the south airfield between runways 25L and 25R at LAX. This study is an extension of the Phase I and II studies conducted at FFC in February and April 2001. Phase III data were compared objectively against Baseline data collected during Phases I and II. Subjective evaluations by participating LAX controllers were obtained with regard to workload, efficiency, and safety criteria. To facilitate the comparison of Baseline and Phase III data, the same scenarios were used for Phase III that were used during Phases I and II. A total of twelve 45-minute runs were conducted over the 3-day test period. Quantitative data from these runs were compared with the Baseline data from the 2001 studies. Confidential controller surveys were administered after each run. In addition to runway and taxiway changes related to the addition of the center taxiway, several other factors may affect the accuracy of the quantitative data, the validity of the survey data, and the comparison of the Phase III results with the Baseline data. The contribution of these factors must be considered in the evaluation of the center taxiway. Ratings for survey questions were relative to LAX operations in early 2001 ("pre-9/11"). 2 Departure rates for the center-taxiway configuration compared very closely with the Baseline data for the two visual-flight-rules (VFR) scenarios. There was an 8% reduction in airport departure rate for the instrument-flight-rules (IFR) scenario, amounting to 3 flights per hour on both the north and south airfields. Taxi-in times for arrivals landing on the south runways ranged from 3% less to 16% higher with the center-taxiway concept as compared to the Baseline data. The exception was Skywest arrivals taxiing to the "Box," whose taxi distance increased significantly with the closure of taxiways J and K for crossing. Taxi-out times for departures ranged from a reduction of 12% compared to Baseline, to an increase of 27%.				
Comments	*Related to workload, safety, and efficiency; controllers at LAX; new taxiway procedures.*				
Potential Gaps	*Nothing about V/PDs; only related to changing a taxiway for a small portion of LAX.*				
Link	https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070031988.pdf				

Reference #	17	**General Area**	RSA and RPZ	**Specific Area**	Surface Operations
Title	*The Impact of Airport Characteristics on Airport Surface Accidents and Incidents*				
Source/Agency	*Journal of Safety Research*				
Authors	Sabine Wilke; Arnab Majumdar; Washington Y. Ochieng			**Year**	2015
Abstract	Airport surface safety and in particular runway and taxiway safety is acknowledged globally as one of aviation's greatest challenges. To improve this key area of aviation safety, it is necessary to identify and understand the causal and contributing factors on safety occurrences. While the contribution of human factors, operations, and procedures has been researched extensively, the impact of the airport and its associated characteristics itself has received little or no attention.				
Comments	*Good methodology to analyze runway safety and incursions; non-standard reporting around the globe, leads to problems with head-to-head comparisons; demonstrates relationship between airport geometric complexity and human factors relate to safety occurrences.*				
Potential Gaps	*Distributed to only 3 countries (US, NZ, and Norway); challenges with non-standardized reports; overall a good study and did reference V/PDs.*				
Link	https://www.sciencedirect.com/science/article/pii/S0022437515000183				

Reference #	18	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Safety Monitor Algorithm for Runway Incursion Detection and Alerting*				
Source/Agency	NASA				
Authors	David Green; Denise Jones			**Year**	2002
Abstract	The Runway Safety Monitor (RSM) is an algorithm for runway incursion detection and alerting that was developed in support of NASA's Runway Incursion Prevention System (RIPS) research conducted under the NASA Aviation Safety Program's Synthetic Vision System element. The RSM algorithm provides pilots with enhanced situational awareness and warnings of runway incursions in sufficient time to take evasive action and avoid accidents during landings, takeoffs, or taxiing on the runway. The RSM currently runs as a component of the NASA Integrated Display System, an experimental avionics software system for terminal area and surface operations. However, the RSM algorithm can be implemented as a separate program to run on any aircraft with traffic data link capability. The report documents the RSM software and describes in detail how RSM performs runway incursion detection and alerting functions for NASA RIPS. The report also describes the RIPS flight tests conducted at the Dallas-Ft Worth International Airport (DFW) during September and October of 2000, and the RSM performance results and lessons learned from those flight tests.				
Comments	*Analysis of lessons learned from flight testing the software; limited to flight testing only, nothing related to V/PDs.*				
Potential Gaps	*Runway Safety Monitor detects runway incursions but does not prevent them.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20020025579				

Reference #	19	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Rimdas: A Proposed System for Reducing Runway Incursions*				
Source/Agency	*Ergonomics in Design*				
Authors	Peter N. Squire; Jane H. Barrow; Kevin T. Durkee; Carl "Mac" Smith; Jennifer C. Moore; Raja Parasuraman			**Year**	2010
Abstract	To address the increasingly serious problem of runway incursions at airports, we developed a novel design based on inexpensive sensor technology and a hybrid cognitive engineering development plan. Alerting time and monetary costs were critical factors in the creation of a low-cost, scalable, and flexible system that can directly warn pilots and air traffic controllers of impending incursions. This article describes the human-centered design process used to develop an alternative to current runway incursion prevention systems. Because it is cost-effective, the system could be employed at nearly any airport regardless of size or budget.				
Comments	*Developed a cost-effective prevention system (RIMDAS).*				
Potential Gaps	*Based on having hardware installed around the airport for the system to work.*				
Link	https://journals.sagepub.com/doi/abs/10.1518/106480410X12737888532723				

Reference #	20	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Data-Driven Prediction of Runway Incursions with Uncertainty Quantification*				
Source/Agency	*Journal of Computing in Civil Engineering*				
Authors	I. Song, S.M.ASCE; I. Cho, Ph.D., M.ASCE; T. Tessitore; T. Gurcsik			**Year**	2018
Abstract	In 2015 only, more than 1,500 runway incursions (RIs) occurred at US airports, which could result in serious runway collisions. Nonlinear interactions among many factors and complex data structures pose challenges to RI prevention, and reportedly, the annual RI occurrence is gradually increasing. This study seeks to offer a data-driven solution of advanced statistical learning and prediction by leveraging the generalized additive model (GAM). The GAM holds a powerful flexibility with little restriction to many variables over a broad range of modeling distributions. This study proposes a method to systematically obtain, parse, and transform various factors from diverse databases to give rise to interpretable datasets. It also presents high-performance computational procedures to automatically select out salient factors to achieve the best GAM with a strong predictive power.				
Comments	*Found 5 significant predictors of runway incursion risk.*				
Potential Gaps	*Mentions V/PDs, but the article doesn't focus on their impacts.*				
Link	https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29CP.1943-5487.0000733				

Reference #	21	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Pathprox-A Runway Incursion Alerting System*				
Source/Agency	IEEE				
Authors	R. Cassell; C. Evers; Y.E. Yang			**Year**	2000
Abstract	This paper describes a Runway Incursion Advisory and Alerting System (RIAAS), intended to help minimize the number of runway incursions and provide conflict alerts for all aircraft and vehicles on the airport surface. PathProx is an RIAAS avionics system designed to provide timely alerts directly to the pilot. Airport surface incursions have been identified as one of the most significant safety hazards in civil aviation, and yet thus far, there is no operational system to alert pilots automatically at the onset of such conflicts. PathProx is designed to monitor aircraft that are either on the airport surface area or are still within the airport's arrival and departure zones. The prototype design specifies that the system is activated whenever an aircraft enters an arrival or departure zone associated with a runway. ADS-B and/or TIS traffic data from other aircraft and ground vehicles within the proximity of this zone are processed by the system, which tracks their movement. Decision rules are set up to issue alerts based on the states and proximity of the aircraft. The goal of the system when implemented is a reduction in the number of runway incursions and also an improvement in the reaction time by pilots to avoid such conflicts.				
Comments	*RIAAS provides alerts to aircraft and vehicles.*				
Potential Gaps	*Paper discussed concept only; says testing ongoing with NASA Langely in conjunction with RIPS.*				
Link	https://ieeexplore.ieee.org/abstract/document/884934				

Reference #	22	**General Area**	RSA and RPZ	**Specific Area**	Causes of RIs
Title	*Study of the Causes of Runway Incursions and Related Incidents*				
Source/Agency	**IEEE**				
Authors	G.L. Adam; R.H. Lentz; R.W. Bair			**Year**	1992
Abstract	An analysis of the causes of runway incursions is discussed. It is seen that control of airport surface operations is complex. Runway incursions usually occur because of multiple factors that combine to form a critical chain of events, culminating in an incident if uninterrupted. Taken individually, these same factors may seem insignificant. It is included that there is no single outstanding cause, and there is no single solution.				
Comments	*Presents human interface of surface movement (including V/PDs); cites multiple factors which converge resulting in an RI.*				
Potential Gaps	*Findings in paper only preliminary; identifies multiple solutions needed but fails to actively suggest any specific.*				
Link	https://ieeexplore.ieee.org/abstract/document/269816				

Reference #	23	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*A Fresh Look at Runway Incursions: Onboard Surface Movement Awareness and Alerting System Based on SVS*				
Source/Agency	*Enhanced and Synthetic Vision 2006*				
Authors	Christoph Vernaleken; Lamir Mihalic; Mathias Güttler; Uwe Klingauf			**Year**	2006
Abstract	Increasing traffic density on the aerodrome surface due to the continuous worldwide growth in the number of flight operations does not only cause capacity and efficiency problems, but also increases the risk of serious incidents and accidents on the airport movement area. Of these, Runway Incursions are the by far most safety critical. In fact, the worst-ever accident in civil aviation, the collision of two Boeing B747s on Tenerife in 1977 with 583 fatalities, was caused by a Runway Incursion. Therefore, various Runway Safety programs have recently been initiated around the globe, often focusing on ground-based measures such as improved surveillance. However, as a lack of flight crew situational awareness is a key causal factor in many Runway Incursion incidents and accidents, there is a strong need for an onboard solution, which should be capable of interacting cooperatively with ground-based ATM systems, such as A-SMGCS where available. This paper defines the concept of preventive and reactive Runway Incursion avoidance and describes a Surface Movement Awareness & Alerting System (SMAAS) designed to alert the flight crew if they are at risk of infringing a runway. Both the SVS flight deck displays and the corresponding alerting algorithms utilize an ED 99A/RTCA DO-272A compliant aerodrome database, as well as airport operational, traffic and clearance data received via ADS-B or other data links, respectively. The displays provide the crew with enhanced positional, operational, clearance and traffic awareness, and they are used to visualize alerts. A future enhancement of the system will provide intelligent alerting for conflicts caused by surrounding traffic.				
Comments	*Combining trials of surface alerting systems and synthetic vision systems.*				
Potential Gaps	*Small number of participants (15 airline pilots).*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/6226/62260J/A-fresh-look-at-runway-incursions--onboard-surface-movement/10.1117/12.664897.short?SSO=1				

Reference #	24	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Detection of Runway and Obstacles using Electro-optical and Infrared Sensors before Landing*				
Source/Agency	*Defense Science Journal, Vol. 64*				
Authors	Satish Kumar Vegula; S. K. Kashyap; N. Shanthakumar			**Year**	2014
Abstract	For safe aircraft operations, detection of runway incursions especially during landing and takeoff is essential. And it is important that such detection technique is capable of detecting the distant objects so that pilot has enough response time to take corrective action. This paper presents techniques to detect runway and runway incursions using electro-optical color camera and medium wave infrared sensor on-board the aircraft during approach for landing. The detection process consists of horizon detection to reduce runway search space in sensor image and then detect runway and obstacles. The information is then presented to the pilot to improve pilot situational awareness. The performance of the proposed techniques are evaluated in flight simulators with simulated images of electro-optical and infrared sensors on-board the aircraft during approach for landing at a distance of 3 nautical miles from runway threshold during day/night and in low visibility CAT II foggy conditions. Effectiveness of the techniques with statistics of runway detection, miss detection and false alarm for different case studies have been provided and discussed.				
Comments	*Use of electro-optical color camera and medium wave infrared sensor on-board aircraft for use with pilots in low visibility conditions.*				
Potential Gaps	*Limited to only use on-board aircraft, use in vehicles not discussed.*				
Link	https://publications.drdo.gov.in/ojs/index.php/dsj/article/view/2765				

Reference #	25	**General Area**	RSA and RPZ	**Specific Area**	Causal Factors
Title	*Prioritizing Risks Via Several Expert Perspectives with Application to Runway Safety*				
Source/Agency	*Reliability Engineering & System Safety*				
Authors	Ellen C.Rogerson; James H.Lambert			**Year**	2012
Abstract	Factor hierarchies have been widely used in the literature to represent the view of an expert of what factors most contribute to reliability or safety. The methods for rating and aggregating the influences across a set of expert-elicited factors to risk or reliability are well known as multiple criteria decision analysis. This paper describes a method for distinguishing levels of risk across a set of locations via the use of multiple factor hierarchies. The method avoids averaging across experts and is thus useful for situations where experts disagree and where an absence of expert consensus on the causative or contributing factors is important information for risk management. A case study demonstrates using seven expert perspectives on the airport-specific factors that can contribute to runway incursions. The results are described for eighty towered airports in the US. The expert perspectives include differing relative emphases across the following set of factors: airport geometry, operations, weather, geography, and days since last safety review. Future work is suggested to include human factors issues as pilot-and-controller communications styles at airports.				
Comments	*Use a factor hierarchy framework with expert panelists to examine a case study of a runway incursion to determine contributing factors of an RI.*				
Potential Gaps	*Limited to use of seven experts and only 23 runway incursion events.*				
Link	https://www.sciencedirect.com/science/article/pii/S095183201200035X				

Reference #	26	**General Area**	Airside Driving	**Specific Area**	Archival RI Analysis
Title	*Runway Safety*				
Source/Agency	*Air Traffic Control Quarterly*				
Authors	Kim Cardosi; Stephanie Chase; Danielle Eon			**Year**	2016
Abstract	Information provided through analysis of runway incursions is useful in many ways. Analysis of the errors made by pilots, controllers, and vehicle drivers is the first step toward developing error mitigation strategies. Furthermore, successful design of future systems requires knowledge of characteristics of the incursions experienced today as well as the successes and limitations of previously implemented strategies. This paper explores what is known about the human errors and other factors that have been identified as contributing to runway incursions and offers some error mitigation strategies. The data presented will be useful in helping to design the most effective tools for safety, increasing capacity, and for estimating the safety benefits of proposed system enhancements.				
Comments	*Good article on human error related to RIs, including V/PD; entire section on Driver Errors (p. 318); a nice summary and layout identifying contributing factors related to RIs.*				
Potential Gaps	*Mostly an archival assessment of contributing factors, no apparent data collection.*				
Link	https://arc.aiaa.org/doi/abs/10.2514/atcq.18.3.303				

Reference #	27	**General Area**	RSA and RPZ	**Specific Area**	Runway Safety
Title	*Runway Safety at Airports: A Systematic Approach for Implementing Ultra-Safe Options*				
Source/Agency	*Journal of Air Transport Management*				
Authors	B.M.Horowitz; J.R.Santos			**Year**	2009
Abstract	Enhancing airport runway safety is a difficult problem because runway accidents are rare events. Nonetheless, investments are being directed at improving safety for US airport ground traffic control systems. This paper shows that under these circumstances it is difficult to assess and measure the added safety offered by new replacement systems. We develop a framework for introducing and sequencing system improvements to provide greater assurances in enhancing safety. This framework shows how a new method can first be introduced as a secondary system, to test and verify its efficacy prior to its adoption as a primary system.				
Comments	*Identifies primary and secondary levels of implementing runway safety; proposes a mostly statistical based framework to measure effectiveness of runway safety initiatives.*				
Potential Gaps	*Conceptual in nature only, completed as part of a class project and turned into a journal paper. Does not seem specific to V/PDs.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0969699709000283				

Reference #	28	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Autonomous UV-Enhanced-Vision System That Prevents Runway Incursions at Medium-Size Airports*				
Source/Agency	*Enhanced and Synthetic Vision 2001*				
Authors	Victor J. Norris Jr.			**Year**	2001
Abstract	Runway incursions have been declared the nation's foremost aviation safety issue by the National Transportation Safety Board and the Federal Aviation Administration in testimony before congressional aviation committees. Technology solutions to date have been disappointing. After 12 years of development, the frequency of runway incursions shows no sign of abating, even as the cost for such systems continues to rise beyond $DLR9 million per airport. Application of ultraviolet technology offers incremental, low-cost, near- term improvements in runway incursion prevention and other enhancements to aviation safety, as well as increases in airport throughput capability, i.e., a reduction in delays.				
Comments	*Paper proposing the use of UV technology as a tool to reduce RIs, especially in low visibility conditions, such as fog; does mention benefits for drivers.*				
Potential Gaps	*Appears to be designed to present conceptual topic and to solicit funding so that the system could be tested over 6 months at $500K.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/4363/0000/Autonomous-UV-enhanced-vision-system-that-prevents-runway-incursions-at/10.1117/12.438034.short				

Reference #	29	**General Area**	RSA and RPZ	**Specific Area**	Archival Data Assessment
Title	*A Correlation Study of the Relationship Between Human Factor Errors and the Occurrence of Runway Incursions*				
Source/Agency	*International Journal of Professional Aviation Training & Testing Research*				
Authors	Kim Renee Torres; Donald S. Metscher; Marvin Smith			**Year**	2011
Abstract	Runway incursions have been a problem since the advent of airports. As air traffic has increased, so have the number of runway incursions. Throughout the years, many research studies have been conducted and systems developed in an attempt to reduce the rate of runway incursions. Despite best efforts, the rate of runway incursions has continued to rise. This research did not attempt to address remedies for runway incursions; instead it attempted to identify the most common causes of runway incursions. With a better understanding of the causes of runway incursions, the Federal Aviation Administration and the aviation community can better utilize their efforts and resources to reduce the persistent safety threat caused by runway incursions.				
Comments	*Does not address remedies of RIs, but looked at relationships between causal factors using Chi-Square and Correlations; found lack of situational awareness to be a leading issue.*				
Potential Gaps	*Findings are not causal in nature, but rather correlational and relationship based.*				
Link	http://ojs.library.okstate.edu/osu/index.php/IJPATTR/article/view/428				

Reference #	30	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*A Method for Rating the Severity of Runway Incursions*				
Source/Agency	U.S. Department of Transportation				
Authors	Kim Cardosi; Daniel Hannon; Thomas Sheridan,			**Year**	2005
Abstract	Risk is a function of the probability of an event and the severity of the consequences of that event. Any discussion of issues of risk in surface operations must include a valid and reliable measure of the severity of the outcome of runway incursions. This paper describes an automated method for rating the severity of the outcome of runway incursions. This model was developed using the same criteria and decisions that experts currently use to determine the severity of an incursion. The model assigns a severity rating based on the information contained in the preliminary report of the incident. This includes: the geometry of the situation that resulted in the incursion and the closest proximity (horizontal or vertical), visibility, type aircraft, and whether or not (and characteristics of) the avoidance maneuver. The initial validation was conducted by comparing the model's assessment of 307 runway incursions to the assessment conducted by a panel of subject matter experts in the FAA Runway Safety Office. In 92% of the incidents, the model matched the group's ratings (of three levels of severity). Patterns of discrepancies are well defined and discussed. Ongoing validation efforts are also described. Finally, possible applications to losses of standard separation in the air are explored.				
Comments	*Examines the risk equation (likelihood* severity) and attempts to produce a model to identify the severity of the RI.*				
Potential Gaps	*Initial data, continued validation of the model was still on-going at the time this article was published.*				
Link	https://pdfs.semanticscholar.org/5fdc/910ec29793ed8624b8fee1cb1d769e8709f4.pdf				

Reference #	31	**General Area**	RSA and RPZ	**Specific Area**	RI Causal Factors
Title	*Analysis on the Threats and Errors Caused by the Runway Incursions and the Corresponding Controlling Ways*				
Source/Agency	*Journal of Safety and Environment*				
Authors	**HUO Zhi-qin; HAN Song-chen**			**Year**	2012
Abstract	The paper is aimed at presenting an analysis on the threats and errors caused by the runway incursions and the corresponding controlling ways. In order to identify the mutual relation of all the different types of data of runway incursions, we have done a quantitative study on the unexpected accidents on such runway incursions based on the model of the threat and mismanagement. Then, we have analyzed the relation between the results and contributing factors by multivariate regression analysis in a method of the least square. The correlation coefficient in regard to the typical threat and typical error has been found equal to 0.83,while the correlation coefficient of the typical error and runway incursion is 0.86,with the correlation coefficient of typical threat and runway incursion being 0.94.At the same time, we have worked out the two-element linear regression equation for the runway incursions, their threats and errors. The equation for the runway incursion(y), threat(x1) and error(x2) was found to be y=-0.50819+0.039136x1+0.063816x2. The results of our calculation indicate that the typical errors are likely to impose a great impact on the runway incursions, which proves to have a great advantage for the Pareto Diagram to distinguish "the most crucial minority factors" from all. The contributing factors of the runway incursions in China Civil Aviation Industry can thus be illustrated as follows: the operator or the vehicle-caused runway accidents without authorization mainly result from the failure of flight area management; the failure of the proper coordination between the civil and the military aviation agencies; short of runway incursion consciousness on the part of the airport workers due to the insufficient training. Compared with the advanced aviation countries, China, our motherland, is characteristic of its own specific aviation-control environment in terms of runway incursions. Thus, the above-said three main contributing factors may account for perhaps over half of all runway incursions.				
Comments	*Used model of threat and mismanagement; appears to use dataset from China; found vehicles were a major factor/threat.*				
Potential Gaps	*Seems to have a limited data sample; is not well written.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTOTAL-AQHJ201204043.htm				

Reference #	32	**General Area**	Airside Driving	**Specific Area**	Driver Training
Title	*Runway Incursions: An Industry Examination of FAA Initiatives and Objectives*				
Source/Agency	*International Journal of Applied Aviation Studies*				
Authors	William B. Rankin II			**Year**	2008
Abstract	Previous research by Rankin in 1994 addressed the problem of runway incursions at the largest US towered airports and examined the perceptions of industry officials as to the effectiveness of the FAA initiatives or objectives implemented by the FAA Runway Incursion Plan of 1991. A similar study was completed in 2007 and investigates perception of industry officials as to the effectiveness of the FAA initiatives contained in the FAA Runway Safety Blueprint 2002-2004. For purposes of this paper, the studies are compared to see if there is a continued similarity of the perceived effectiveness by industry officials of the FAA initiatives or objectives. Since airport driver training was ranked as the number one initiate in the 1994 study and is not included in the FAA Runway Safety Blueprint 2002- 2004, the 2007 study asked industry officials if airport driver training should, or should not be included in the FAA Runway Safety Blueprint.				
Comments	*Paper focuses on airport driver training; found the FAA left this area out of its runway safety blueprint; highlights the key focal areas missing from FAA blueprint.*				
Potential Gaps	*Study has a focus on airside driving but is quite old at this point. Methods were quite challenging to follow, only used 19 participants.*				
Link	https://www.researchgate.net/profile/Alex_De_Voogt/publication/239522783_Stress_in_ballooning_An_exploratory_cortisol_study/links/59de6787aca27247d794369d/Stress-in-ballooning-An-exploratory-cortisol-study.pdf#page=41				

Reference #	33	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Prevention of Runway Incursions Due to Closed Runways or Unsuitable Runway Choices by Enhanced Crew Situational Awareness and Alerting*				
Source/Agency	*Enhanced and Synthetic Vision 2007*				
Authors	Christoph Vernaleken; Carole Urvoy; Uwe Klingauf			**Year**	2007
Abstract	Of all incidents on the aerodrome surface, Runway Incursions, i.e. the incorrect presence of an aircraft on a runway, are the by far most safety-critical, resulting in many fatalities if they lead to an accident. A lack of flight crew situational awareness is almost always a causal factor in these occurrences, and like any Runway Incursion, the special case of choosing a closed or unsuitable runway - including mistaking a taxiway for a runway - may have catastrophic consequences, as the Singapore Airlines Flight SQ006 accident at Taipei in 2000 and, most recently, Comair Flight 5191, tragically show. In other incidents, such as UPS Flight 896 at Denver in 2001 departing from a closed runway or China Airlines Flight 11 taking off from a taxiway at Anchorage in 2002, a disaster was only avoided by mere luck. This paper describes how the concept for an onboard Surface Movement Awareness and Alerting System (SMAAS) can be applied to this special case and might help to prevent flight crews from taking off or landing on closed runways, unsuitable runways or taxiways, and presents initial evaluation results. An airport moving map based on an ED-99A/DO- 272A compliant Aerodrome Mapping Database (AMDB) is used to visualize runway closures and other applicable airport restrictions, based on NOTAM and D-ATIS data, to provide the crew with enhanced situational awareness in terms of position and operational environment. If this is not sufficient to prevent a hazardous situation, e.g. in case the crew is distracted, a tailored alerting concept consisting of both visual and aural alerts consistent with existing warning systems catches the crew's attention. Therefore, this paper also develops the concept of a machine-readable electronic Pre-flight Information Bulletin (ePIB) to bring relevant NOTAM information to the flight deck prior to the flight, with a possibility to receive updates via data link while the aircraft is airborne.				
Comments	*Focuses on flight crews; technology designed to prevent pilots from taking off on closed runways or taxiways; initial results showed increase in pilot situational awareness.*				
Potential Gaps	*Does not address applicability for use with drivers; limited to a sample of 15 pilots.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/6559/65590I/Prevention-of-runway-incursions-due-to-closed-runways-or-unsuitable/10.1117/12.719573.short				

Reference #	34	**General Area**	RSA and RPZ	**Specific Area**	Archival Analysis
Title	*Runway Incursion Severity Risk Analysis.*				
Source/Agency	Federal Aviation Administration				
Authors	Lee Biernbaum; Garrett Hagemann			**Year**	2012
Abstract	Runway incursions are defined as the unauthorized presence of a vehicle, pedestrian, or aircraft on a runway. Identifying situations or conditions in which runway incursions are more likely to be severe can suggest policy implications and areas for future safety research. Previous work in this area focused on a narrative approach. This study seeks to examine runway incursions from a statistical perspective and provide insights into the broad trends underlying severity. This report analyzes 10 years of runway incursion event information. A variety of FAA data sources were used to provide information on the event itself, airport characteristics, and airport operations at the time of the incident. Weather information was also incorporated using automated weather readings from airports. The culmination of the analysis is a series of discrete choice models focusing on different sets of incident characteristics. As this represents the first regression-based analysis of these data, the results are suggestive rather than definitive. For example, controller incidents appear to be more severe on average. The results also suggest some areas for further investigation: specifically, a need for understanding the frequency of incursions and improvements to the severity measure.				
Comments	*Reviews 10 years of data on RIs 2001-2010; correlational design; controller issues most severe; runway intersections increase risk.*				
Potential Gaps	*Archival in nature; about ten years old; limited to correlations not causation.*				
Link	https://rosap.ntl.bts.gov/view/dot/9717				

Reference #	35	**General Area**	Airside Driving	**Specific Area**	Signage and Training
Title	*Runway Incursions and Prevention Systems*				
Source/Agency	Emerald Group Publishing Limited				
Authors	D. McLean			**Year**	2004
Abstract	Some aircraft runway collisions are described first to illustrate some common features of a runway incursion (RI) incident. Then, using the FAA definition of runway incursion, some data relating to RI incidents are presented to show that both RIs and incursion rates are growing steadily in the USA. Data for UK airport operations also indicate that the incursion rates in Britain are of the same order. Hence there is a need for some form of RI prevention. Most of the technological prevention systems available, or being developed, are briefly described before the paper concludes with the suggestion that effective prevention may be more swiftly obtained by improving airside signage and training for airport workers who use runways and taxiways in their vehicles.				
Comments	*Review of runway incursions in US and UK; findings suggest better airside signage and training; discusses not all solutions need to be technological.*				
Potential Gaps	*A review of other studies, but no data to backup claims or demonstrate that better signage or training actually results in a reduction in RIs.*				
Link	https://www.emeraldinsight.com/doi/abs/10.1108/00022660410555149				

Reference #	36	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Fatal US Runway Collisions Over the Next Two Decades*				
Source/Agency	*Air Traffic Control Quarterly*				
Authors	Arnold Barnett; Gary Paull; Joseph Iadeluca			**Year**	2016
Abstract	Recent data raise the possibility that runway collisions at towered US airports could kill 700–800 people and seriously injure 200 others over the years 2003–2022. This projection—which is mid-range rather than best or worst case—arises from historical records about fatal runway collisions, from airport-specific traffic growth forecasts, from analyses of weather hazards, and from a review of all 292 US runway incursions in 1997.				
Comments	*Takes a look at predicting RIs and fatalities between 2003-2022 at towered airports.*				
Potential Gaps	*Study is approaching the end of its prediction window (2022). Focused primarily on impacts of aircraft over V/PDs.*				
Link	https://arc.aiaa.org/doi/abs/10.2514/atcq.8.4.253				

Reference #	37	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Cockpit Technology for the Prevention of General Aviation Runway Incursions*				
Source/Agency	*International Symposium on Aviation Psychology*				
Authors	**Lawrence J. Prinzel III; Denise R. Jones**			**Year**	2007
Abstract	General aviation accounted for 74 percent of runway incursions but only 57 percent of the operations during the four-year period from fiscal year (FY) 2001 through FY2004. Elements of the NASA Runway Incursion Prevention System were adapted and tested for general aviation aircraft. Sixteen General Aviation pilots, of varying levels of certification and amount of experience, participated in a piloted simulation study to evaluate the system for prevention of general aviation runway incursions compared to existing moving map displays. Pilots flew numerous complex, high workload approaches under varying weather and visibility conditions. A rare-event runway incursion scenario was presented, unbeknownst to the pilots, which represented a typical runway incursion situation. The results validated the efficacy and safety need for a runway incursion prevention system for general aviation aircraft.				
Comments	*Electronic flight bag helped improve RI detection with a sample of general aviation pilots, especially with audible alerting included; findings similar to prior studies using commercial and business aircraft pilots.*				
Potential Gaps	*Only 16 participants, limited to general aviation pilots not vehicle operators.*				
Link	https://corescholar.libraries.wright.edu/isap_2007/42/				

Reference #	38	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Runway Safety Program Evaluation with Uncertainties of Benefits and Costs*				
Source/Agency	*Journal of Risk Research*				
Authors	Ellen C. Rogerson , James H. Lambert & Alexander F. Johns			**Year**	2013
Abstract	Risk and safety programs need to be monitored and evaluated through real-world experience and performance. Several perspectives on the program might be useful across organizational units, stakeholders, and subject-matter experts. Quantifications of risks, benefits, and costs of the programs as well as the associated parameter uncertainties will vary by perspective. The literature has quantified the benefits of a safety program in single stakeholder/expert perspectives. This paper describes a layering of perspectives of program effectiveness and characterizes the variation of estimated program efficacy across the several perspectives. Within each perspective, the uncertainties of model selection and the estimation of cost-benefit analysis parameters are addressed via interval numbers. The approach is demonstrated for safety trainings that are aimed to reduce runway incursions for 80 airports across a region, an issue of highest priority for the US National Transportation Safety Board. The several perspectives of the demonstration are the pilot/driver, the airport owner/operator, and the safety regulator. The results suggest for each of the perspectives which of the airports should receive the trainings. The paper will be of interest for the performance evaluation of safety programs with uncertainties of program benefits and costs and multiple agencies, users, customers, and other stakeholders/experts.				
Comments	*Present multi-layered perspectives on cost-benefit of safety programs related to prevent RIs. Pilot/driver was one of the perspectives reviewed. Pilot/drivers felt programs were warranted in the majority of situations.*				
Potential Gaps	*Limited in the number of cases analyzed; limited to only 3 stakeholder groups.*				
Link	https://www.tandfonline.com/doi/abs/10.1080/13669877.2012.725674				

Reference #	39	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Statistical Modelling of Runway Incursions*				
Source/Agency	Transportation Research Board				
Authors	Mathew, Jijo K; Major, Wesley L; Hubbard, Sarah M; Bullock, Darcy M			**Year**	2016
Abstract	Runway incursions continue to be an aviation safety concern. Between 2001 and 2014 there were 15,278 runway incursions at United States airports ranging in size from small general aviation (GA) to large commercial airline hubs. In June 2015, the FAA announced the Runway Incursion Mitigation (RIM) program to identify airport risk factors that might contribute to a runway incursion and develop strategies to help airport stakeholders mitigate those risks. Budget is always a constraint for airport improvements, so it is important to have systematic methods to prioritize resource allocation and identify which technologies to invest in. This paper uses econometrics-based modelling techniques to identify statistically significant factors in data provided by the FAA Runway Safety Office – Runway Incursions (RWS). The model identified statistically significant findings between airports categories defined by the National Plan of Integrated Airport Systems (NPIAS). Overall, the model showed that incursion characteristics differ depending on the category of airport. Only one variable, "number of years since 2001", was found to be significant for all the three airport categories for severity A incursions. This suggests that the factors that correlate with runway incursions vary depending on the size of the airport and the incursion severity. As a result, the most appropriate countermeasures will vary depending on the category of airport. For example, operational incidents are more likely at large airports. In contrast, at GA/non-hub airports, pilot deviations were significant in severity C and D, perhaps because the pilots who utilize these airports are recreational and business users who might be unfamiliar with the airport layout and their respective hotspots.				
Comments	*Used statistical modeling to help airport prioritize resource allocation; incursion characteristics differed as a function of airport category.*				
Potential Gaps	*Predictive factors varied significantly between the different causes of incursions and differing airport categories; suggests that a one-size-fits-all approach may not work.*				
Link	https://trid.trb.org/view/1392851				

Reference #	40	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Identification of Causal Paths and Prediction of Runway Incursion Risk by Means of Bayesian Belief Networks*				
Source/Agency	*Transportation Research Record*				
Authors	Benjamin Jeffry Goodheart			**Year**	2014
Abstract	In the United States and worldwide, runway incursions are acknowledged as a critical concern for aviation safety. Despite efforts to the contrary, however, the rate at which these events occur in the United States has steadily risen. Analyses of the causes of runway incursions have frequently been limited to discrete events and have not addressed the dynamic interactions that led to breaches of runway safety. This paper emphasizes the need for cross-domain methods of causation analysis applied to runway incursions in the United States. A holistic modeling technique using Bayesian belief networks to interpret causation in the presence of sparse data is outlined, with intended application at the systems level. Further, the importance of investigating runway incursions probabilistically and of incorporating information from human factors, technological, and organizational perspectives is supported. A method for structuring Bayesian networks with quantitative and qualitative event analyses in conjunction with structured expert probability estimation is outlined, and results are presented for propagation of evidence through the model as well as for causal analysis. The model provides a dynamic, inferential platform for future evaluation of the causes of runway incursions. The results in part confirm what is known about the causes of runway incursions, but more important shed light on multifaceted causal interactions in a modeling space that allows causal inference and evaluation of changes to the system in a dynamic setting. Suggestions for additional research are discussed; the prominent suggestion is a need for future testing coupled with a focus on higher levels of quantification while exploring means of enhancing availability of relevant data.				
Comments	*Suggests the development of a holistic approach to determining RI causes is best; develops model using advanced statistical analysis.*				
Potential Gaps	*Development of the initial model; further research needed to provide further validation.*				
Link	https://journals.sagepub.com/doi/abs/10.3141/2400-02				

Reference #	41	**General Area**	RSA and RPZ	**Specific Area**	Causal Factors
Title	*Reason Analysis of Runway Incursions Based on Grey Theory*				
Source/Agency	*Journal of Safety and Environment*				
Authors	**Zhang Xiao-quan; Yang Wen-tao**			**Year**	2010
Abstract	Reason analysis of runway incursions is an important context in the study of civil aviation airport unsafe events. This paper is aimed at presenting the authors' analysis and their method in looking for the main reasons of runway incursions with different severities and suggesting the targeted measures to prevent the occurrence of runway incursions. Firstly, the definition of runway incursions and classification of relevant criteria are introduced. On this basis, by means of grey relational analysis of different severities and factors of runway incursions , the grey relational degree of class AB runway incursions and pilot deviations, operational errors/deviations as well as vehicle/ pedestrian deviations can be respectively calculated as follows: 0.658 3, 0.662 2, 0.667 3. On the other hand, the grey relational degree of class CD runway incursions and pilot deviations, operational errors/deviations and vehicle/pedestrian deviations are 0.852 9, 0.839 2, 0.745 5, respectively. The results have shown that the key factors leading to the class AB and class CD runway incursions are vehicle/pedestrian deviations and pilot deviations respectively. The paper has summarized that it's critical to prevent class AB runway incursions by reinforcing the quality of communication and the vehicle/ pedestrian management on their access to the aircraft movement area. It is also critical to prevent class CD runway incursions by strengthening the awareness of pilots on the regulations and controller' s instructions compliance as well as strengthening the crew resource management.				
Comments	*Study found V/PD leading factor to A/B incursions; suggest increasing communication between ATC and drivers.*				
Potential Gaps	*Unable to collect full paper; unable to assess methods, samples, etc.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTOTAL-AQHJ201005037.htm				

Reference #	42	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Safety Monitor Algorithm for Single and Crossing Runway Incursion Detection and Alerting*				
Source/Agency	NASA				
Authors	Green, David F., Jr.			**Year**	2006
Abstract	The Runway Safety Monitor (RSM) is an aircraft-based algorithm for runway incursion detection and alerting that was developed in support of NASA's Runway Incursion Prevention System (RIPS) research conducted under the NASA Aviation Safety and Security Program's Synthetic Vision System project. The RSM algorithm provides warnings of runway incursions in sufficient time for pilots to take evasive action and avoid accidents during landings, takeoffs or when taxiing on the runway. The report documents the RSM software and describes in detail how RSM performs runway incursion detection and alerting functions for NASA RIPS. The report also describes the RIPS flight tests conducted at the Reno/Tahoe International Airport (RNO) and the Wallops Flight Facility (WAL) during July and August of 2004, and the RSM performance results and lessons learned from those flight tests.				
Comments	*Provides an assessment of Runway Safety Monitor for detection and alerting of RI; assessed 7 scenarios in testing; system performed consistently and effectively.*				
Potential Gaps	*Testing based on medium and large airports; GA airport testing needed; no mention of use with V/PDs.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20060007563				

Reference #	43	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Risk-Based Airport Selection for Runway Safety Assessments Through the Development and Application of Systems-Driven Prioritization Methodologies*				
Source/Agency	IEEE				
Authors	Kyle M. Galle; John C. Ale; Mohammad M. Hossain; +7 authors			**Year**	2010
Abstract	A runway incursion is the erroneous presence of an aircraft or other object on the runway. Runway incursions are rare precursors to aviation accidents and result from a variety of complex factors. Current quantitative methods are inadequate for analysis, forecasting, and understanding the risk profiles of airports. The Federal Aviation Administration (FAA) biennially employs runway safety action teams (RSATs) to evaluate airports with the aim of reducing runway incursions. This manuscript describes the development of a decision-making tool that combines systems methodologies to help the FAA select airports at which employing RSATs would be the most beneficial for the reduction of collision risk. These methodologies include hierarchical Bayesian modeling (HBM) and analytic hierarchy process (AHP). HBM leverages the similarities between airports through conditioning incursion rate estimates on both historical data and the data sampled from hyper-distributions fitted using data from similar airports. AHP decomposes these RSAT placement decisions into a hierarchy of decisions to be examined independently; as the system evolves, the method allows the FAA to reflect changes in its knowledge and preferences in the weights of corresponding risk factors. The key deliverable of this project, a workbook decision tool, places HBM within the AHP hierarchy. The final methodology output presents an ordered list of airports according to potential risk-reduction from RSATs. This combination further incorporates risk-based and decision-based approaches in order to better allocate resources and reduce runway incursions. The tool meets project goals by utilizing the FAA's data to provide an analytically justifiable prioritized list, while building on current best practices for the RSAT selection process.				
Comments	*Conducts advanced statistical modeling of airports with FAA runway safety action teams (RSATs); helps RSATs set prioritizations.*				
Potential Gaps	*Unable to find full paper; limited to only airports with RSATs.*				
Link	https://arc.aiaa.org/doi/abs/10.2514/6.2008-8959				

Reference #	44	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*A Risk-Based Framework for Assessment of Runway Incursion Events*				
Source/Agency	Eleventh USA/Europe Air Traffic Management Research and Development Seminar				
Authors	Sybert Stroeve; Bas van Doorn; Bert Bakker			**Year**	2015
Abstract	Current safety management of aerodrome operations uses a severity-based categorization of runway incursion events. This severity assessment is mainly based upon the outcome of a runway incursion event, in particular on the closest distance attained. As such the severity depends to a considerable extent on uncontrolled random circumstances and we argue that it is not suitable as prime indicator for safety management of aerodrome operations. In this paper we present a new framework for the evaluation of runway incursion events, which is based on the risk of scenarios associated with the initiation of runway incursion events, rather than on the outcomes of the events. In support of this framework an inventory of scenarios is provided, which can represent most runway incursion events involving a conflict with an aircraft. A main step in the framework is the assessment of the conditional probability of a collision given a runway incursion scenario. This can be effectively achieved for large sets of scenarios by agent-based dynamic risk modelling. The results provide detailed feedback on risks of runway incursion scenarios, thus enabling effective safety management for the most safety critical situations.				
Comments	*Tries to establish a new framework based on risk of scenario rather than outcome; uses information up until the initiation of an incursion.*				
Potential Gaps	*Limited in terms of cases/scenarios examined; does not seem that V/PDs were considered as part of the framework.*				
Link	http://atmseminar.org/seminarContent/seminar11/papers/366_Stroeve_0121150328-Final-Paper-4-23-15.pdf				

Reference #	45	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Direct Alerting to the Cockpit for Runway Incursions*				
Source/Agency	IEEE/AIAA 26th Digital Avionics Systems Conference				
Authors	Duane Ludwig			**Year**	2007
Abstract	The NTSB has identified the reduction of runway incursions as one of the top priorities for the FAA to address. A number of systems based on ground-based technologies have been developed and deployed: airport movement area safely system (AMASS), the airport surface detection equipment, Model X (ASDE-X), and the runway status light (RWSL) system. Nevertheless, these methods are not expected to fully resolve the runway incursion problem. The expected adoption of automatic dependent surveillance-broadcast (ADS-B) systems will enable cockpit-based alerting solutions that fill in the gaps and provide flight crews with timely information regarding potential conflicts. This paper describes the background, requirements, and development issues relating to a direct alert to the cockpit (DAC) system. It also describes a PC-based simulation tool that has been developed for the DAC effort. Before development commences, top level requirements are laid out and key assumptions are made regarding the runway conflict problem and how direct alerting might address it. Other technologies are examined as well to determine the gaps that must be covered. The first step in the DAC development process involves identifying all of the potential runway incursion scenarios. ADS-B data is used to establish a "track file" of position, speed, and heading for the own-ship and each detected traffic element. The DAC logic then formulates vectors that intelligently predict vehicle locations for critical look-ahead times, based on the possible scenarios. Finally, the system then analyzes vehicle performance capabilities to determine if and precisely when a particular alert is provided to the cockpit. A primary challenge of the DAC effort is developing an alerting system that is not perceived as a nuisance to flight crews and airport traffic managers. The goal is to produce logic that will significantly reduce runway incursions while minimizing false alerts that would adversely impact an airport's effici...				
Comments	*Work is to examine direct alert to the cockpit (DAC) effects to prevent runway incursions; system works with ADS-B; outlines requirements for such a system to be successful.*				
Potential Gaps	*Mostly conceptual in nature; could be applicable to V/PDs; only tested on a PC-based flight simulator.*				
Link	https://ieeexplore.ieee.org/abstract/document/4391930				

Reference #	46	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Operational Evaluation of Runway Status Lights*				
Source/Agency	*Lincoln Laboratory Journal*				
Authors	James R. Eggert; Bradley R. Howes; Maria Picardi Kuffner; Harald Wilhelmsen; D. Jonathan Bernays			**Year**	2006
Abstract	To maintain safe separation of aircraft on the airport surface, air traffic controllers issue verbal clearances to pilots to sequence aircraft arrivals, departures, and runway crossings. Although controllers and pilots work together successfully most of the time, mistakes do occasionally happen, causing several hundred runway incursions a year—and, less frequently, near misses and collisions—in the United States. With this rate of incursions, it is imperative to have an independent warning system as a backup to the current system. Runway status lights, a system of automated, surveillance-driven stoplights, have been designed to provide this backup function. The lights are installed at runway-taxiway intersections and at departure points along the runways. They provide a clear signal to pilots crossing or departing from a runway, warning them of potential conflicts with traffic already on the runway. Existing FAA-installed radar surveillance is coupled with Lincoln Laboratory–developed algorithms to generate the light commands. To be compatible with operations at the busiest airports, the algorithms must drive the lights such that during normal operations pilots will almost never encounter a red light when it is safe to cross or depart from a runway. A minimal error rate must be maintained even in the face of inevitable imperfections in the surveillance system used to drive the safety logic. A prototype runway status light system has been designed at Lincoln Laboratory and installed at the Dallas/Fort Worth International Airport, where Laboratory personnel have worked with the FAA to complete an operational evaluation of the system, demonstrating the feasibility of runway status lights in the challenging, complex environment of one of the world's busiest airports.				
Comments	*Suggests independent warning system from ATC/pilots; runway status lights; technical assessment shows 99.5% accuracy; good operational feedback.*				
Potential Gaps	*Slightly old study; V/PDs are not a focus of the study, but they are mentioned; the system could be applicable and helpful to them.*				
Link	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.72.8084&rep=rep1&type=pdf				

Reference #	47	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Autonomous Low-Cost Electro-Optical System that Prevents Runway Incursion by Providing Direct Warnings to Flight Crews*				
Source/Agency	*Enhanced and Synthetic Vision*				
Authors	Victor J. Norris Jr.			**Year**	2003
Abstract	Norris Electro Optical Systems (NEOS) has developed a sensor that detects the local presence of aircraft on an airport surface. It operates in the ultraviolet (UV) region where no natural background noise is present, thereby enabling reliable, hands off operation, throughout the environment extremes of high noon to low visibility conditions. These characteristics have been validated by the Federal Aviation Administration (FAA). NEOS is applying these capabilities to enable a low cost, autonomous, electro optically based, runway incursion prevention system that conforms to the National Transportation Safety Board's (NTSB) recommendation for a direct warning to flight crews of the potential for a runway incursion.				
Comments	*Related to Ref #28; discusses avionics and non-avionic solutions; conducted pilot testing; system designed to prevent RIs not detect them; proactive rather than reactive approach; relatively low cost, $750K per runway.*				
Potential Gaps	*Small test sample: favorable results, but more research is needed.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5081/0000/Autonomous-low-cost-electro-optical-system-that-prevents-runway-incursion/10.1117/12.499290.short?SSO=1				

Reference #	48	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Low Cost Runway Incursion Detection System for General Aviation Airports*				
Source/Agency	IEEE				
Authors	I. K. Dabipi;J; Bryan Burrows-McElwain; Chris Hartman			**Year**	2010
Abstract	The purpose of this paper is to introduce the reader to a freshman engineering design project where students were required to design a novel low cost runway incursion detection system that might have future application for small general aviation airport operations by applying sound engineering problem solving criterion. Given the direction of Aviation towards autonomous navigation, this project provides a meaningful medium to educate freshman engineering students on both concept and teamwork principles. The goals of the project were (a) to introduce collaboration across disciplines given the students' intended majors, (b) to enhance scientific inquiry, (c) to foster communication among the group as well as enhance communication between the students and the client who provides the project objectives, and (d) the group management structure and its implication as it applies to achieving the overall objectives of the project. As an integrated department with both Engineering and Aviation Science faculty, it was natural for the Aviation Science faculty to serve as clients, who then generate plausible problems that can benefit both the Aviation Science and Engineering students in the program and these problems are then used as the basis for a structured engineering design approach for introducing engineering design fundamentals to the freshman engineering class. The unique nature of the assignment lies in the need for the concept to be low cost and practical. Team leadership styles were evaluated and compared against design outcomes. This paper examines both the engineering aspect of the students' learning as well as their leadership growth and interaction between group members as well as the interaction with the client. With students from various engineering backgrounds involved in the course, this paper also provides the audience the ability to examine the applicability of this approach to other subject areas.				
Comments	*Based on freshman design project; proposed low cost system for small general aviation airports; tested design on a small scale in the lab.*				
Potential Gaps	*Designed a small-scale RI detection system; the paper was more focused on the groupwork aspect of the engineering design course.*				
Link	https://ieeexplore.ieee.org/abstract/document/5673192				

Reference #	49	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Application of Pathprox Runway Incursion Alerting to General Aviation Operations*				
Source/Agency	IEEE				
Authors	R. Cassell			**Year**	2005
Abstract	This paper describes the application of the PathProx/spl trade/ runway incursion advisory and alerting system to general aviation (GA) aircraft operations. Airport surface incursions have been identified by the National Transportation Safety Board (NTSB) as one of the most significant safety hazards in civil aviation. PathProx is a system developed by Rannoch Corporation to help address this problem. It is an aircraft-based runway incursion alerting system, providing runway incursion alerts directly to the pilot(s). The testing and analyses that have been performed demonstrate significant safety benefits of PathProx. Among the other improvements in operations provided by PathProx include improved situational awareness, self-separation, and conflict detection and alerting without reliance on a ground infrastructure and ATC. It is also an enabling technology for operations such as the NASA Small Aircraft Transportation System (SATS) high volume operations.				
Comments	*Related to Ref #21; attempting to move from commercial operations to general aviation operations; discusses how system would work related to GA.*				
Potential Gaps	*Mentions testing of the system in a GA environment, but the paper does not report any data to support any findings.*				
Link	https://ieeexplore.ieee.org/abstract/document/1563366				

Reference #	50	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*NASA Runway Incursion Prevention System (RIPS) Dallas-Fort Worth Demonstration Performance Analysis*				
Source/Agency	NASA				
Authors	Cassell, Rick; Evers, Carl; Esche, Jeff; Sleep, Benjamin; Jones, Denise R.			**Year**	2002
Abstract	NASA's Aviation Safety Program Synthetic Vision System project conducted a Runway Incursion Prevention System (RIPS) flight test at the Dallas-Fort Worth International Airport in October 2000. The RIPS research system includes advanced displays, airport surveillance system, data links, positioning system, and alerting algorithms to provide pilots with enhanced situational awareness, supplemental guidance cues, a real-time display of traffic information, and warnings of runway incursions. This report describes the aircraft and ground-based runway incursion alerting systems and traffic positioning systems (Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B)). A performance analysis of these systems is also presented.				
Comments	*Report on demonstration of RIPS at Dallas/Fort Worth airport; aircraft and ground-based systems tested; test results suggest good use of system with minor misses and false alerts.*				
Potential Gaps	*Additional work needed to improve accuracy; further programming necessary to incorporate more smoothly with ADS-B.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20020053649				

Reference #	51	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention System ADS-B and DGPS Data Link Analysis Dallas-Fort Worth International Airport*				
Source/Agency	NASA				
Authors	Timmerman, J.; Jones, Denise R.			**Year**	2002
Abstract	A Runway Incursion Prevention System (RIPS) was tested at the Dallas - Ft. Worth International Airport in October 2000. The system integrated airborne and ground components to provide both pilots and controllers with enhanced situational awareness, supplemental guidance cues, a real-time display of traffic information, and warning of runway incursions in order to prevent runway incidents while also improving operational capability. Rockwell Collins provided and supported a prototype Automatic Dependent Surveillance - Broadcast (ADS-B) system using 1090 MHz and a prototype Differential GPS (DGPS) system onboard the NASA Boeing 757 research aircraft. This report describes the Rockwell Collins contributions to the RIPS flight test, summarizes the development process, and analyzes both ADS-B and DGPS data collected during the flight test. In addition, results are report on interoperability tests conducted between the NASA Advanced General Aviation Transport Experiments (AGATE) ADS-B flight test system and the NASA Boeing 757 ADS-B system.				
Comments	*Report addresses the RIP portion of flight testing at DFW airport, specifically incorporation of ADS-B and differential GPS; incursions properly alerted in 11 of 12 trial scenarios.*				
Potential Gaps	*Used only 12 studies for testing; research is almost 20 years old.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20020013329				

Reference #	52	**General Area**	RSA and RPZ	**Specific Area**	Archival Coding
Title	*Error Types and Related Error Detection Mechanisms in the Aviation Domain: An Analysis of Aviation Safety Reporting System Incident Reports*				
Source/Agency	*The International Journal of Aviation Psychology*				
Authors	Nadine B. Sarter; Heather M. Alexander			**Year**	2009
Abstract	Human error is considered a contributing factor in 70% to 80% of all aviation accidents. Because errors can never be eliminated completely, a further reduction of the already low accident rate in this domain will require investments in better support for error management. In particular, a better understanding of the nature and effectiveness of error detection mechanisms is needed. With this goal in mind, NASA Aviation Safety Reporting System incident reports were analyzed in terms of the formal characteristics of underlying errors, the cognitive stage, and the performance level at which these errors occurred, and with respect to the processes that led to their detection and, thus, prevented these incidents from turning into accidents. The majority of incidents involved lapses (i.e., failures to perform a required action) or mistakes, such as errors in intention formation and strategy choice. These errors were most often detected based on routine checks and the observed outcome of an action, respectively. Most slips appear to have been discovered by the crew before they could lead to a problem worth reporting. Our findings suggest a need for more effective feedback in support of data-driven monitoring, especially in the case of errors of omission and for shared knowledge of intent between airborne and ground-based operators to promote the more timely and reliable detection of mistakes.				
Comments	*Reviewed NASA ASRS reports to determine characteristics of underlying errors within reports; suggests more feedback to support data-driven monitoring and to close the communication loop.*				
Potential Gaps	*Archival study looking at past NASA ASRS reports; study published in 2000; not specific to runway incursions, but related to general ASRS reports in analysis.*				
Link	https://www.tandfonline.com/doi/abs/10.1207/S15327108IJAP1002_5				

Reference #	53	**General Area**	Choose an item.	**Specific Area**	
Title	*Warning, Runway Occupied: An Evaluation of Tower Controller Behavior when Maintaining Runway Safety*				
Source/Agency	29th Digital Avionics Systems Conference				
Authors	Ronald K. Stevens; Julian Sanchez			**Year**	2010
Abstract	As runway safety alerting tools are added into the tower environment, it is important to understand how controllers will integrate new visual and auditory information into their decision-making process, especially in critical situations. To date, research into the behavior of Tower controllers has been largely based on field observations. Since runway incursions are generally rare events and cannot be `controlled', we lack an understanding of controller behavior in responding to these events. In an effort to better understand these behaviors, a Human-In-The-Loop (HITL) simulation was conducted to gain insight into the response behavior of Tower Controllers when runway safety alerts are generated. The simulation described provides a snapshot of current day tower controller performance, both in terms of decisions and interactions that can be considered a baseline for which to compare proposed future implementations of new or enhanced capabilities.				
Comments	*Conducted a human-in-the-loop simulation to examine controller behavior after a runway safety alert occurred; given an alert, most controller's first reaction was to examine the airport surface detection equipment (ASDE-X).*				
Potential Gaps	*Study limited to only 8 participants; some controllers stated their standard operating procedures determined how they were supposed to respond to alerts.*				
Link	https://ieeexplore.ieee.org/abstract/document/5655339				

Reference #	54	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Incorporating Controller Intent into a Runway Incursion Prevention System*				
Source/Agency	IEEE/AIAA 28th Digital Avionics Systems Conference				
Authors	Karen M. Feigh; Daniel P. J. Bruneau			**Year**	2009
Abstract	This work presents a solution to prevent and reduce the severity of runway incursions. This solution, called the Controller Clearance Broadcast System (CCBS), addresses the root causes of many runway incursions as well as mitigating the impact of those that do occur. Specifically, the CCBS design incorporates controller intent, by serving as an intermediary system to capture controller clearances, vet them for appropriateness, and then broadcast them via both analog radio channels and digitally via ADS-B. CCBS is anticipated to benefit the air transportation system by: 1) increasing operational efficiency; 2) decreasing the numbers of pilot deviation and operational errors; 3) decreasing radio channel congestion; and 4) increasing the ability to `remote tower' smaller airports. The CCBS includes visual displays for tower controllers and pilots, an expert system to improve operational efficiency, a critiquing system to prevent erroneous clearances, and an alerting system to provide warnings to both pilots and controllers about clearance deviations. The system is highly flexible, and accommodates various levels of aircraft and airport equipage, to allow a gradual transition from analog to digital based clearances. A software prototype of the CCBS has been created and shown the feasibility of the basic clearance capture functionality. Further research into the creation of a fully functional CCBS prototype is warranted as it will address a number of areas of research important for use in NextGen.				
Comments	*Examines the controller clearance broadcast system to address root causes of RIs; consists of tower and flight deck components; works to verify appropriateness of controller's commands relative to the situation; created a prototype system; focuses on non-verbal communication to reduce errors.*				
Potential Gaps	*Conceptual paper in nature, while a prototype was developed, no extensive testing of the system's effectiveness was completed.*				
Link	https://ieeexplore.ieee.org/abstract/document/5347490				

Reference #	55	**General Area**	RSA and RPZ	**Specific Area**	Standardization/Regulation
Title	*Ensuring Global Runway Safety: A Look at the Future'*				
Source/Agency	*Air & Space Law*				
Authors	Ruwantissa **Abeyratne**			**Year**	
Abstract	From 24 to 26 May 2011, the International Civil Aviation Organization (ICAO) hosted a Symposium on Global Runway Safety. The objectives of the Symposium were to highlight the evolution towards a more integrated safety management approach in ICAO's runway safety programme, coordinate a global effort for improving runway safety by identifying what a State can do to improve runway safety outcomes, identify a common framework for the enhancement of runway safety, promote and gain commitment from partners to deliver regional runway safety workshops across the globe, and identify content and format for subsequent runway safety workshops. The Symposium was held against the backdrop of ICAO Assembly Resolution A37-15 (Consolidated statement of continuing ICAO policies and associated practices related specifically to air navigation), which was adopted at the 37th Session of the Assembly held in Montreal from 28 September to 8 October 2010. Appendix P to the Resolution calls upon ICAO to keep under review the technical requirements for aerodromes and requests States to ensure that safety management systems are introduced at their aerodromes. States are also called upon to place greater emphasis on the management of aerodrome operations, with runway safety given a high priority. This article posits the basic fact that issues of runway safety require the standardization and harmonization of rules, which cannot all be ensured through regulation. It examines what has already been accomplished through ICAO and discusses certain proactive measures for runway safety in the future, using the outcome of the ICAO symposium as a backdrop to the discussions.				
Comments	*Unable to find full article; goal of symposium was to move toward a more integrated and standardized approach to safety management and runway safety.*				
Potential Gaps	*Conceptual in nature; does not appear any data or assessments were collected as part of the work.*				
Link	http://www.kluwerlawonline.com/abstract.php?area=Journals&id=AILA2011040				

Reference #	56	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Aviation Safety Benefits of Nasa Synthetic Vision: Low Visibility Loss-of-Control, Runway Incursion Detection, and CFIT Experiments*				
Source/Agency	NASA				
Authors	Lawrence J. Frinzel III; Monica F. Hughes; Lynda J. Kramer; Jarvis J. Arthur			**Year**	2004
Abstract	A national aviation safety goal was established to reduce the accident rate by 80% by 2007. Reducing low visibility as a causal factor in general aviation and commercial accidents may help meet that goal. The paper describes research conducted at the NASA Langley Research Center on the efficacy of synthetic vision to mitigate spatial disorientation, runway incursions, and controlled-flight-into-terrain.				
Comments	*Evaluation of synthetic vision in low visibility situations.*				
Potential Gaps	*Unable to find full report.*				
Link	*https://s3.amazonaws.com/academia.edu.documents/30664640/GetTRDoc.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1559504828&Signature=Amhy7Y%2FUxnO7QMGzjnIIvmXJNog%3D&response-content-disposition=inline%3B%20filename%3DDESIGN_OF_LEARNING_ENVIRONMENTS_FOR_COMP.pdf#page=179*				

Reference #	57	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Statistical Methods for Modeling the Risk of Runway Excursions*				
Source/Agency	*Journal of Risk Research*				
Authors	Douglas Wagner; Kash Barker			**Year**	2013
Abstract	The goals of this paper are to: (i) enhance the manner in which fatal airport runway excursions are modeled and quantified and (ii) explore a means to mitigate their occurrence and severity. While other research in predicting runway excursions has focused on the type of excursion, this work focuses on predicting if the excursion will generate fatalities. As the adverse effects of fatalities can be extreme in nature, there exists a need to be able to: (i) understand the root causes of fatal excursions, (ii) predict the likelihood of fatal excursions, and (iii) measure the efficacy of risk management strategies employed to prevent them. This work summarizes and applies techniques of data analysis for runway excursions, a significant problem in air travel safety which can lead to fatalities. The techniques deployed in this work to model excursions include logistic regression and Bayesian logistic regression, each of which have strengths and weaknesses in terms of descriptive (e.g. highlighting factors that impact fatalities) and prescriptive (e.g. predicting fatalities under particular operating conditions) domains. An innovative use of the results of this data analysis is in enhancing the likelihood assessment of the traditional risk matrix, which combines (often arbitrary) assessments of likelihood and consequence for particular risk scenarios. Several real-world excursion response options aimed at reducing fatalities through improvements to aviation facilities and processes are compared on the basis of impact, cost, and feasibility.				
Comments	*Development of a model to predict if fatalities will result from a runway excursion using logistic regression (non-fatal or fatal); designed to help the likelihood assessment of the risk matrix; used archival data from ACRP database; human error and adverse weather were two significant predictors; overruns most fatal category of runway excursion.*				
Potential Gaps	*Model was developed for runway excursion not incursions but could still have related content.*				
Link	https://www.tandfonline.com/doi/abs/10.1080/13669877.2013.822913				

Reference #	58	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Runway Incursions: A Case Study Analysis*				
Source/Agency	Purdue University				
Authors	Bradley G. Cozza; John P. Young			**Year**	2013
Abstract	Utilizing publicly-available information gathered from government resources, a case study analysis of runway incursion data endeavored to determine the correlation between the reported incursions that occurred at American airports between fiscal years 2009 and 2011 and the meteorological conditions, times of day, and presence of an air traffic control tower. With runway incursions long-plaguing the safety of United States aviators, their passengers, and aviation personnel, continued research aimed at refining the body of knowledge underpinning incursions coupled with ongoing prevention efforts aspire to diminish the annual incidence of incursions, increase safety, and save lives. In accordance with this mission, mining the National Transportation Safety Board's (NTSB) and National Aeronautics and Space Administration's (NASA) runway incursion databases and analyzing the resulting data with the Pearson correlation indicated a higher likelihood of incursions amid clear weather, during the daylight hours, and at airports with an air traffic control tower.				
Comments	*Correlational analysis of NTSB and NASA data.*				
Potential Gaps	*College graduate capstone project (non-published); extremely small sample sizes restricts value of the research.*				
Link	https://docs.lib.purdue.edu/atgrads/24/				

Reference #	59	**General Area**	RSA and RPZ	**Specific Area**	Aviation Psychology
Title	*Attention to Safety and the Psychology of Surprise*				
Source/Agency	University of Illinois				
Authors	Christopher D. Wickens			**Year**	2001
Abstract	Aviation accidents are rare and often triggered by surprising atypical events, often where important data do not get noticed or attended. Yet most psychological research on attention and human response deals with and statistically analyzes "typical" or "average" behavior, not the psychology of surprise. We emphasize the relevance of attention to safety, to automation, and to the psychology of surprise and briefly summarize some research on automation and free flight that highlights this linkage. Implications for design, training and modeling and research are then described.				
Comments	*Discusses the effect of surprise in aviation and psychology research; uses some example relating to runway incursions and surprised responses; focuses on the importance of attention for pilots and controllers.*				
Potential Gaps	*Mostly conceptual in nature; does not focus on V/PD.*				
Link	*https://www.researchgate.net/profile/Christopher_Wickens/publication/267701201_ATTENTION_TO_SAFETY_AND_THE_PSYCHOLOGY_OF_SURPRISE/links/54a080710cf256bf8bae1a62.pdf*				

Reference #	60	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Use of Inductive Loop Detectors to Prevent Runway Incursions*				
Source/Agency	**IEEE**				
Authors	M. Hassan; P. Stiglic			**Year**	1994
Abstract	The team of Teledyne Controls (Teledyne) and Detector Systems, Inc. (DSI) conducted a test program, under FAA Contract DTF A01-92-C00043, to evaluate alternate technologies which might prevent runway incursions. Specifically, the major scope of the program was to evaluate the suitability of the inductive loop sensors for detecting both aircraft and ground vehicles in an airport environment. This paper presents the results from extensive testing carried out at the Long Beach Airport in the spring of 1993.				
Comments	*Use of inductive loop sensors to detect both aircraft and vehicles on the airport environment; testing carried out at Long Beach Airport in Spring 1993.*				
Potential Gaps	*Rather old study (1994); only able to obtain the first page of the paper.*				
Link	https://ieeexplore.ieee.org/abstract/document/316655				

Reference #	61	**General Area**	RSA and RPZ	**Specific Area**	Software Evaluation
Title	*Design of Experiment for the Pilot Evaluation of an Airborne Runway Incursion Alerting System*				
Source/Agency	26th International Congress of the Aeronautical Sciences				
Authors	S. Szasz; J. Gauci; D. Zammit-Mangion; B. Zammit; A. Sammut; D. Harris			**Year**	2008
Abstract	Runway incursions pose a significant threat to the continued safety of commercial aviation. In response, the Runway Collision Avoidance Function (RCAF) was developed by the University of Malta and evaluated at Cranfield University as part of the European Programme FLYSAFE. This paper discusses the design of experiment developed in preparation of the said evaluations, addressing the objectives of the test programme and explains how these objectives were met.				
Comments	*Describes design of experiment to test runway collision avoidance function (RCAF); discusses scenarios and testing protocol to be used.*				
Potential Gaps	*The paper discusses the experimental protocol developed to assess the RCAF, but it provides no data as to the results or findings of the study.*				
Link	http://icas.org/ICAS_ARCHIVE/ICAS2008/PAPERS/257.PDF				

Reference #	62	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Individual Pilot Factors Predict Simulated Runway Incursion Outcomes*				
Source/Agency	*International Symposium on Aviation Psychology*				
Authors	**Kathleen Van Benthem; Chris M. Herdman**			**Year**	2013
Abstract	Runway incursions are a critical issue facing the aviation industry, with general aviation accounting for 77 percent of runway incursions involving pilot deviations. The present study reports on the value of individual pilot factors in predicting the outcome of a simulated surprise runway incursion. Significant predictors of runway incursion management were pilot rating, self-rated awareness of the impact of other aircraft on flight, and perceptions of the mental demands of the flight tasks. In light of the aviation industry's reliance upon pilots' self-monitoring of competence, strategies for reducing runway incursions can capitalize on evidence that higher self-rated ability to maintain a comprehensive mental model of relevant airspace, and better judgments of the mental demands of high workload conditions predicted superior incursion management outcomes.				
Comments	*Reviewed individual pilot factors to predict RI outcomes; pilot rating, self-rated awareness, and perceptions of mental demands were significant predictors; 93 participants completed simulator tasks where a rouge aircraft was present.*				
Potential Gaps	*Limited in the number of factors examined.*				
Link	https://corescholar.libraries.wright.edu/isap_2013/18/				

Reference #	63	**General Area**	RSA and RPZ	**Specific Area**	Experiments
Title	*Scene-Linked Symbology to Improve Situation Awareness*				
Source/Agency	AGARD Conference Proceedings				
Authors	Robert S. McCann; David C. Foyle			**Year**	1995
Abstract	This paper reviews recent research conducted in the Flight Management and Human Factors Division of NASA Ames Research Center on superimposed symbology (as found on HUDs and HMDs). We first identify various performance problems which suggest that superimposed symbology impairs pilots' ability to maintain simultaneous awareness of instrument information and information in the forward visual scene. Results of experiments supporting an attentional account of the impairment are reported.				
Comments	*Reviewed pilot's situational awareness with tools such as HUDs and HMDs in a series of experiments; examining for pilot information processing while receiving information from HUDs and HMDs.*				
Potential Gaps	*Quite a dated study at this point; no focus on V/PD.*				
Link	https://hsi.arc.nasa.gov/groups/hcsl/publications/McCann&Foyle_AGARD95%20.pdf				

Reference #	64	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Human Factors Assessment of Runway Status Lights and Final Approach Runway Occupancy Signal*				
Source/Agency	Eighth USA/Europe Air Traffic Management Research and Development Seminar				
Authors	Maria Picardi Kuffner; Captain Robert Perkins			**Year**	2009
Abstract	Runway incursions have been a persistent problem in airport operations for decades, both in the National Airspace System (NAS) and worldwide. The deadliest accident in the history of commercial aviation occurred at Tenerife Airport in the Canary Islands. As commercial airliners become larger and airports more congested the potential for major accidents on the airport surface is expected to increase. Runway Status Lights (RWSL) have shown promise in precluding this potentiality through demonstrated operational suitability and measured reductions in runway incursions as cited independently in an audit by the US Inspector General. RWSL will be deployed to 22 airports in the near future. MIT Lincoln Laboratory has recently completed human factors assessments in support of the Federal Aviation Administration's (FAA) ongoing operational evaluations of RWSL at Dallas/Ft. Worth International Airport (DFW) and RWSL at San Diego International Airport (SAN). The evaluations of RWSL at DFW and SAN began in 2004 and 2006, respectively. In addition, we have been assessing preliminary data from an ongoing operational evaluation of the Final Approach Runway Occupancy Signal (FAROS) at DFW that began four months ago. The assessments were developed to evaluate the effectiveness and operational suitability of RWSL and FAROS in reducing runway incursions and preventing accidents. The human factors assessments conducted to measure and record RWSL and FAROS operational suitability are presented here (with the FAROS data subject to change as the ongoing operational evaluation continues). The process established to include human factors research, development, and testing is specifically described.				
Comments	*Human factors assessment of runway status lights (RWSL); data from 2004 (DFW) and 2006 (SAN); also final approach runway occupancy signal (FAROS) at DFW; systems designed to improve pilot and driver situational awareness; training needed for pilots/drivers to understand signals.*				
Potential Gaps	*Preliminary deployment of these technologies at two airports; systems appear to be favorably received and supported by pilot unions.*				
Link	http://www.atmseminar.org/seminarcontent/seminar8/papers/p_114_hf.pdf				

Reference #	65	**General Area**	Airside Driving	**Specific Area**	Archival Causation
Title	*An Analysis of the Causes of Airfield Incursions Attributed to Ground Vehicles*				
Source/Agency	*Journal of Airport Management*				
Authors	Young, Seth; Vlek, Joost			**Year**	2009
Abstract	In an effort to contribute to the identification and mitigation of safety risks on civil use airfields, this paper investigates the occurrence and probable causes of airfield incursions caused specifically by ground vehicle operations. Such operations were found to be responsible for nearly 20 per cent of all reported airfield incursions at airports within the USA. The research described in this paper investigated more than 2,000 individual airfield 'vehicle' incursions, as reported to the US Federal Aviation Administration, in an effort to identify their probable causes. Analysis of the data revealed that such incursions may be the result of four primary root causes: driver distraction, inadequate training, lack of situational awareness, or lack of proper communication. As a result of these findings, the authors suggest the targeted implementation of both improved training programs and enhanced technologies to improve overall situational awareness while operating ground vehicles on an airfield. Proper implementation of technology and enhanced training programs may be found to reduce these vehicle incursions and thus lead to improved airfield operational safety.				
Comments	*Paper specifically looks at ground vehicle operations; cause of 20% of airfield incursions; found four main causes: driver distraction, inadequate training, lack of situational awareness, or lack of proper communication; over 2700 FAA reports between 1998-2008.*				
Potential Gaps	*Archival study in nature, but it appears to be well done.*				
Link	https://www.ingentaconnect.com/content/hsp/cam/2009/00000003/00000003/art00011				

Reference #	66	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Probabilistic Causal Modelling of Risk Factors Contributing to Runway Collisions: Case Studies*				
Source/Agency	*Human Factors and Aerospace Safety Journal*				
Authors	Lechner, Kathlene W; Luxhoj, James T			**Year**	2005
Abstract	The U.S. National Airspace System (NAS) is complex and constrained by capacity limitations. The frequency of commercial aircraft accidents is rare, but modeling the precursors leading to those accidents is challenging due to the intricacies of the system. The sequence of events model used by the National Transportation Safety Board (NTSB) when investigating the causes of accidents does not capture the probabilistic interdependencies of risk factors. Modeling of non-linear multiple causality and probabilistic dependencies would be a more realistic way of examining the accidents. The Aviation System Risk Model (ASRM) was developed to provide advanced risk assessments for certain kinds of accidents. The model uses Bayesian Belief Networks and influence diagrams to provide risk assessments, and it incorporates human factors analysis in evaluating the causes of accidents. This paper presents a detailed study of three specific runway incursion accident cases.				
Comments	*Uses advanced statistical modeling to assess the risk of causes of accidents; developed the Aviation System Risk Model (ASRM).*				
Potential Gaps	*Unable to find digital copy.*				
Link	https://trid.trb.org/view/786303				

Reference #	67	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Flight Deck Based Indications and Alerting to Increase Runway Safety*				
Source/Agency	Integrated Communications, Navigation and Surveillance Conference				
Authors	Peter M. Moertl; James D. Nickum			**Year**	2008
Abstract	This paper describes the development of a surface alerting capability based on the use of Automatic Dependent Surveillance-Broadcast (ADS-B) that is projected for use by many classes of aircraft and at a range of airports. The capability is intended to help reduce the risk of runway incursions and collisions. The capability is developed by a working group that is part of RTCA Special Committee (SC) 186. The capability has been termed the Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (ATSA SURF IA). The capability description is currently in draft status and is projected to be completed by mid-2009. This paper presents the current activity along with a concept description and a description of the main engineering and human factors issues.				
Comments	*Describes use of ADS-B for surface alerting to prevent RIs; alerts would be presented on the flight deck; preliminary simulations and test was scheduled for 2008 with concept development scheduled to be completed mid-2009.*				
Potential Gaps	*No specific mention of V/PD, but conceivable that this would work inside vehicles as well; topic conceptual in nature.*				
Link	https://ieeexplore.ieee.org/abstract/document/4559198				

Reference #	68	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Flight Test Measurement of Pilot Reaction Times to Runway Incursions: Out-the-Window vs. Synthetic Vision*				
Source/Agency	The 21st Digital Avionics Systems Conference				
Authors	C.W. Jennings; J.D. Powell			**Year**	2002
Abstract	Researchers at Stanford University have developed, and flight tested a runway incursion alerting system for aircraft on final approach. The system utilizes synthetic vision and ADS-B. The objectives of the flight test were to conduct a proof of concept and to compare the reaction times to incursion between pilots looking out the window and pilots looking at the display. In April 2001 we flew 98 approaches (incursions occurred on 72 approaches) into Moffett Federal Airfield. A specially equipped Ford Winstar Van generated the incursions while a Cessna Caravan flew approaches. Pilots looking out the window tended to see incursions at the runway threshold before the pilot using the display. The reaction time of the out the window pilot was a function of visibility conditions and the location of the incursion along the runway. The reaction time of the pilot looking at the synthetic vision display was insensitive to these factors.				
Comments	*Conducted field testing, used one aircraft and one vehicle; synthetic vision system; pilots tended to spot the looming incursion visually before with the system being tested; the author attributed this to the good visibility used during flight testing; two-thirds were flown at night*				
Potential Gaps	*Proof of concept study; limited to 5 pilots; display pilots were 2.4 second behind out the window pilots in detecting the possible incursion*				
Link	https://ieeexplore.ieee.org/abstract/document/1052975				

Reference #	69	**General Area**	Airside Driving	**Specific Area**	Archival Research
Title	*Runway Incursions: Airport Movement Area Driver Training Demographics Suggests Revisions to Airport Driver Training Methods*				
Source/Agency	*Journal of Management and Marketing Research*				
Authors	William Rankin; John Cokley			**Year**	2009
Abstract	This paper examines the problem of runway incursions at the (OEP-35) U.S. towered airports. According to the FAA Runway Safety Report (2004), vehicle deviations accounted for 20% (291 events) of all runway incursions during the period of 2000 through 2003. The focus of this quantitative correlational study is whether demographic characteristics are a significant factor in the airport movement area driver training that employees receive at Operational Evolution Plan (OEP-35) US towered airports. Airport driver training officials at the OEP-35 airports were surveyed using a five-point Likert-type survey. The data from this study suggested that demographic characteristics are significant factors in the airport driver training that employees receive at Operational Evolution Plan (OEP-35) US towered airports, and vary by geographic region, as well as ethnic and cultural influences prevalent in each region. The data from this study may assist airport operators in identifying significant demographic characteristics that affect the outcomes of their driver training programs, and potential improvements that may enhance airport movement area driver training programs in various geographic regions.				
Comments	*Analysis looked into V/PDs; found demographic characteristics are significant factors in airport driver training; administered via a survey instrument; age, education level, income were significant; race and marital status were not significant; race was significant for south Florida airport; findings suggest the longer a person is employed (and the more recurrent training they received) the more prepared they are to drive on the airport; suggests the need for annual recurrent training; repeat of article #130.*				
Potential Gaps	*Slightly older study, but specific to airport driving and training; results are not reported very clearly.*				
Link	https://core.ac.uk/download/pdf/15087520.pdf				

Reference #	70	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Contrasting Safety Assessments of a Runway Incursion Scenario: Event Sequence Analysis Versus Multi-Agent Dynamic Risk Modelling*				
Source/Agency	*Reliability Engineering & System Safety*				
Authors	Sybert H.Stroeve; Henk A.P.Blom; G.J. (Bert)Bakker			**Year**	2013
Abstract	In the safety literature it has been argued, that in a complex socio-technical system safety cannot be well analyzed by event sequence-based approaches but requires to capture the complex interactions and performance variability of the socio-technical system. In order to evaluate the quantitative and practical consequences of these arguments, this study compares two approaches to assess accident risk of an example safety critical sociotechnical system. It contrasts an event sequence-based assessment with a multi-agent dynamic risk model (MA-DRM) based assessment, both of which are performed for a particular runway incursion scenario. The event sequence analysis uses the well-known event tree modelling formalism and the MA-DRM based approach combines agent-based modelling, hybrid Petri nets and rare event Monte Carlo simulation. The comparison addresses qualitative and quantitative differences in the methods, attained risk levels, and in the prime factors influencing the safety of the operation. The assessments show considerable differences in the accident risk implications of the performance of human operators and technical systems in the runway incursion scenario. In contrast with the event sequence-based results, the MA-DRM based results show that the accident risk is not manifest from the performance of and relations between individual human operators and technical systems. Instead, the safety risk emerges from the totality of the performance and interactions in the agent-based model of the safety critical operation considered, which coincides very well with the argumentation in the safety literature.				
Comments	*Advanced statistical modeling comparing event sequence modeling with multi-agent dynamic risk modeling; the advanced modeling suggests safety risk is the result of the total performance and interactions of agents in the model.*				
Potential Gaps	*Modeling does not allow for causal interpretations.*				
Link	https://www.sciencedirect.com/science/article/pii/S0951832012001433				

Reference #	71	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Strengthening Air Traffic Safety Management by Moving from Outcome-Based Towards Risk-Based Evaluation of Runway Incursions*				
Source/Agency	*Reliability Engineering & System Safety*				
Authors	Sybert H.Stroeve; Pradip Som; Bas A.van Doorn; G.J.(Bert) Bakker			**Year**	2016
Abstract	Current safety management of aerodrome operations uses judgements of severity categories to evaluate runway incursions. Incident data show a small minority of severe incursions and a large majority of less severe incursions. We show that these severity judgements are mainly based upon the outcomes of runway incursions, in particular on the closest distances attained. As such, the severity-based evaluation leads to coincidental safety management feedback, wherein causes and risk implications of runway incursions are not well considered. In this paper we present a new framework for the evaluation of runway incursions, which effectively uses all runway incursions, which judges same types of causes similarly, and which structures causes and risk implications. The framework is based on risks of scenarios associated with the initiation of runway incursions. As a basis an inventory of scenarios is provided, which can represent almost all runway incursions involving a conflict with an aircraft. A main step in the framework is the assessment of the conditional probability of a collision given a runway incursion scenario. This can be effectively achieved for large sets of scenarios by agent-based dynamic risk modelling. The results provide detailed feedback on risks of runway incursion scenarios, thus enabling effective safety management.				
Comments	*Discusses moving from an outcome-based to a risk-based evaluation of RIs; create an inventory of RI scenarios and use probability to predict RIs; uses information leading up to the RI – outcome of event is less of a focus.*				
Potential Gaps	*More information needed on what future data should be gathered on RIs; more data needed to further validation of the model.*				
Link	https://www.sciencedirect.com/science/article/pii/S0951832015003300				

Reference #	72	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Controller-Pilot Communications Using a VDL Mode 2 Datalink for the NASA Runway Incursion Prevention System*				
Source/Agency	DASC. 20th Digital Avionics Systems Conference				
Authors	S. Gunawardena; J.M. Rankin			**Year**	2002
Abstract	NASA's Runway Incursion Prevention System (RIPS) was tested between September and October 2000 at the Dallas Fort-Worth International Airport (DFW). Controller-Pilot Datalink Communications (CPDLC) represented one component of the RIPS program. Air traffic controllers relayed surface operations instructions to NASA's 757 research aircraft via a Controller Communications and Situational Awareness Terminal (C-CAST). The Onyx mainframe computer aboard the 757 decoded these messages and sent automatic acknowledgements back to the C-CAST. The CPDLC messages were sent over a datalink utilizing the ICAO-defined VHF Digital Link (VDL) Mode 2 protocol. This paper presents implementation and performance details of the datalink. The paper describes the VDL Mode 2 protocol, the overall architecture of the CPDLC system, hardware-software interfacing details, CPDLC message formats, signal coverage data for the DFW airport, and design details of the Airborne Datalink Manager (ADLM) software used for this work.				
Comments	*Analysis of the RIPS testing at DFW; paper focuses on the use of controller-pilot datalink communications; controller's verbal command dictated to system, reviewed by controller, and send textually to pilot; pilot received message on electronic moving map display.*				
Potential Gaps	*Testing completed in 2002; likely would require hardware upgrades to ATC and pilot equipment; focused on testing the upload and download of messages, not really an operational test being conducted in simulated flight operations.*				
Link	https://ieeexplore.ieee.org/abstract/document/963335				

Reference #	73	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Development of a Bayesian Belief Network Runway Incursion and Excursion Model*				
Source/Agency	American Society for Engineering Management, 2014 International Annual Conference				
Authors	Green, Lawrence L.			**Year**	2014
Abstract	In a previous work, a statistical analysis of runway incursion (RI) event data was conducted to ascertain the relevance of this data to the top ten Technical Challenges (TC) of the National Aeronautics and Space Administration (NASA) Aviation Safety Program (AvSP). The study revealed connections to several of the AvSP top ten TC and identified numerous primary causes and contributing factors of RI events. The statistical analysis served as the basis for developing a system-level Bayesian Belief Network (BBN) model for RI events, also previously reported. Through literature searches and data analysis, this RI event network has now been extended to also model runway excursion (RE) events. These RI and RE event networks have been further modified and vetted by a Subject Matter Expert (SME) panel. The combined system-level BBN model will allow NASA to generically model the causes of RI and RE events and to assess the effectiveness of technology products being developed under NASA funding. These products are intended to reduce the frequency of runway safety incidents/accidents, and to improve runway safety in general. The development and structure of the BBN for both RI and RE events are documented in this paper.				
Comments	*Developed an advanced statistical model to predict runway incursions; current study added runway excursions to the statistical model; models validated by subject matter experts.*				
Potential Gaps	*Further testing needed beyond preliminary model validation.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20150000581				

Reference #	74	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Flight Simulator Evaluation of Pilot Performance with the Runway Awareness and Advisory System (RAAS)*				
Source/Agency	23rd Digital Avionics Systems Conference				
Authors	R. Khatwa			**Year**	2004
Abstract	This paper provides an overview of a human factors evaluation to objectively assess pilot performance and the operational safety benefits of the runway awareness and advisory system (RAAS). This evaluation was the last one of a series that formed a critical element of the iterative design process adopted to develop the RAAS. The purpose of the RAAS is to enhance flight crew position awareness during aircraft surface operations and on final approach. Factors such as effect of RAAS on pilot spatial (position) awareness, decision-making, workload, overall pilot acceptability and ease of learning the RAAS functionality were evaluated. A non-RAAS group served as the reference group A Boeing 737-400 flight simulator was used in a between-subjects experiment design. Crews were subjected to a range of operational scenarios that included both normal and, non-normal conditions associated with runway incursions. Evaluation data show that RAAS improved pilot position awareness during surface operations and on approach to landing. RAAS resulted in earlier pilot recognition of potential position awareness related conflicts. Furthermore, RAAS improved pilot decision-making and did not increase workload. There were no RAAS-induced crew errors observed in any of the scenarios. Subjects were able to satisfactorily complete all flight deck tasks, execute crew procedures and crew co-ordination associated with all scenarios with the aid of RAAS. Ratings for overall pilot acceptability and learnability of RAAS were very favorable. Overall, these data indicate a favorable impact of RAAS on crew performance and operational safety.				
Comments	*Experimental design to assess runway awareness and advisory system (RAAS); improved pilot SA and decision-making without increasing workload.*				
Potential Gaps	*While favorable findings, did not look at V/PDs as participants; would require hardware changes to implement; study is becoming dated.*				
Link	https://ieeexplore.ieee.org/abstract/document/1391343				

Reference #	75	**General Area**	RSA and RPZ	**Specific Area**	Runway Safety
Title	*Runway Safety*				
Source/Agency	*Human Factors Impacts in Air Traffic Management (book)*				
Authors	Kim M. Cardosi			**Year**	2017
Abstract	The worst collision in aviation history was the result of a runway incursion. It occurred in 1977 at Tenerife and resulted in 583 fatalities. It is rare for a runway incursion to result in a fatal accident. Since 1st January 1990 there have been four fatal accidents resulting from runway incursions at airports with an operating air traffic control tower in the US. Nonetheless, runway incursions clearly pose significant threats to aviation safety and efficiency. Part One: The Problem What the Numbers Tell Us Table 3.1 Classification of runway incursions by year.				
Comments	*Chapter on Runway Safety in an edited book.*				
Potential Gaps	*Unable to gain access to full chapter.*				
Link	https://www.taylorfrancis.com/books/e/9781315253015/chapters/10.4324/9781315253015-11				

Reference #	76	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Incursion Prevention System Concept Verification: Ground Systems and STIS-B Link Analysis*				
Source/Agency	20th Digital Avionics Systems Conference				
Authors	R. Mueller; K. Belamqaddam; S. Pendergast; K. Krauss			**Year**	2001
Abstract	Recent programs such as NASA's Runway Incursion Prevention System (RIPS) have placed newly developed airport surveillance systems and technology at Dallas-Fort Worth (DFW) International airport for testing in an attempt to develop systems that will reduce the risk of runway incursions. The primary objective of the RIPS test conducted in October 2000 at DFW was to assess and validate the performance of communication, navigation and surveillance (CNS) infrastructure technologies and incursion alerting systems for preventing runway incursion. The test included analysis of both ground systems and the Surface Traffic Information Systems-Broadcast (STIS-B) data link.				
Comments	*Another study from the DFW airport trials of RIPS; paper discusses the ground-based systems and airborne portion of the surface traffic information systems-broadcast (STIS-B) datalink.*				
Potential Gaps	*Slightly dated; preliminary analysis; further need of testing regarding safety and alerting system.*				
Link	https://ieeexplore.ieee.org/abstract/document/963341				

Reference #	77	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Simulator Evaluation of Runway Incursion Prevention Technology for General Aviation Operations*				
Source/Agency	NASA				
Authors	Jones, Denise R; Prinzel, Lawrence J., III			**Year**	2011
Abstract	A Runway Incursion Prevention System (RIPS) has been designed under previous research to enhance airport surface operations situation awareness and provide cockpit alerts of potential runway conflict, during transport aircraft category operations, in order to prevent runway incidents while also improving operations capability. This study investigated an adaptation of RIPS for low-end general aviation operations using a fixed-based simulator at the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC). The purpose of the study was to evaluate modified RIPS aircraft-based incursion detection algorithms and associated alerting and airport surface display concepts for low-end general aviation operations. This paper gives an overview of the system, simulation study, and test results.				
Comments	*Continues studies related to RIPS; this study focuses on use with general aviation; somewhat mixed results – in some scenarios, looking out the window was better for pilots, in others the alerts helped; overall the system appeared to be beneficial.*				
Potential Gaps	*Test conducted in a simulator; only used 16 pilots; no mention of testing drivers, but possible that a similar system could have value to airport drivers.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20110005513				

Reference #	78	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Airborne FLIR Sensors for Runway Incursion Detection*				
Source/Agency	*Enhanced and Synthetic Vision 2009*				
Authors	Cynthia Archer; Joseph White; Robert Neece			**Year**	2009
Abstract	Forward Looking Infrared (FLIR) sensors are potential components in hazard monitoring systems for general aviation aircraft. FLIR sensors can provide images of the runway area when normal visibility is reduced by meteorological conditions. We are investigating short wave infrared (SWIR) and long wave infrared (LWIR) cameras. Pre-recorded video taken from an aircraft on approach to landing provides raw data for our analysis. This video includes approaches under four conditions: clear morning, cloudy afternoon, clear evening, and clear night. We used automatic object detection techniques to quantify the ability of these sensors to alert the pilot to potential runway hazards. Our analysis is divided into three stages: locating the airport, tracking the runway, and detecting vehicle sized objects. The success or failure of locating the runway provides information on the ability of the sensors to provide situational awareness. Tracking the runway position from frame to frame provides information on the visibility of runway features, such as landing lights or runway edges, in the scene. Detecting small objects quantifies clutter and provides information on the ability of these sensors to image potential hazards. In this paper, we present results from our analysis of sample approach video.				
Comments	*Use of forward looking infrared (FLIR) systems for increased runway sensing, especially in times of low visibility.*				
Potential Gaps	*Some limitations of the systems. LWIR may not be helpful in cloudy/rainy weather; SWIR works well when there is sufficient lighting; future work will investigate FLIR in conjunction with radar.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/7328/73280E/Airborne-FLIR-sensors-for-runway-incursion-detection/10.1117/12.818138.short?SSO=1				

Reference #	79	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Real Time Runway Incursion Cockpit Advisory*				
Source/Agency	26th Digital Avionics Systems Conference				
Authors	Dana Hal; Larry Surace			**Year**	2007
Abstract	Currently, alerts of potential runway incursions are generated by surveillance detection equipment and presented to air traffic controllers on display systems within the tower at properly equipped airports. In worst case scenarios, the process is performed manually by visual contact from aircrews or air traffic controllers. From the controller perspective, they must process this information, decipher specific aircraft of interest, and provide a warning or recommended resolution to the aircrew via voice communication. These "manual intervention" techniques result in reduced margin of safety in time critical incursion situations. The goal of the real-time runway incursion cockpit advisory flight test program is to add automation into this process by sending real-time runway incursion advisories directly to the flight crews of the potentially involved aircraft as well as to the air traffic controller. This paper describes the on-going collaboration between Sensis Corporation and Honeywell Aerospace to evaluate a ground and air solution for detecting, processing, and reporting real-time cockpit safety advisories in the event of a runway incursion. For this program, the surface taxi, short final approach, and immediate departure are the areas of interest. For these aircraft operating areas, advisories are generated, and data linked to the specific flight crews. Sensis Corporation's airport surface detection equipment model X (ASDE-X) system installed as a test system at Syracuse Hancock International Airport (SYR) was used as the detection and conflict prediction system. The SYR ASDE-X implementation was optimized for detection of a set of primary runway incursion scenarios. The processing and calculation of aircraft positional information is accomplished by the ASDE-X multi-sensor data processor. Reporting of advisory conditions to the aircraft is accomplished through existing remote unit (RU) mode S encoded uplink at 1030 MHz. This demonstration program made use of seve...				
Comments	*Working to design a system to provide real-time RI alerts within the cockpit; reduce the manual intervention required with the current system through air traffic controllers; testing completed at Syracuse, NY; combine ASDE-X with TCAS via datalink; minimal changes required to existing hardware.*				
Potential Gaps	*Study limited to only testing two scenarios at one airport.*				
Link	https://ieeexplore.ieee.org/abstract/document/4391926				

Reference #	80	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Safety Risk Analysis of Runway Incursion Alert Systems in the Tower and Cockpit by Multi-Agent Systemic Accident Modelling*				
Source/Agency	National Aerospace Laboratory NLR				
Authors	S.H. Stroeve; G.J. Bakker; H.A.P. Blom			**Year**	2007
Abstract	Runway incursion alert systems in air traffic control towers and cockpits are intended to reduce runway incursion risk. Analysis of the effectiveness of such systems is challenging, because of the context-dependent distributed and dynamic interactions of multiple human operators and technical systems in a runway incursion scenario. Recent views in the safety literature indicate that for risk assessment of such complex scenarios, we need systemic accident modelling, which considers accidents as emergent phenomena from the performance variability of a system. This paper uses multi-agent situation awareness as a prime concept for systemic accident modelling of a runway incursion scenario.				
Comments	*Advanced statistical analysis to determine effectiveness of alert systems. Results indicate that in poor visibility conditions ATC risk reduction was one order of magnitude reduced and two orders of magnitude reduced for pilots; alerts less effective in good weather conditions.*				
Potential Gaps	*Limited to monte carlo simulation for events.*				
Link	https://reports.nlr.nl/xmlui/bitstream/handle/10921/425/TP-2007-563.pdf?sequence=1				

Reference #	81	**General Area**	RSA and RPZ	**Specific Area**	Archival Review
Title	*Software Challenges in Aviation Systems*				
Source/Agency	International Conference on Computer Safety, Reliability, and Security				
Authors	John C. Knight			**Year**	2002
Abstract	The role of computers in aviation is extensive and growing. Many crucial systems, both on board and on the ground, rely for their correct operation on sophisticated computer systems. This dependence is increasing as more and more functionality is implemented using computers and as entirely new systems are developed. Several new concepts are being developed specifically to address current safety issues in aviation such as runway incursions.				
Comments	*Paper provides a summary of computers and technological systems in aviation, along with automation dependence.*				
Potential Gaps	*Unable to find full article to review.*				
Link	https://link.springer.com/chapter/10.1007/3-540-45732-1_12				

Reference #	82	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Fusion of Airborne Radar and FLIR Sensors for Runway Incursion Detection*				
Source/Agency	28th Digital Avionics Systems Conference				
Authors	Joseph White; Cynthia Archer; James G. Haidt; Charles L. Britt; Robert Neece			**Year**	2009
Abstract	Objects on the runway are a leading cause of accidents to landing aircraft. A recent study by RTI for NASA investigated the detection of those objects from the aircraft using sensors commonly found on commercial aircraft: infrared cameras and weather radar. Attention was given to sensor enhancements that would improve the probability of detection, followed by the development of detection routines for each sensor. Finally, a fusion process was developed based on a tracking system. A laboratory-based demonstration fusion system has been developed for the detection of runway incursions. This system uses FLIR data recorded from an aircraft on approach including long-wave and short-wave infrared video, aircraft navigation data from NASA flight tests, and simulated radar data based on the flight test parameters. The radar data are obtained from an updated NASA/RTI-developed Airborne Doppler Weather Radar Simulation (ADWRS) program. This paper describes the fusion process and presents initial results of system performance under clear weather night conditions. We show how the FLIR processor effectively extracts targets of opportunity from the infrared imagery. The LWIR provides good target detection capabilities at night when out-the-window visibility is limited to lighted objects. The performance of the fusion algorithm is discussed, showing how it effectively removed false alarms from the FLIR and radar data. The fusion process successfully tracked targets of opportunity and classified them accurately according to the incursion hazard they represented.				
Comments	*System created combines FLIR and airborne weather radar to detect objects on the runway ahead of landing aircraft; system was shown to successfully track and accurately classify the incursion hazard.*				
Potential Gaps	*Data collected for clear, night weather only; single case study of data collection.*				
Link	https://ieeexplore.ieee.org/abstract/document/5347475				

Reference #	83	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Research on the Algorithms of Runway Incursion Severity Classification and its Application*				
Source/Agency	*Journal of Safety and Environment*				
Authors	LUO Jun; LIN Xue-ning; LI Yi			**Year**	2013
Abstract	This paper intends to put its focus on the study of the runway incursions in the airport in hoping to identify the complicated situations that may account for the runway safety accidents on the theoretical basis. In proceeding with our study, first of all, we have done systematic analysis of the severity of macro factors likely involving the Runway Incursion Severity Classification (RISC). And then, we have made a comprehensive description and analysis of all the likely-involving factors of runway incursion based on the ten most-likely involved aspects, while conforming the validity of the said factors in a given situation. Secondly, to optimize the runway incursion severity classification, we have adopted the G1 method and expertise experience analysis in defining the weight coefficients of those factors. This paper mainly takes 'a somewhat aircraft's taking-off runway incursion scenario as its case study sample whereas the taxiing aircraft on the runaway as another case. In addition, the paper has provided a table of runway incursion severity category in different minimum distances. Besides, we have also constructed a mathematical algorithm model of runway incursion severity classification, which is correspondingly based on the minimum severity classification and the severity classification influenced by the maximum weight factors, with the study of the severity of the mentioned factors in different statuses. What's more, the paper has divided the incursion of single runway into different scenarios given in the respective initial table, in which the severity rates of an actual runway incursion were given as the accounting results by means of linear algorithm, vector algorithm, probabilistic algorithm. And, finally, typical cases have been introduced to verify the validity of the different methods presented in this model. Meanwhile, the interpolation method has also been adopted to calculate the minimum distances of the severity classification of runway incursion, which does not exist in the initial table. The results of the above calculation prove to be consistent with what was calculated by using RISC software.				
Comments	*Provides an assessment of major causal factors of RIs; creates a table of distances to help classify level of severity; use of probabilistic algorithm to detect severity rates.*				
Potential Gaps	*Unable to find full article to review.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTOTAL-AQHJ201304052.htm				

Reference #	84	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Pilot Evaluations of Runway Status Light System*				
Source/Agency	NASA Langley Research Center				
Authors	Young, Steven D; Wills, Robert W.; Smith, R. Marshall			**Year**	1996
Abstract	This study focuses on use of the Transport Systems Research Vehicle (TSRV) Simulator at the Langley Research Center to obtain pilot opinion and input on the Federal Aviation Administration's Runway Status Light System (RWSL) prior to installation in an operational airport environment. The RWSL has been designed to reduce the likelihood of runway incursions by visually alerting pilots when a runway is occupied. Demonstrations of the RWSL in the TSRV Simulator allowed pilots to evaluate the system in a realistic cockpit environment.				
Comments	*Use of simulator to gather pilot's opinions of FAA's runway status light system before installation and operation; pilots unanimously supported the system; felts the system will reduce the likelihood of RIs; authors suggest need for pilot training on the system.*				
Potential Gaps	*Use of only 21 pilots; no discussion on V/PD, but certainly applicable if installed at airports.*				
Link	https://ntrs.nasa.gov/search.jsp?R=19970001468				

Reference #	85	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Analysis of Taxi Conformance Monitoring Algorithms and Performance*				
Source/Agency	Integrated Communications, Navigation and Surveillance Conference				
Authors	Christopher R. Brinton; Stephen C. Atkins; Abraham Hall			**Year**	2007
Abstract	Current airport surface safety systems that are intended to protect against runway incursions provide conflict alerts with minimal lead time, and do not provide any protection against errors in taxi routing unless a conflict or collision is imminent. The safety of the airport surface operation may be increased through the use of a taxi route conformance monitoring tool, which would alert both pilots and controllers automatically when a flight deviates from its assigned taxi route. This paper addresses an analysis of performance of a prototype taxi conformance algorithm. The analysis presented in this paper was conducted using flight plan data and airport surface surveillance data from the Louisville, Kentucky airport, where detailed information is available to support the operation of these prototype algorithms. Through the operation of these algorithms with recorded data, we have analyzed taxi conformance monitoring performance with regard to the occurrence of false alarms, missed alerts, and the response time to positively identified taxi conformance deviations.				
Comments	*Prototype taxi system that would alert pilots and controllers when a flight deviates from its assigned taxi route; attempt to proactively avoid an RI before it occurs; results indicate that the prototype is feasible, but more research necessary to finalize algorithm.*				
Potential Gaps	*Data only collected from one airport in Louisville, KY.*				
Link	https://ieeexplore.ieee.org/abstract/document/4272197				

Reference #	86	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Increasing Airport Efficiency: Injecting New Technology*				
Source/Agency	IEEE				
Authors	E. Piazza			**Year**	2002
Abstract	Advanced surface movement guidance and control systems (A-SMGCS) - called airport surface detection equipment in North America - can potentially solve the airport capacity bottleneck while maintaining at least the current safety level. A-SMGCS are becoming increasingly sophisticated and play a major role in avoiding runway incursions. To investigate the feasibility of phasing in new technology to ease airport operations, the European Commission has funded several research projects. The latest project, called VISION (improVed aIrport A-SMGCS by integrated multisensor data fuSION), aims to apply all the technologies developed in previous projects, including A-SMGCS, to a set of real airports.				
Comments	*Idea of using intelligent transportation systems and AI to predict taxi routes on the airport surface; four test sites installed; findings indicate increases in capacity, safety, and reduced vocal communication; also appears to work with vehicles.*				
Potential Gaps	*Limited in number of airports testing; dated article.*				
Link	https://ieeexplore.ieee.org/abstract/document/1005625				

Reference #	87	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Research on Evolution Mechanism of Runway Incursion Risks Based on System Dynamics*				
Source/Agency	*Advances in Intelligent Systems and Computingbook series*				
Authors	Xianli Zhao; Fan Luo			**Year**	2014
Abstract	Based on system dynamics theory, the system boundary of runway incursion is confirmed. The causal loop diagram and system flow diagram of runway incursion risks evolution are built. The logical relationship and feedback mechanisms between the factors are analyzed. The process of runway incursion evolution is revealed, and the trend of this evolution is forecasted. Based on the System Dynamics Software Vensim, the simulation results show that the risk value of runway incursion stabilizes after experiencing the peak value in a period of time.				
Comments	*Advanced statistical modeling to forecast the risk value of an RI.*				
Potential Gaps	*Unable to find full article.*				
Link	https://link.springer.com/chapter/10.1007/978-3-642-54927-4_26				

Reference #	88	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Advanced Statistical Learning and Prediction of Complex Runway Incursion*				
Source/Agency	International Conference on Highway Pavements and Airfield Technology				
Authors	I. Song; I. Cho,Ph.D.M.ASCE; T. Tessitore; T. Gurcsik			**Year**	2017
Abstract	In 2015, 1,507 runway incursions capable of inducing collisions occurred at airports in the United States, so it is obviously very important to identify significant factors underlying such incursions, to predict potential runway incursion occurrences, and to prepare systematic programs for reducing the number of incursions and prevent runway collisions. Presence of a large volume of data, multiple variables, and complex interactions among them pose a significant challenge to resolving this problem. To tackle this challenge, we developed a data-driven prediction model using a component of advanced statistical theory, i.e., a generalized additive model (GAM). GAM can account for flexible modeling of multiple variables over a broad range of modeling distributions. We obtained, parsed, and transformed various predictor variables from many heterogeneous databases to create interpretable datasets for statistical modeling. We demonstrated promising performance of GAM while making systematic investigations into prediction accuracy of runway incursion at United States airports (including all types of commercial, military, and other general data). Results show that GAM can identify critical factors (airport complexity, number of operations, and visibility) in predicting a number of the runway incursions. Performance comparison of two popular GAM smoothers (i.e., cubic regression splines and thin plate regression splines) has demonstrated promising accuracy of both methods. These results imply that statistical predictions developed using GAM will help in better prediction of runway incursion when more data become available in the future.				
Comments	*Advanced statistical model developed across multiple databases to predict critical factors in the number of RIs; airport complexity, number of operations, and visibility were key factors.*				
Potential Gaps	*Additional validations of model necessary.*				
Link	https://ascelibrary.org/doi/abs/10.1061/9780784480953.004				

Reference #	89	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*3-D Perspective Displays for Guidance and Traffic Awareness*				
Source/Agency	Stanford University				
Authors	Chad Jennings; Keith W. Alter; Andrew K. Barrows; Per Enge; J. David Powell			**Year**	1999
Abstract	In August 1999 the Stanford University GPS Lab performed a series of flight tests designed to explore the possibilities of dynamically updating tunnels, enhanced height-above-terrain awareness, and traffic awareness in a 3D perspective tunnel-in-the-sky display. Based on current accident reports from the NTSB specific experiments regarding CFIT (Controlled Flight Into Terrain) accidents and runway incursions were performed. The results are subjective in nature and point out that a properly researched display holds excellent potential for aviation. Future work in several disciplines is necessary before such a display could be utilized in common practice. All the same, a system that mixes precise positioning information from a sensor such as WAAS, attitude information, and eventually the position and intent of other aircraft from a sensor such as ADS-B into an intuitive image has exciting possibilities.				
Comments	*Encourages the use of a proper display to increase awareness and reduce chance of things like CFIT and RIs.*				
Potential Gaps	*Preliminary study; results subjective; did not compare RI tool with another aircraft or visual so unable to determine how much additional alert the system provided.*				
Link	https://www.researchgate.net/profile/Cw_Jennings/publication/265996252_3-D_Perspective_Displays_for_Guidance_and_Traffic_Awareness/links/54c199450cf2dd3cb958cca1.pdf				

Reference #	90	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Formal Verification of the NASA Runway Safety Monitor*				
Source/Agency	*Electronic Notes in Theoretical Computer Science*				
Authors	Radu I. Siminiceanu; Gianfranco Ciardo			**Year**	2005
Abstract	The Runway Safety Monitor (RSM) designed by Lockheed Martin is part of NASA's effort to reduce aviation accidents. We developed a Petri net model of the RSM protocol and used the model checking functions of our tool SMART to investigate behaviors that can be classified as missed alarm scenarios in RSM. To apply discrete-state techniques and mitigate the impact of the resulting state-space explosion phenomenon, our model uses a highly discretized view of the system obtained by partitioning the monitored runway zone into a grid of smaller volumes and by considering scenarios involving only two aircraft. The model also assumes that there are no communication failures, such as bad input from radar or lack of incoming data, thus it relies on a consistent view of reality by all participants. In spite of these simplifications, we were able to expose potential problems in the RSM conceptual design. Our findings were forwarded to the design engineers, who undertook corrective action. The results stress the high level of efficiency attained by the new model checking algorithms implemented in our tool SMART and demonstrate their applicability to real-world systems. Attempts to verify RSM with NuSMV and SPIN have failed due to excessive memory consumption.				
Comments	*Developed a modeling analysis of the Runway Safety Monitor designed by Lockheed Martin; provided findings not detected during actual flight testing; found concern of scenarios with low levels of likelihood.*				
Potential Gaps	*Found problems with false alarms and further research is needed to reduce.*				
Link	https://www.sciencedirect.com/science/article/pii/S1571066105002434				

Reference #	91	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*The Aerospace Performance Factor: Utilization of the Analytical Hierarchy Process to Develop a Balanced Performance and Safety Indicator of the National Airspace System for the Federal Aviation Administration*				
Source/Agency	*FAA*				
Authors	Thomas Michael Lintner; Steven D. Smith; Scott Smurthwaite, PhD			**Year**	2009
Abstract	The central mission of the Federal Aviation Administration (FAA) is the safety of the national airspace system (NAS). Historically, basic metrics such as traffic counts, delays, flight cancellations, incidents, and accidents were used to gauge performance. This method of analysis was effective at looking at isolated events but failed to take into account an overall system-wide assessment of the national airspace system. Currently, the Office of Safety is developing the Aerospace Performance Factor (APF) in order to better understand the overall system-wide events and their relative contribution to the overall safety of the national airspace. In this process, the APF utilizes aspects of the Analytical Hierarchy Process (AHP) method to establish structure and create a measurement of historical FAA aerospace incidents. It presents the results of the measurement as a graphical representation of the system's performance over time. The APF is an effective tool for assessing the relative performance of the FAA's airspace and has been adopted by other groups within the aviation arena including the European-based commercial airline easyJet, the Irish Aviation Authority (IAA), the United Kingdom's National Air Traffic Services (NATS), and the European Organization for the Safety of Air Navigation (EUROCONTROL).				
Comments	*Goal of designing an aerospace performance factor, which uses analytical hierarchical processes; presents graphical representation of system's performance over a period of time.*				
Potential Gaps	*An initial performance measurement: other groups such as EASA and airlines working to develop their own performance measures.*				
Link	http://isahp.org/2009Proceedings/Final_Papers/83_Smurthwaite_Lintner_Smith_PerformanceIndicatorsForNationalAirspaceFAA_REV_FIN.pdf				

Reference #	92	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Incursion Reduction Program (RIRP) Surveillance System, NASA/FAA Atlanta Demonstration*				
Source/Agency	IEEE				
Authors	V. Capezzuto; D. Olster; M. Curry; S.L. Pendergast			**Year**	1998
Abstract	Discusses a prototype Airport Movement Area Safety System (AMASS) originally designed to receive ASDE-3 and ARTS-IIIA data. These two data sources were applied to safety logic to provide air traffic controllers with conflict alert advisories on arrival and surface targets. The prototype AMASS was enhanced by software and hardware changes to perform multiple sensor data fusion, which provided a complete track and identification picture of the airport movement area. This surface surveillance system, combined with enhanced data links and displays, demonstrated the capability to maintain situational awareness in the tower and cockpit. This paper describes the performance of this surveillance system, as well as the impact of the system to current FAA airport services.				
Comments	*System increased surveillance capabilities: initial trial conducted in Atlanta; future trials would be at DFW.*				
Potential Gaps	*Older study.*				
Link	https://ieeexplore.ieee.org/abstract/document/739820				

Reference #	93	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Evaluation of a Prototype Advanced Taxiway Guidance System (ATGS)*				
Source/Agency	Federal Aviation Administration				
Authors	Katz, E S			**Year**	2002
Abstract	The Federal Aviation Administration (FAA), Office of Aviation Research, Airport Technology Research and Development Branch, AAR-410 has designed, installed, and elevated a prototype Advanced Taxiway Guidance System (ATGS) at the Atlantic City International Airport (ACY). The principal feature of this prototype is automatically controlled taxiway lighting, which is used to provide improved surface route guidance to taxiing aircraft. The system is also designed to detect and provide Air Traffic Control (ATC) alarms for potential runway incursions, pilot route deviations and route conflicts between aircraft.				
Comments	*Use automatically controllable airport lighting for taxiing aircraft; consists of integration of a number of systems; testing indicates systems can be integrated.*				
Potential Gaps	*Prototype only; proof of concept testing; comments were received by pilots.*				
Link	https://trid.trb.org/view/653824				

Reference #	94	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Runway Incursion Risk Assessment Based on Fuzzy Sets Theory and Improved TOPSIS Method*				
Source/Agency	*China Safety Science Journal*				
Authors	LUO Jun; LIN Xue-ning			**Year**	2012
Abstract	In order to prevent civil aviation airport's runway incursion accidents and reduce the pressure on the tower controllers, which comes from civil aviation airport's runway safety operation, an ATC evaluation system of indexes influencing runway incursion was established, according to the control traffic control factors described in the Manual on the Prevention of Runway Incursions published by ICAO. Firstly, an evaluation model was built using fuzzy set theory. Fuzzy probability values of sub-indexes were calculated, these values each reflect the risk of each sub-index. Secondly, the reliability and validity values of sub-indexes were calculated using improved TOPSIS method. The results show that there is no difference between the sequence of the risk probabilities of sub-indexes and that of their fuzzy probabilities. Lastly, recommendations for preventing runway incursion accidents were put forward.				
Comments	*Built a model to evaluate an ATC evaluation of RIs.*				
Potential Gaps	*Unable to find full article for review.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTotal-ZAQK201212018.htm				

Reference #	95	**General Area**	RSA and RPZ	**Specific Area**	RI Measurement
Title	*Runway Incursion and Methods for Safety Performance Measurement*				
Source/Agency	*Production Management and Engineering Sciences*				
Authors	Vittek, P.; Lališ, A.; Stojić, S.; Plos, V.			**Year**	2016
Abstract	Aviation industry as a whole is detecting long-lasting safety improvement trend. Extensive legislation and internal operational rules supported the establishment of the high standard and efficient oversight for civil aviation authorities. Actual level of safety is often expressed as a ratio of the total number of accidents to realized operational cycles. However, in today's world, accidents are generally rare; hence authors integrate innovative approach to safety which enables safety performance evaluation. The approach utilizes safety performance indicators as fundamental tool in the process of evaluation. This paper focuses on Runway Incursion, one of the major phenomenon in aviation safety. It has great potential to seriously affect safety during the most critical phases of flight—during takeoff and landing. Additionally, this paper presents results of descriptive and explanatory factors analysis. It outlines their implementation into the model, which will enable future safety performance quantification of the corrective measurements preventing Runway Incursion.				
Comments	*Discusses using safety performance indicators to measure safety performance; paper focuses on RIs; presents descriptive and explanatory factors.*				
Potential Gaps	*Unable to find full article to review.*				
Link	https://www.ingentaconnect.com/content/rout/26by1f/2016/00000001/00000001/art00057				

Reference #	96	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Influencing Factors of Runway Incursion Risk and their Interaction Mechanism Based on Dematel-ism*				
Source/Agency	*Tehnicki Vjesnik - Technical Gazette*				
Authors	Zhang, Pan-Ke, and Fan Luo			**Year**	2019
Abstract	Original scientific paper Runway incursion is the safety management core of civil airports, and the influencing factor of runway incursion is a hot topic in the practical and academic circles. To identify key influencing factors and determine interaction ways, typical runway incursions were analyzed using the software-hardware-environment-liveware model (SHELL). Fifteen influencing factors were identified and extracted. The centrality and cause of influencing factors were calculated by decision-making trial and evaluation laboratory (DEMATEL) and interpretative structural modelling (ISM). A multi-layer interpretative structural model was constructed for layering of influencing factors. Results indicate that inadequate attention of airport leaders to safety is the root factor. System formulation and educational training are deep influencing factors. Oversight and the operation error rate of ground officials are direct influencing factors. Runway incursion could be fundamentally controlled and prevented by improving the root factor. The proposed DEMATEL-ISM method can analyze the influencing factors of runway incursions and their influencing mechanism, thereby offsetting the shortcomings of the linear risk factor statistical model and offering a novel decision-making idea and approach for runway incursion control.				
Comments	*Used archival data and SHELL model to create a structural model of 15 influencing factors in RIs; inadequate attention, poor system formulation and training are influencing factors; oversight and operation error are direct influencing factors.*				
Potential Gaps	*Only used 149 cases (18 caused by V/PDs) and only 56 questionnaires; this seems like a very small sample size given the advanced statistical modeling analysis performed.*				
Link	https://go.galegroup.com/ps/anonymous?id=GALE%7CA534101189&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=13303651&p=AONE&sw=w				

Reference #	97	**General Area**	SMS	**Specific Area**	Qualitative Study
Title	*Aviation System Safety and Pilot Risk Perception: Implications for Enhancing Decision-Making Skills*				
Source/Agency	*Journal of Air Transportation Worldwide*				
Authors	Green, Mavis F.			**Year**	2001
Abstract	This research explores risk perception in a defined population of flight instructors and the implications of these views for flight training. Flight instructors and students engaged in collegiate aviation flight training were interviewed for this qualitative study. Thirty-three percent of the instructors interviewed reported that flying is not a risky activity. This is important because research identifies risk perception as one factor influencing instructional choices. These choices can then impact the subsequent decision-making processes of flight students. Facilitating pilot decision-making through the use of an appropriate type of learning that incorporates the modeling of consensually validated cognitive procedures and risk management processes is discussed.				
Comments	*Qualitative study using university flight instructors and student's assessment of flying and risk; 33% of instructors said flying was not a risky activity; pilot decision-making and judgment could be impacted as a result of poor risk assessment and perception.*				
Potential Gaps	*Not specific to runway incursions.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20010102957				

Reference #	98	**General Area**	SMS	**Specific Area**	Software/Technology
Title	*ADS-B System Failure Modes and Models*				
Source/Agency	The Royal Institute of Navigation				
Authors	Busyairah Syd Ali; Washington Ochieng; Arnab Majumdar; Wolfgang Schuster			**Year**	2014
Abstract	Automatic Dependent Surveillance Broadcast (ADS-B) is envisioned to support seamless aircraft surveillance and enhanced air-to-air and air-to-ground applications. ADS-B is an integrated system, dependent on on-board navigation systems to obtain aircraft state information as well as a communication data link to broadcast this information to Air Traffic Control (ATC) on the ground and other ADS-B equipped aircraft. To quantify system safety, a good understanding of the potential failure modes of the system is vital. ADS-B system failure modes include those from the communication and navigation systems and human and environmental factors, as well as ADS-B-specific components. In this paper, potential failure modes of the ADS-B system are identified using an approach developed in this paper. The end output of the approach is an ADS-B failure mode register. However, the approach is transferable to other ATC surveillance systems. The paper further provides the failure classification and modelling, and also analyses the failure modes' impact on ATC operations and finally proposes potential mitigations. It is important to note that the work carried out in this paper is based on the assumption that the ADS-B operates as the primary surveillance source for the ATC.				
Comments	*An analysis of ADS-B failures and fault modes; discusses failure mode occurrence causes, failure characteristics, and potential impacts affecting ATC operations and aircraft navigation.*				
Potential Gaps	*Paper not directly related to runway incursions, but it could be if ADS-B components are used or proposed as part of RI mitigation strategy.*				
Link	https://www.cambridge.org/core/journals/journal-of-navigation/article/adsb-system-failure-modes-and-models/26028032DD367A3647ECFCE64AE95E31				

Reference #	99	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*The Local Area Augmentation System: An Airport Surveillance Application Supporting the FAA Runway Incursion Reduction Program Demonstration at the Dallas/Fort Worth International Airport*				
Source/Agency	IEEE				
Authors	C.C. Hawes; M.F. DiBenedetto			**Year**	2002
Abstract	The Federal Aviation Administration (FAA) created the Runway Incursion Reduction Program (RIRP) to reduce runway incursions throughout the National Airspace System (NAS) by increasing situational awareness, incursion monitoring, and information alerting for Air Traffic Controllers (ATC), pilots, and surface vehicle operators. A recent RIRP activity involved undertaking a technical evaluation and demonstration of a prototype system at the Dallas/Fort Worth International Airport (DFW). A Local Area Augmentation System (LAAS) was one of the major sensor subsystems included in this system. As part of the RIRP team, the Ohio University Avionics Engineering Center (AEC) installed, operated, and tested the LAAS ground facility (LGF) at DFW. LAAS is a differential GPS-based precision approach and landing system that can be used to support surface operations. This paper will provide an overview of the RIRP system architecture and an introduction to LAAS. Also included are a discussion of the LGF site selection, detailed description of LGF, the test equipment used for performing accuracy and coverage assessments, and the data collection activities performed.				
Comments	*Paper discusses local area augmentation system (LAAS) related to the runway incursion reduction program, which became RIPS and was tested at DFW airport; LAAS was one of the major sensors in the system; paper provides a discussion on this component of the overall system.*				
Potential Gaps	*Slightly dated study; describes the setup and structure of the LAAS component of the overall system.*				
Link	https://ieeexplore.ieee.org/abstract/document/963339				

Reference #	100	**General Area**	SMS	**Specific Area**	Experiments
Title	*Target Cuing in Visual Search: The Effects of Conformality and Display Location on the Allocation of Visual Attention*				
Source/Agency	*Human Factors Journal*				
Authors	Michelle Yeh; Christopher Wickens; Jacob Seagull			**Year**	1999
Abstract	Two experiments were performed to examine how frame of reference (world referenced vs. screen-referenced) and target expectancy can modulate the effects of target cuing in directing attention for see-through helmet-mounted displays (HMDs). In the first experiment, the degree of world referencing was varied by the spatial accuracy of the cue; in the second, the degree of world referencing was varied more radically between a world-referenced HMD and a hand-held display. Participants were asked to detect, identify, and give azimuth information for targets hidden in terrain presented in the far domain (i.e., the world) while performing a monitoring task in the near domain (i.e., the display). The results of both experiments revealed a cost-benefit trade-off for cuing such that the presence of cuing aided the target detection task for expected targets but drew attention away from the presence of unexpected targets in the environment. Analyses support the observation that this effect can be mediated by the display: The world-referenced display reduced the cost of cognitive tunneling relative to the screen-referenced display in Experiment 1; this cost was further reduced in Experiment 2 when participants were using a hand-held display. Potential applications of this research include important design guidelines and specifications for automated target recognition systems as well as any terrain-and-targeting display system in which superimposed symbology is included, specifically in assessing the costs and benefits of attentional cuing and the means by which this information is displayed.				
Comments	*Two studies, one on frame of reference, curing, and viewing condition, study 2 on heads up versus heads down displays; cuing was helpful for finding the specified target, but pulled attention away from unspecified targets; findings suggest a cost/benefit to clutter-scan tradeoffs.*				
Potential Gaps	*Not directly related to RIs, but concepts could relate; older study, from 1999.*				
Link	https://journals.sagepub.com/doi/abs/10.1518/001872099779656752				

Reference #	101	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Reducing Pilot / ATC Communication Errors Using Voice Recognition*				
Source/Agency	Politehnica University				
Authors	Claudiu, Geacăr			**Year**	2010
Abstract	Traditionally, pilots and air traffic controllers use radios to communicate with each other. As air traffic increases, routes get more and more diverse and light and ultra-light aircraft are becoming more and more popular, the classic system is beginning to show its weaknesses. The two main issues regarding classic radio communications are channel congestion and the language – related problems. Statistics have shown that almost 80% of all pilot radio communications contain one or more errors. Furthermore, in the case of the air traffic controllers, the same statistics show that 30% of all incidents are caused, among others, by communication errors and 23% of flight level intrusions are caused by communications errors (40% in the case of runway incursions). Channel congestion issues are approached today by CPDL (Controller – Pilot Data Link), which uses an alternate system for the routine tasks that take up most of the available channel. One of the best-known applications of CPDL is Eurocontrol's Link2000+, which is set to become operational in all EU countries by 2016.				
Comments	*Paper discusses challenges with verbal communication between ATC-pilots, specifically related to misunderstandings and breakdowns in communication; proposes use of datalink and textual communication to reduce congestion and language/understanding difficulties.*				
Potential Gaps	*Conceptual paper with no testing or data collection.*				
Link	https://pdfs.semanticscholar.org/febe/0b4c8dcd838c6432807f34f49aff874772f2.pdf				

Reference #	102	**General Area**	RSA and RPZ	**Specific Area**	Ground Operations/Taxi
Title	*Information Requirements for Low-Visibility Taxi Operations: What Pilots Say*				
Source/Agency	NASA Ames Research Center				
Authors	Anthony D. Andre			**Year**	1995
Abstract	Low-visibility conditions present a host of problems for the National Airspace System. While many modern aircraft are equipped with automation that allows them to land under low-visibility conditions, there is no such corresponding technology to aid the pilots in taxiing the aircraft from runway to gate, or vice versa. Consequently, flight throughput and sequencing is severely constrained, especially at the major airports. Current efforts within NASA, the FAA, and the commercial aviation industry are aimed at developing technologies to increase the efficiency and safety of taxi operations under low-visibility conditions. Based on cockpit observations, pilot interviews, and pilot-controller communications, this paper presents an analysis of current problems experienced by pilots during the taxi operations and presents their views on key issues related to the introduction of electronic taxi map displays in the cockpit. The data were collected by the author while serving as a flight deck observer aboard thirty-five commercial carrier flights. The implications of these data for the justification and design of advanced cockpit displays for taxi operations are discussed, and the importance of including pilot experiences, opinions, and attitudes in the research and design process is stressed.				
Comments	*Not directly related to RIs but could apply contextually; discusses issues related to low-visibility taxi; data collected as a flight observer; data suggests design of advanced cockpit displays to help with low-visibility taxi.*				
Potential Gaps	*Dated study, 1995; data samples from researchers serving as a flight observer and talking to/interviewing flight crews (35).*				
Link	https://humansystems.arc.nasa.gov/groups/hcsl/publications/Andre_AvPsyc95_jumpseat.pdf				

Reference #	103	**General Area**	Airside Driving	**Specific Area**	Software/Technology
Title	*Development of an Airport Ground Vehicle Runway Incursion Warning System*				
Source/Agency	Federal Aviation Administration				
Authors	Nicholas Subbotin			**Year**	2011
Abstract	The Federal Aviation Administration continues to assess ways to prevent runway incursions and other airport operational incursions, especially during ground vehicle operations at airports. The minimum operational performance specifications described in this report identify a stand-alone incursion warning system for a ground vehicle driver. A global positioning system (GPS) was used to provide vehicle location information for this warning system. The objectives of this research were to evaluate current navigation devices for use in airport ground vehicles to prevent airport incursions, provide recommendation criteria for the design and operation of a system defining both minimum performance and optimal features, and provide cost estimates for the procurement of equipment. The two types of devices that were evaluated could be modified and used as an airport ground vehicle runway incursion warning system to prevent runway incursions. The first device demonstrated a preconfigured system that functions without additional modifications for all airports. The second device was a custom system with software and hardware components that can be modified to the airport user's needs. Based on this report, minimum performance criteria for an airport ground vehicle incursion warning system were established. Minimum performance criteria included the vehicle location accuracy equal to a wide area augmentation system GPS accuracy of…				
Comments	*Study specifically looked at systems related to preventing vehicle incursions at airports using current navigation devices/equipment; the report established minimum performance criteria for an airport ground vehicle incursion warning system; tool designed to enhance situational awareness of the driver; cost for system ranges from $1K-4K per vehicle or $100K for a system-wide implementation.*				
Potential Gaps	*Only looked at two devices; otherwise a pretty good and relevant report.*				
Link	*http://www.tc.faa.gov/its/worldpac/techrpt/ar11-26.pdf*				

Reference #	104	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Using Computational Cognitive Modeling to Diagnose Possible Sources of Aviation Error*				
Source/Agency	*The International Journal of Aviation Psychology*				
Authors	Michael D. Byrne; Alex Kirlik			**Year**	2009
Abstract	We present a computational model of a closed-loop, pilot-aircraft-visual scene-taxiway system created to shed light on possible sources of taxi error. The creation of the cognitive aspects of the model with ACT-R (Adaptive Control of Thought-Rational) required us to conduct studies with subject matter experts to identify the experiential adaptations pilots bring to taxiing. Five decision strategies were found, ranging from cognitively intensive but precise to fast and frugal but robust. We provide evidence for the model by comparing its behavior to a National Aeronautics and Space Administration Ames Research Center simulation of Chicago O'Hare surface operations. Decision horizons were highly variable; the model selected the most accurate strategy given the time available. We found a signature in the simulation data of the use of globally robust heuristics to cope with short decision horizons as revealed by the errors occurring most frequently at atypical taxiway geometries or clearance routes. These data provided empirical support for the model.				
Comments	*Developed a simulation model to prevent taxi error; conducted simulations of ORD at NASA Ames.*				
Potential Gaps	*Model does not generalize to operational taxi scenarios; could be possibly applied to vehicles operating on the airport surface.*				
Link	https://www.tandfonline.com/doi/abs/10.1207/s15327108ijap1502_2				

Reference #	105	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Runway Obstacle Detection Using Onboard Sensors: Modeling and Simulation Analysis*				
Source/Agency	IEEE/AIAA 27th Digital Avionics Systems Conference				
Authors	Ananth Vadlamani; Mark Smearcheck; Sumit Bhattacharya; Zhen Zhu; Maarten Uijt de Haag			**Year**	2008
Abstract	In recent years, the increasing demand on the national airspace system (NAS) has propelled further research on new technologies, communication systems, sensors and methods to handle the growing congestion around the terminal area. These include programs such as the runway incursion prevention system (RIPS), automatic dependent surveillance - broadcast (ADS-B), the national aeronautics and space administration (NASA) synthetic vision systems (SVS) and more recently, NASA's integrated intelligent flight deck (IIFD) project. One of the aspects of the IIFD is an external hazard monitor (EHM) function that interfaces with onboard terrain and obstacle databases, communications, and also with aircraft sensors. The EHM is envisioned to provide improved obstacle detection and hazard evaluation with added integrity and reliability. The work in this paper is performed in support of the EHM function and presents a modeling and simulation framework that models the aircraft sensors, synthesizes their measurements and analyzes their runway obstacle detection capability using both simulations and flight data playback. Various sensor parameters, measurement errors and physical properties of potential runway hazards/objects are evaluated in the simulations. Particular sensors that are considered for this work are: airborne laser scanner (ALS), 3D imaging camera, and forward-looking infrared camera (FLIR). The sensors are evaluated with regard to detection metrics such as probability of detection and time-to-alarm. Furthermore, results from the simulations using playback of actual flight test data in the vicinity of Braxton county airport (K48I), WV and Reno (RNO), NV are presented.				
Comments	*As part of the integrated intelligent flight deck system and external hazard monitor, a statistical framework/model was developed; designed to detect runway obstructions.*				
Potential Gaps	*Describes the technical and conceptual aspects of the system; could work for vehicles; no data on testing provided.*				
Link	https://ieeexplore.ieee.org/abstract/document/4702844				

Reference #	106	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Radar Imaging with ALG - The On-Board Low Visibility Landing Aid*				
Source/Agency	IEE Aviation Surveillance Systems				
Authors				**Year**	2002
Abstract	MBDA, in conjunction with BAE SYSTEMS Controls, California, are responsible for the design and development of a prototype real time imaging radar system known as ALG, autonomous landing guidance. The radar system generates frequent images that are presented to a pilot on a HUD to enable landing without the use of other landing aids in low visibility conditions. A prototype ALG system has been operational on both commercial and military aircraft since 1996 and trials have included seventy-five 0,0 landings by the USAF using the system. The paper provides a description of ALG and its installation on various platforms. The paper is illustrated with videos showing results of landings, runway incursion and surveillance. (4 pages).				
Comments	*Prototype system to help pilots land in low visibility conditions with a HUD and without other landing resources; 75 trials conducted so far for commercial and military aircraft.*				
Potential Gaps	*Unable to find full article; dated article, 2002.*				
Link	https://digital-library.theiet.org/content/conferences/10.1049/ic_20020016				

Reference #	107	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Optimization of Taxiway Routing and Runway Scheduling*				
Source/Agency	IEEE Transactions on Intelligent Transportation Systems				
Authors	Gillian Clare; Arthur G. Richards			**Year**	2011
Abstract	This paper describes a mixed-integer linear programming optimization method for the coupled problems of airport taxiway routing and runway scheduling. The receding-horizon formulation and the use of iteration in the avoidance constraints allows the scalability of the baseline algorithm presented, with examples based on Heathrow Airport, London, U.K., which contains up to 240 aircraft. The results show that average taxi times can be reduced by half, compared with the first-come-first-served approach. The main advantage is shown with the departure aircraft flow. Comparative testing demonstrates that iteration reduces the computational demand of the required separation constraints while introducing no loss in performance.				
Comments	*Advanced statistical model to forecast taxiway routing and scheduling; reduced taxi times by half compared to the first come, first served approach.*				
Potential Gaps	*Simulation limited to Heathrow Airport in London.*				
Link	https://ieeexplore.ieee.org/abstract/document/5752242				

Reference #	108	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*FAA Evaluation of UV Technology for Runway Incursion Prevention and Low-Visibility Landings*				
Source/Agency	*Proc. SPIE 5081, Enhanced and Synthetic Vision*				
Authors	Victor J. Norris Jr.			**Year**	2003
Abstract	The Federal Aviation Administration (FAA) is currently evaluating a solar blind ultraviolet (UV) technology, called FogEye, that is being developed by Norris Electro Optical Systems. The technology allows for transmission and reception of low-level UV signals that are free of any natural background noise. It also offers favorable atmospheric transmission characteristics. Conclusions of the FAA evaluation thus far are that the technology has considerable merit, and that applications such as preventing runway incursions and use as an Integrity Monitor during low visibility landings should be operationally assessed.				
Comments	*Use of UV technology system called FogEye for low visibility operations; preliminary findings show the system has merit.*				
Potential Gaps	*Rather old study (2003); mostly conceptual description in the paper.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5081/0000/FAA-evaluation-of-UV-technology-for-runway-incursion-prevention-and/10.1117/12.499275.short?SSO=1				

Reference #	109	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*A Decision Support Methodology for Dynamic Taxiway and Runway Conflict Prevention*				
Source/Agency	*Decision Support Systems Journal*				
Authors	Steven J.Landry; Xin W.Chen; Shimon Y.Nof			**Year**	2013
Abstract	Logic needed for decision support to detect and resolve airport surface conflicts is defined in this article based on complex network theory. In this article, conflicts in airport surface operations are defined, along with a methodology to model and analyze airport surface constraints. The conflict detection and resolution logic take advantage of properties of complex conflict networks for effective conflict detection and resolution. It is demonstrated and validated with the case of a modeled Hartsfield Atlanta International Airport. Further research will also include validation of the conflict detection and resolution logic with real airport surface operations data.				
Comments	*Advanced statistical model to determine conflict detection and resolution; demonstrated and validated in a case modeled at ATL.*				
Potential Gaps	*Preliminary study: next steps will involve testing the model with real life data.*				
Link	https://www.sciencedirect.com/science/article/pii/S0167923613000328				

Reference #	110	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*The Essential Synthesis of Problem Frames and Assurance Cases*				
Source/Agency	*Expert Systems Journal*				
Authors	Elisabeth A. Strunk; John C. Knight			**Year**	2008
Abstract	Problem frames and assurance cases are two current research areas that can improve – and have improved – system dependability, in critical and noncritical systems alike. While these two techniques are effective separately, their synthesis is much more powerful. This paper describes the synthesis of these two techniques and the rationale behind the synthesis, the particular pieces that influence each other, and the beginning of a process to integrate the two in software system development. A detailed example of the application of the synthesis is also provided.				
Comments	*Paper is about problem frames and assurance cases; example used within the paper relates to the FAA's runways safety monitor; technique provides a framework for linking software requirements and specifications.*				
Potential Gaps	*Example conceptual in nature to demonstrate their framework.*				
Link	https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-0394.2008.00452.x				

Reference #	111	**General Area**	RSA and RPZ	**Specific Area**	Position Paper
Title	*Runway Incursions – Clear and Constant Danger*				
Source/Agency	*Incas Bulletin*				
Authors	Maria Mrazova			**Year**	2014
Abstract	Runway safety plays an important role in aviation industry. This paper deals with runway safety – runway incursion as a serious safety concern. Focusing attention on this issue is necessary due to many collisions with a significant loss of life and many aircraft damages. The first paragraph deals with general information about runway incursions with concentration on statistical overview of runway incidents. The second paragraph describes possible ways of mitigating processes that will lead to decreasing rate of incidents mainly at airports with confusing runway/taxiway orientation, such as Zurich Airport. It also emphasizes importance of hot spots identification and subsequently their location at each airport. The last part of this paper deals with practical illustration of runway safety at mentioned Zurich Airport due to its confusing emplacement of runways and taxiways. Not less important are also positions of Action Plans and Action Teams at the point of solving problems related to runway incidents. Briefly, runway safety is an ongoing effort and we are committed to finding ways of making a safe system even safer. In addition to current runway safety initiatives, the following efforts will further the progress of increasing runway safety over the next several years.				
Comments	*Provides a description of RIs; identifies values of things like hot spots and runway safety teams to prevent incursions.*				
Potential Gaps	*Mostly a position paper on RIs and suggestions for prevention.*				
Link	http://bulletin.incas.ro/files/mrazova__vol_6_issue_3.pdf				

Reference #	112	**General Area**	SMS	**Specific Area**	Descriptive Study
Title	*Runway Incursions and their Prevention*				
Source/Agency	*Measurement and Control Journal*				
Authors	Captain I. Monro; Professor D. McLean			**Year**	2004
Abstract	A runway incursion (RI) is defined by the Federal Aviation Authority (FAA) of the USA as "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard, or results in a loss of separation with an aircraft taking-off, or intending to take-off, or landing, or intending to land". RIs, then, involve collisions of aircraft with aircraft, aircraft with buildings, or runway furniture, or vehicles on the ground, whether moving or stationary. Since there were 430 RIs reported in the USA in the year 2000 it is hardly surprising to learn that the US National Transportation Safety Board regards RIs as one of the USA's most important transportation safety issues and, since 2001, has included their prevention on its "most wanted" list of safety improvements. There are no corresponding data relating to RIs in the UK, for the Civil Aviation Authority (CAA) regards such information as confidential. It is the expressed view of the CAA that because it follows the standards laid down in ICAO (International Civil Aviation Organization) Annex 14, that adherence, of itself, will prevent any runway incursions. (Fleming[2001]). This paper deals with some data relating to RIs in the USA, and also some corresponding figures for the UK. (These UK figures were inferred from official CAA statistics for Airprox incidents and runway collisions, in addition to records obtained from the British Airways Safety Information System (BASIS)). From a comparison of the two sets of data it is shown that the rate of RIs may be relatively higher in the UK than in the USA. A description of the latest technological methods of preventing RIs follows, before concluding with the suggestion that the most immediate and effective improvement in RI reduction is likely to be as a result of improved runway surface markings and better airport signage airside.				
Comments	*UK CAA (at least as of this article's publication dat3, 2002) keeps RI data confidential; paper suggests RIs occur at a higher rate in UK than USA; provides a description of technological methods of preventing RIs.*				
Potential Gaps	*Mostly descriptive in nature; limited original contribution to the body of knowledge.*				
Link	https://journals.sagepub.com/doi/pdf/10.1177/002029400403700203				

Reference #	113	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Electro-Optic Sensors to Aid Tower Air Traffic Controllers*				
Source/Agency	HFES conference				
Authors	Dino Piccione; William K. Krebs; Penny Warren; Ron G. Driggers			**Year**	2002
Abstract	Background: Tower air traffic controllers separate aircraft to assure safety and expedite the flow of traffic. During poor visibility (e.g., fog) the aircraft landing and departure rate decreases significantly which can result in flight delays. The purpose of this study was to investigate the feasibility of using electro-optic sensors to enhance tower controller visual capabilities during poor atmospheric or low-illumination conditions. Methods: Day and nighttime visible, mid-and long-wave infrared digital imagery were collected at an airfield. To validate the collected imagery, a human-in-the-loop analytic model was used to predict an average military observer's visual discrimination of a target on the airport surface. Results: The field data collection and model results found that electro-optic sensors, in particular long-wave infrared, improved operators nighttime detection, recognition, and identification of targets on the airfield surface. Conclusions: Actual or potential applications of this research include integrating electro-optic sensors into the tower to improve aircraft movement during poor visibility.				
Comments	*Conducted an experiment; findings indicate long-wave infrared improved nighttime detection, recognition, and identification of targets on the airfield; sensors could be integrated into the two to help controllers during periods of low visibility.*				
Potential Gaps	*Dated study, 2002; data only collected from one airport, Pax River.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/154193120204600111				

Reference #	114	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Development and Implementation of an Exocentric ASMGCS Display*				
Source/Agency	19th Digital Avionics Systems Conference				
Authors	E. Theunissen; R.M. Rademaker			**Year**	2000
Abstract	At present, the data presentation capability of the electronic displays on board the aircraft is not used to support surface operations. In this paper, the rationale behind an exocentric spatial display in which the pilot derives the required control actions from an understanding of the guidance requirements is discussed. The goal of this type of data presentation is to eliminate factors such as misinterpretation of taxi instructions and unfamiliarity with the airport layout. An implementation on real flight display hardware has been performed to prove the feasibility with respect to capability and performance of today's state-of-the-art flight displays.				
Comments	*Conceptual paper on the benefit of displays on the flight deck to eliminate issues related to breakdowns in communications.*				
Potential Gaps	*Dated study, 2000; mostly conceptual in nature.*				
Link	https://ieeexplore.ieee.org/abstract/document/884936				

Reference #	115	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Surveillance Performance Requirements for Runway Incursion Prevention Systems*				
Source/Agency	Massachusetts Inst of Tech Lexington Lincoln Lab				
Authors	Thompson, S D; Eggert, J R			**Year**	2001
Abstract	In response to concerns over the number of runway incursions and runway conflicts at U.S. airports, the Federal Aviation Administration is sponsoring research and development of safety systems for the airport surface. Two types of safety systems are being actively pursued: a tower cab alerting system and a runway status light system.				
Comments	*One of the initial papers written on a tower cab alerting system, Airport Movement Area Safety System (AMASS) and Runway Status Light System; both systems operate automatically; report focuses on position accuracy and surveillance update rate; findings indicate that a system incorporating runway status lights with tower cab alerting will be effective in preventing most RI accidents.*				
Potential Gaps	*An older study, 2001, but a precursor to a lot of the other studies that have resulted from the early 2000 DFW runway safety studies.*				
Link	https://apps.dtic.mil/docs/citations/ADA396218				

Reference #	116	**General Area**	Airside Driving	**Specific Area**	Experiment
Title	*In-Vehicle Glance Duration: Distributions, Tails, and Model of Crash Risk*				
Source/Agency	*TRB journal*				
Authors	William J. Horrey; Christopher D. Wickens			**Year**	2007
Abstract	In general, the unsafe conditions that are likely to produce a motor vehicle crash reside not at the mean of a given distribution (in other words, under typical conditions), but rather in the tails of the distribution. For example, an unusually slow response to a traffic obstacle, rather than an average response, may result in a collision. Although that situation means that crashes are the exception and not the norm, it has implications for how safety-critical data are approached and handled. In this current paper, experimental data collected in a driving simulator are used to demonstrate how an analysis of the average glance durations to an in-vehicle display might lead to different conclusions about safety compared with an alternative analysis of the tail end of the distribution. In addition, a model of crash risk based on the distribution of in-vehicle glances is described, as well as several characteristics of the traffic environment.				
Comments	*Study on glance duration to an in-vehicle display could impact safety; study suggests that greater likelihood of an accident occurs for those participants who are father away from the mean glance time than who are near the mean; considered whether assess the mean of scores is really the best evaluation.*				
Potential Gaps	*Study not conducted in an aviation domain, but potentially applicable; study limited to 11 participants.*				
Link	https://journals.sagepub.com/doi/abs/10.3141/2018-04				

Reference #	117	**General Area**	Airside Driving	**Specific Area**	V/PD Winter Ops
Title	*Preventing Vehicle–Aircraft Incidents During Winter Operations and Periods of Low Visibility*				
Source/Agency	ACRP				
Authors	Quilty, Stephen M			**Year**	2008
Abstract	This synthesis study is intended to inform airport operators about factors affecting safe winter operations and the prevention of runway incursions by airport snow removal equipment operators. The information contained in this report can be of value to airport operators in their efforts to provide a safer operating environment when engaged in snow and ice removal operations during normal and low visibility conditions. Information used in this study was acquired through a review of the literature and interviews with airport operators and industry experts.				
Comments	*Study focuses on V/PDs, specifically avoiding RIs during snow removal operations; data collected via literature review and interviews.*				
Potential Gaps	*Unable to find full article to review; maybe we can request through ACRP?*				
Link	https://trid.trb.org/view/875467				

Reference #	118	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Computer-Aided System for Detecting Runway Incursions*				
Source/Agency	*Proceedings Volume 2220, Sensing, Imaging, and Vision for Control and Guidance of Aerospace Vehicles*				
Authors	Banavar Sridhar; Gano B. Chatterji			**Year**	1994
Abstract	A synthetic vision system for enhancing the pilot's ability to navigate and control the aircraft on the ground is described. The system uses the onboard airport database and images acquired by external sensors. Additional navigation information needed by the system is provided by the Inertial Navigation System and the Global Positioning System. The various functions of the system, such as image enhancement, map generation, obstacle detection, collision avoidance, guidance, etc., are identified. The available technologies, some of which were developed at NASA, that are applicable to the aircraft ground navigation problem are noted. Example images of a truck crossing the runway while the aircraft flies close to the runway centerline are described. These images are from a sequence of images acquired during one of the several flight experiments conducted by NASA to acquire data to be used for the development and verification of the synthetic vision concepts. These experiments provide a realistic database including video and infrared images, motion states from the Inertial Navigation System and the Global Positioning System, and camera parameters.				
Comments	*Study looked at the use of an aircraft synthetic vision system for pilots to better navigate on the ground.*				
Potential Gaps	*Dated study, 1994; mostly conceptual, describes on-going experiments at the time, but does not report their results.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/2220/0000/Computer-aided-system-for-detecting-runway-incursions/10.1117/12.179617.short				

Reference #	119	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Don't Go There: Using Runway Intersection Lights to Prevent Runway Incursions*				
Source/Agency	*HFES Proceedings*				
Authors	Kathleen McGarry			**Year**	2008
Abstract	This paper describes the results of a Human-in-the-Loop simulation, conducted at MITRE/CAASD's Integrated Air Traffic Management Laboratory for the FAA, evaluating the effectiveness of integrated ground-based warning systems for improved runway safety. The evaluated warning systems contained technologies to enhance pilot awareness, as well as warn pilots about runway safety risks. Pilots experienced simulation scenarios with a warning system that provided visual warnings about surface traffic. In addition, pilots experienced simulation scenarios in a baseline condition, with no warnings. The ground-based warnings consisted of Runway Intersection Lights (RILs). Results indicate significant safety benefits of these direct pilot warnings by reducing the likelihood of runway safety incidents. The study did find shortcomings with some aspects of the warnings; mitigations are suggested.				
Comments	*Experimental design testing runway visual warning system with pilots in a simulator; overall, findings suggest runway intersection light system resulted in significant safety benefits.*				
Potential Gaps	*Limited sample size, only used 10 participants.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/154193120805200105				

Reference #	120	**General Area**	RSA and RPZ	**Specific Area**	Archival Data
Title	*Mitigating Runway Incursions: A Safety Benefits Assessment of Airport Surface Moving Map Displays*				
Source/Agency	United States Department of Transportation				
Authors	Stephanie Chase; Danielle Eon; Michelle Yeh			**Year**	2010
Abstract	Airport surface moving maps vary in the capabilities provided (e.g., the depiction of ownership position and/or traffic, the presentation of taxi route, and indicating or alerting the potential for runway incursions). The purpose of this effort was to understand and to attempt to quantify the benefits offered by these different capabilities using data from runway incursions and surface incidents for Fiscal Year FY2007 and FY2008. Based on the scenarios and errors involved, we estimated the number of these incidents and incursions that may have been mitigated had a surface moving map with specific capabilities been available. The results indicated that a surface moving map with ownership position could mitigate approximately one-third of all runway incursions in FY2007 and FY2008. This benefit doubled with the addition of all surface traffic (aircraft and surface vehicles) on the surface moving map display.				
Comments	*Descriptive study using archival data; reviewed RI reports and determined that approximately 1/3 could have been prevented if the aircraft were equipped with a surface airport moving map display.*				
Potential Gaps	*Mostly descriptive in nature using an archival dataset.*				
Link	https://rosap.ntl.bts.gov/view/dot/9026				

Reference #	121	**General Area**	SMS	**Specific Area**	Statistical Modeling
Title	*Research on Risk of Airport Based on Bowtie Model*				
Source/Agency	*Journal of Safety Science and Technology*				
Authors	**GAO Yang; LUO Xu-feng**			**Year**	2009
Abstract	Hidden dangers, cause of the accident and consequences were evaluated by model of Bowtie which focus on unsubstantial stage of risk and organize control. Making Use of model of Bowtie, the airport safety risk was analyzed, in-depth analysis runway incursions as an example, discuss organization factors impacting airport safety were discussed. The structure important degree and the probability of taking place Runway incursions in the different stage and condition were calculated. From view of risk management and organization safety, it can provide theoretical basis and practical guidance with runway incursions.				
Comments	*Used bowtie method to assess airport safety risk, specifically runway incursions.*				
Potential Gaps	*Unable to access the full article.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTOTAL-LDBK200905023.htm				

Reference #	122	**General Area**	RSA and RPZ	**Specific Area**	Qualitative
Title	*Improving Taxi Efficiency Through Coordinated Runway Crossings*				
Source/Agency	INTERNATIONAL SYMPOSIUM ON AVIATION PSYCHOLOGY				
Authors	**Becky L. Hooey**			**Year**	2005
Abstract	The Coordinated Runway Crossing concept aims to improve the efficiency of airport surface operations by providing taxi clearances that contain a time or speed component. The goal is to enable pilots to arrive at, and cross, active runways without a delay. Eight commercial captains participated in a ninety-minute semi-structured interview that explored issues associated with coordinated runway crossings. The results of these interviews were used to generate preliminary information requirements, system requirements, and procedural requirements for a future coordinated runway crossing system.				
Comments	*Interview with 8 pilots to determine system parameter and development needs for a program to help pilots taxi; system would help pilots arrive at and cross runways without a delay.*				
Potential Gaps	*Good study for gaining pilot's perspectives on this type of system; more information needed as to the system's possible operational benefit.*				
Link	https://corescholar.libraries.wright.edu/isap_2005/45/				

Reference #	123	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Using a CDTI with Indications to Prevent Runway Incursions*				
Source/Agency	*International Symposium on Aviation Psychology*				
Authors	**Kathleen McGarry; John Helleberg**			**Year**	2011
Abstract	A human-in-the-loop simulation was performed to evaluate an advanced Aircraft Dependent Surveillance – Broadcast (ADS-B) application that provides runway safety indications on a Cockpit Display of Traffic Information (CDTI) implemented on a Class 2 Electronic Flight Bag (EFB). There are display limitations associated with the use of a Class 2 EFB including when the ownship symbol is shown, and how the surface moving map is displayed at various stages of flight. Nineteen pilots viewed the CDTI in a baseline condition without indications, and then in two conditions with traffic and/or runway indications while operating a medium fidelity flight simulator. Subjective results indicate that pilots preferred a CDTI with runway indications over a baseline CDTI without such indications. Pilots reported that it was difficult to determine the location of traffic relative to ownship when the display was in North-up mode. The objective performance results showed few performance differences across display types.				
Comments	*Pilots reported that they preferred a cockpit display of traffic information with runway indication over one without; they also reported difficulty in interpreting the device in the North up display versus the Track up view; used a factorial design.*				
Potential Gaps	*Only used 19 pilots.*				
Link	https://corescholar.libraries.wright.edu/isap_2011/72/				

Reference #	124	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*WIFI-Based PCL for Monitoring Private Airfields*				
Source/Agency	*IEEE Aerospace and Electronic Systems Magazine*				
Authors	F. Colone; T. Martelli; C. Bongioanni; D. Pastina; P. Lombardo			**Year**	2017
Abstract	In recent years, a number of studies have looked at the use of passive coherent location (PCL) radar systems for short-range surveillance applications [1]-[8]. In such applications, the transmitters for mobile personal communication and network connection have been successfully exploited as illuminators of opportunity; these include the base stations of the global system for mobile communications, universal mobile telecommunications system, worldwide interoperability for microwave access (WiMAX), and long-term evolution (LTE).				
Comments	*Analysis of a WIFI-based passive radar system for small, private airfields.*				
Potential Gaps	*Proof of concept and prototype testing.*				
Link	https://ieeexplore.ieee.org/abstract/document/7917421/				

Reference #	125	**General Area**	RSA and RPZ	**Specific Area**	Literature Review
Title	*Runway Incursion: Human Factors in Runway Incursions*				
Source/Agency	Wright-Patterson AFB				
Authors	Knott, Ben; Gannon, Aaron; Rench, Mike			**Year**	2000
Abstract	The runway incursion issue is a major concern for the Federal Aviation Administration (FAA) and is one of the top five aviation safety issues for FY 2000 for the FAA Administrator. It is such a significant problem that the Administrator has established a new Runway Incursion Safety Program Office that reports directly to her. The Program Office has responsibility for coordinating multiple taskings in this area across several internal FAA offices. As a part of this overall FAA effort, the Office of the Chief Scientific and Technical Advisor for Human Factors/AAR-100 has asked HSIAC to conduct (1) a search of domestic and international literature/databases on human factors issues of runway incursions and (2) a written review of the key documents from international sources. This document contains a summary of these key documents followed by the citations and abstracts gathered from the literature search.				
Comments	*An annotated bibliography of articles related to RIs.*				
Potential Gaps	*Report completed in 2000.*				
Link	https://apps.dtic.mil/docs/citations/ADA402929				

Reference #	126	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Fast and Robust Detection of Runway Incursions Using Localized Sensors*				
Source/Agency	*IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI)*				
Authors	Janis Schönefeld; Dietmar P. F. Möller			**Year**	2012
Abstract	For over a decade avoiding runway incursions (RI), events where two or more vehicles create a conflicting situation by using the same runway, have been a top ten priority of the National Transportation Safety Board (NTSB). Only the recent technological response in form of area wide deployment of Runway Incursion Prevention and Alerting Systems (RIPAS) improved the situation in the USA and safety seems to have increased significantly. Particularly the Runway Status Lights (RWLS) and the Final Approach Runway Occupancy Signal (FAROS) show a statistically measurable impact. However, in some of the most dangerous RI scenarios the surveillance providing the input for the automatic control of the signals reaches its limitations. The necessary surveillance accuracy needed to deal with such scenarios could be achieved by localized sensors. Therefore, this work provides a comparative analysis of surveillance performance in a very dangerous RI scenario based on the experimental RIPAS design XL-RIAS.				
Comments	*Deployment of RIPAS has increased safety towards RIs in USA; however, in some of the most dangerous scenarios, signals reach or exceed their limitations; this work discusses using localized sensors to solve this problem; uses simulation to assess; findings indicate improvements in system performance.*				
Potential Gaps	*Only examined through a simulation; operational trials needed.*				
Link	https://ieeexplore.ieee.org/abstract/document/6343034				

Reference #	127	**General Area**	RSA and RPZ	**Specific Area**	Descriptive Article
Title	*Runway Incursion 'Call to Action'*				
Source/Agency	UC Berkeley Transportation Library				
Authors	Karp, Aaron			**Year**	2007
Abstract	This article examines the increasing problem of runway incursions in the U.S. It has been more than a decade since a fatal runway incursion involving commercial aircraft in the U.S., but a number of close calls have the Federal Aviation Administration (FAA) calling for action. The number of serious runway incursions went down to 24 from 31 in the prior fiscal year, and the probability of a very serious incursion is extremely low, but the consequences would be disastrous. The article describes the variety of causes for incursions, including airport geometry, language problems, and signage. Solving the problems ranges from improving taxiway and runway signage and lighting to additional training. Included in the article is a discussion of some of the technological solutions that may help alleviate the problem of runway incursions.				
Comments	*Descriptive article on RIs causes, issues, and summary of technical solutions.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://trid.trb.org/view/842322				

Reference #	128	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Analysis of Runway Incursion Influence Factors Based on Gaussian Bayesian Network Model*				
Source/Agency	*Journal of Safety and Environment*				
Authors	**LUO Jun; LIN Xue-ning; YAN Yong-gang**			**Year**	2012
Abstract	The paper is engaged in an analysis of runway incursion influence factors based on Gaussian Bayesian network model, which serves as an essential part of the aviation safety. As we know, with the ever-increasing fast growth of air traffic and air transportation in our country, the incursion of runway accidents have also been becoming a very common topic to pay attention to. In this paper, we would like to analyze the factors that contribute to the runway incursion accidents, which can be roughly divided into 4 categories, that is, the factor of personnel, and those of equipment, environment, and management. Before doing the analysis, we had searched over the runway incursion manual, and collected the statistics of runway incursion recordings. Then, based on the Gaussian Bayesian network model, we have classified suggestions and consultations made by the aviation specialists. And, finally we have set up a Bayesian risk model of incursion influence factors and worked out the average value and plot standard deviation diagram curves of the internal factors on the condition once the external factors had been ascertained by MATLAB. By then, we believe that the Gaussian Bayesian network model, and the average value and standard deviation diagram curves should be able to help us to estimate the consequential cause-and-effect of the factors concerned. By now, the effect of the internal factors on the runway incursion can be defined once the external factors had been ascertained and the standard deviation of internal factors were able to be reduced to the minimum value. All in all, this paper has provided a comprehensive method for clarifying the incursion factors that can help avoid practically needless duplication and pitfalls, overcome the inefficiency of the subjective judgment on the factor values, and bring forward a valuable reference to policy-making and measure-taking to eliminate the runway incursion.				
Comments	*Advanced statistical modeling to determine causal factors of RIs.*				
Potential Gaps	*Unable to find full article for review.*				
Link	http://en.cnki.com.cn/Article_en/CJFDTOTAL-AQHJ201203048.htm				

Reference #	129	**General Area**	Airside Driving	**Specific Area**	Training
Title	*Runway Incursions: A Critical Examination of Airport Driver Training Methods*				
Source/Agency	Northcentral University				
Authors	William B Rankin			**Year**	2006
Abstract	According to the FAA Runway Safety Report (2004), vehicle deviations accounted for 20% (291 events) of all runway incursions during the four-and-a-half-year period of 2000 through 2003. The focus of this quantitative correlational study examined is a relationship existed between the methods used for airport movement area driver training and the number of incursions at 18 of the OEP-35 U.S. towered airports. Airport driver training officials at 18 of the OEP-35 airports were surveyed using a five-point Likert-type survey. The data from this study suggested a relationship exists between the methods used for airport driver training and the number of runway incursions at the largest U.S. towered airports. The data from this study might help to reduce airport liability exposure, property damage, and lower airport liability insurance cost to U.S. airport owners.				
Comments	*Dissertation research: found relationships between method used for training airport drivers and number of runway incursions; study found computer-based training was better than traditional training.*				
Potential Gaps	*Limited to small sample size, 18 airports.*				
Link	http://www.darkskysite.com/sitebuildercontent/sitebuilderfiles/dissertation.pdf				

Reference #	130	**General Area**	Airside Driving	**Specific Area**	Archival Research
Title	*Runway Incursions: Airport Movement Area Driver Training Demographics Suggests Revisions to Airport Driver Training Methods*				
Source/Agency	*Journal of Management and Marketing Research*				
Authors	William Rankin, II; John Cokley			**Year**	2009
Abstract	This paper examines the problem of runway incursions at the (OEP-35) U.S. towered airports. According to the FAA Runway Safety Report (2004), vehicle deviations accounted for 20% (291 events) of all runway incursions during the period of 2000 through 2003. The focus of this quantitative correlational study is whether demographic characteristics are a significant factor in the airport movement area driver training that employees receive at Operational Evolution Plan (OEP-35) US towered airports. Airport driver training officials at the OEP-35 airports were surveyed using a five-point Likert-type survey. The data from this study suggested that demographic characteristics are significant factors in the airport driver training that employees receive at Operational Evolution Plan (OEP-35) US towered airports, and vary by geographic region, as well as ethnic and cultural influences prevalent in each region. The data from this study may assist airport operators in identifying significant demographic characteristics that affect the outcomes of their driver training programs, and potential improvements that may enhance airport movement area driver training programs in various geographic regions.				
Comments	*Analysis looked into V/PDs; found demographic characteristics are significant factors in airport driver training; administered via a survey instrument; age, education level, income were significant; race and marital status were not significant; race was significant for south Florida airport; findings suggest the longer a person is employed (and the more recurrent training they received) the more prepared they are to drive on the airport; suggests the need for annual recurrent training; repeat of article #69.*				
Potential Gaps	*Slightly older study, but specific to airport driving and training; results are not reported very clearly.*				
Link	https://www.researchgate.net/publication/43526363_Runway_incursions_Airport_movement_area_driver_training_demographics_suggests_revisions_to_airport_driver_training_methods				

Reference #	131	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Taxiway Navigation and Situation Awareness (T-NASA) System: Problem, Design Philosophy, and Description of an Integrated Display Suite for Low-Visibility Airport Surface Operations*				
Source/Agency	SAE Technical Paper				
Authors	David C. Foyle; Anthony D. Andre; Robert S. McCann; Elizabeth M. Wenzel; Durand R. Begault; Vernol Battiste			**Year**	1996
Abstract	An integrated cockpit display suite, the T-NASA (Taxiway Navigation and Situation Awareness) system, is under development for NASA's Terminal Area Productivity (TAP) Low-Visibility Landing and Surface Operations (LVLASO) program. This system has three integrated components: Moving Map -- track-up airport surface display with ownship, traffic and graphical route guidance; Scene-Linked Symbology -- route/taxi information virtually projected via a Head-up Display (HUD) onto the forward scene; and, 3-D Audio Ground Collision Avoidance Warning (GCAW) system -- spatially-localized auditory traffic alerts. In this paper, surface operations in low-visibility conditions, the design philosophy of the T-NASA system, and the T-NASA system display components are described.				
Comments	*Development of a integrated cockpit display for better SA during taxi operations.*				
Potential Gaps	*Unable to find full article for review; older article, 1996.*				
Link	https://www.sae.org/publications/technical-papers/content/965551/				

Reference #	132	**General Area**	RSA and RPZ	**Specific Area**	Archival Research
Title	*Human Factors in Airport Surface Incidents: An Analysis of Pilot Reports Submitted to the Aviation Safety Reporting System (ASRS)*				
Source/Agency	DOT-FAA				
Authors	Amanda DiFiore; Kim Cardosi			**Year**	2006
Abstract	The purpose of this study was to examine human factors involved in airport surface incidents as reported by pilots. Reports submitted to the Aviation Safety Reporting System (ASRS) are a good source of information regarding the human performance issues and/or failures that contribute to surface incidents and can be used to supplement the information contained in FAA reports of pilot deviations. This study examined 300 ASRS reports of airport surface movement events (runway incursions and surface incidents) at the 34 busiest towered airports in the U.S., submitted between May 2001 and August 2002. The reports were selected to include those filed by a captain or first officer who was operating the aircraft under FAA Part 121, 135, or 91, and who was directly involved in the incident.				
Comments	*Archival analysis of 231 ASRS reports at 34 busiest US airports; reports were classified into six categories of outcomes and six basic categories of contributing factors.*				
Potential Gaps	*Archival research study: data collected was from 2001-2002.*				
Link	https://rosap.ntl.bts.gov/view/dot/5878				

Reference #	133	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Runway Incursion Event Forecast Model Based on LS-SVR with Multi-Kernel*				
Source/Agency	*Journal of Computers*				
Authors	Guimei Xul; Shengguo Huang			**Year**	2011
Abstract	Forecasting of runway incursion event is very significant to guide the job of civil aviation safety management. It is an important part of the runway incursion early warning management. However, prediction of runway incursion event is a complicated problem due to its non-linearity and the small quantity of training data. As a novel type of learning machine, support vector machine (SVM) has been gaining popularity due to their promising performance, such as dealing with the data of small sample, the high dimension and the excellent generalization ability. However, the generalization ability of SVM often relies on whether the selected kernel function is suitable for real data. To lessen the sensitivity of different kernels and improve generalization ability, least square support vector regression (LS-SVR) with multi-kernel is proposed to forecast the runway incursion event in this paper. The two experimental results indicate that LS-SVR with multi-kernel model is better than LS-SVR with individual kernel model and generalized regression neural network (GRNN) model. Consequently, multi-kernel LS-SVR model is a proper alternative for forecasting of the runway incursion event.				
Comments	*Advanced statistical modeling to forecast an RI event; findings suggest the new model offers improved forecasting for RIs.*				
Potential Gaps	*Data used for study from 2002-2007.*				
Link	http://www.jcomputers.us/vol6/jcp0607-09.pdf				

Reference #	134	**General Area**	RSA and RPZ	**Specific Area**	Historical Analysis
Title	*Aviation Language Problem: Improving Pilot-Controller Communication*				
Source/Agency	*International Professional Communication Conference*				
Authors	A.C. Boschen; R.K. Jones			**Year**	2004
Abstract	From time to time we have had news of airplane crashes the causes of which were breakdown in communication between the pilot and the control tower. We cite here representative examples from a proffered list of 35 such crashes which occurred between 1971 and 2002. There have been a great many more near-accidents, incidents that might have resulted in fatalities, but that we 'lucked out' in one way or another. After noting the officialization of English for world aviation in 1951, the contribution of language confusion to pilot" errors is described. Symptoms of miscommunication are listed. Crashes in which miscommunication was a contributing factor are cited. Examples of the standard phraseology of the FAA, as used by air traffic controllers in the United States, and those stipulated by ICAO2 for international use, are analyzed for confusing elements. These include ambiguities, misnomers, and illogicalities. The problem is further compounded by the inconsistencies between these two standards. Airplane pilots sometimes must make serious split-second decisions, so any possible confusion can lead to disaster. Therefore, every effort must be made to eliminate all possible sources of confusion. We have here a list of successive steps of corrective action that can produce surprising results, at minimal cost.				
Comments	*A descriptive paper highlighting areas of communication breakdowns, especially with ESL environments.*				
Potential Gaps	*Conceptual paper: proposes solutions/studies, but no actual studies conducted.*				
Link	https://ieeexplore.ieee.org/abstract/document/1375313				

Reference #	135	**General Area**	RSA and RPZ	**Specific Area**	Descriptive
Title	*Synthetic Vision Systems*				
Source/Agency	NASA Langley				
Authors	Prinzel, L.J; Kramer, L.J			**Year**	2009
Abstract	A synthetic vision system is an aircraft cockpit display technology that presents the visual environment external to the aircraft using computer-generated imagery in a manner analogous to how it would appear to the pilot if forward visibility were not restricted. The purpose of this chapter is to review the state of synthetic vision systems and discuss selected human factors issues that should be considered when designing such displays.				
Comments	*Provides an explanation and summary of synthetic vision displays for use in low-visibility situations.*				
Potential Gaps	*Conceptual in nature; does provide some suggestions for designs and displays but limited in term of operational justification.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20090007635				

Reference #	136	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling and Experiment
Title	*A Computational Model of Attention/Situation Awareness*				
Source/Agency	*Proceedings of the Human Factors and Ergonomics Society Annual Meeting*				
Authors	Jason S. McCarley; Christopher D. Wickens; Juliana Goh; William J. Horrey			**Year**	2002
Abstract	A computational model of attention and situation awareness (SA) was developed and used to predict pilot errors in the task of taxiing from runway to terminal. The model incorporates a low-level perception/attention module and a higher-level belief-updating module. Attentional scanning is controlled by bottom-up and top-down processes, with the effectiveness of top-down guidance varying as a function of SA. Information sampled by the low-level module is fed forward to the higher-level module for consolidation within a working memory representation of the pilot's situation, with the quality of this representation reflecting the pilot's level of SA. The model was validated by comparing its predictions to the behavior of pilots performing a taxiway simulation. Results indicate that the model successfully predicts the improved performance associated with display augmentations, and provides construct validity regarding the effects of visibility, distraction, and degraded information quality.				
Comments	*Developed and test a model on attention and situational awareness; study found the model was validated along with pilot actual behavior in a taxiing simulation; model successfully predicted improved performance and provided construct validity on visibility, distraction, and degraded information quality.*				
Potential Gaps	*Study used pilots in a taxiing scenario, but possible the findings could transfer to airside driving as well.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/154193120204601730				

Reference #	137	**General Area**	RSA and RPZ	**Specific Area**	Qualitative/Archival
Title	*An Assessment of Predominant Causal Factors of Pilot Deviations that Contribute to Runway Incursions*				
Source/Agency	Middle Tennessee State Univ – Master's Thesis				
Authors	Campbell, Denado			**Year**	2015
Abstract	The aim of this study was to identify predominant causal factors of pilot deviations in runway incursions over a two-year period. Runway incursion reports were obtained from NASA's Aviation Safety Reporting System (ASRS), and a qualitative method was used by classifying and coding each report to a specific causal factor(s). The causal factors that were used were substantiated by research from the Aircraft Owner's and Pilot's Association that found that these causal factors were the most common in runway incursion incidents and accidents. An additional causal factor was also utilized to determine the significance of pilot training in relation to runway incursions. From the reports examined, it was found that miscommunication and situational awareness have the greatest impact on pilots and are most often the major causes of runway incursions. This data can be used to assist airports, airlines, and the FAA to understand trends in pilot deviations, and to find solutions for specific problem areas in runway incursion incidents.				
Comments	*Qualitative analysis of ASRS reports; found miscommunication and situation awareness are the most frequent causal factors.*				
Potential Gaps	*Only looked at pilot deviations; excluded V/PDs from analysis.*				
Link	https://jewlscholar.mtsu.edu/handle/mtsu/4531				

Reference #	138	**General Area**	RSA and RPZ	**Specific Area**	Archival Research
Title	*Operational Errors in Air Traffic Control Towers*				
Source/Agency	*ATC Quarterly*				
Authors	Kim Cardosi			**Year**	2016
Abstract	It is widely recognized that runway incursions are a significant threat to aviation safety. While the importance of understanding the factors that contribute to runway incursions caused by pilot error cannot be underestimated, the factors that contribute to tower controller operational errors are also key to knowing how to prevent, and capture, runway incursions. This research examines the types and causes of controller error in the tower environment with an examination of FAA reports of operational errors and reports submitted to the Aviation Safety Reporting System (ASRS). Controller errors fell into distinct categories involving: memory lapses, communication errors, and inadequate coordination among controllers. Discussion includes suggestions for potential remedies to these errors, changes to the method of recording operational errors, and ideas for future research.				
Comments	*Study reviewed ASRS reports to determine causal factors of controller operational errors; errors most commonly related to memory lapses, communication errors, and inadequate coordination among controllers.*				
Potential Gaps	*Limited to an archival analysis of submitted ASRS reports.*				
Link	https://arc.aiaa.org/doi/abs/10.2514/atcq.10.2.147				

Reference #	139	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Effects of a Final Approach Runway Occupancy Signal (FAROS) on Pilots' Flight Path Tracking, Traffic Detection, and Air Traffic Control Communications*				
Source/Agency	*International Symposium on Aviation Psychology*				
Authors	John Helleberg			**Year**	2005
Abstract	Eighteen pilot participants with varying experience levels flew 36 approaches in a medium fidelity cockpit simulator. Eighteen baseline trials were flown with a standard Precision Approach Path Indicator (PAPI) and 18 trials were flown with the proposed Flashing PAPI (FPAPI). The results showed a significant increase in lateral tracking error with the FPAPI as compared to the PAPI trials, but no increase in vertical tracking errors. There was also a trend toward an increase in the number of radio communications with the FPAPI. Pilots were able to determine runway occupancy status and land, or go-around as required in both the baseline and FPAPI trials.				
Comments	*Had pilots conduct approaches to a runway using a steady PAPI or flashing PAPI; no difference in ability to detect an incursion aircraft in either condition.*				
Potential Gaps	*Only used a small sample of pilots (18) for the study.*				
Link	https://corescholar.libraries.wright.edu/isap_2005/42/				

Reference #	140	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*A New Method to Assess Pilots' Allocation of Visual Attention Using A Head-Up Display*				
Source/Agency	*Proceedings HFES Europe Chapter Conference Toulouse*				
Authors	Axel Hillebrand; Eva Wahrenberg; Dietrich Manzey			**Year**	2012
Abstract	Objectives of the study were the development and validation of a new assessment method for the allocation of visual attention in using head-up displays (HUD). Based on a secondary-task approach, this method specifically allows an evaluation of possible consequences of HUD on pilots' visual behaviour and thus can help to identify inappropriate HUD designs that may lead to cognitive tunneling. Background: There are studies which use the detection of runway incursions to evaluate the impact of HUD design on pilots' visual attention. This method, however, requires a large number of participants and focusses solely on the final approach. Based on a secondary target-detection task with targets presented in different locations of the field of view, the new method reduces the effort to be made for human factors investigations in this field of research. Furthermore, it allows the validation of pilots' visual attention allocation in all flight phases. Method: Twelve experienced pilots flew six approaches while concurrently performing a target detection task. The study was conducted in a low-fidelity simulation environment and involved two independent variables: HUD design and location of the targets within the field of view. Primary-task performance (e.g. deviation from flight path) as well as performance in the target detection task (detection rate, response times) were evaluated. Data of detection rate, response time and deviation from flight path were collected as well as of subjective workload. Results: The method is capable to reproduce well-known effects of HUD design on the allocation of attention. A significant better detection rate for centrally localized targets is achieved and provides evidence for attentional tunneling effects.				
Comments	*The study focused on using a HUD; prior studies have used an incursion example to measure participant's response; this study looked at task performance and target detection, but moved targets around the display; findings indicate participants were significantly better at detecting centrally localized targets which implies attentional tunneling effects.*				
Potential Gaps	*Use a small sample (12 pilots); no consideration of application to V/PDs.*				
Link	http://www.hfes-europe.org/wp-content/uploads/2014/06/Hillebrand.pdf				

Reference #	141	**General Area**	RSA and RPZ	**Specific Area**	Air Traffic Control
Title	*Investigating Linear and Interactive Effects of Shared Mental Models on Safety and Efficiency in a Field Setting.*				
Source/Agency	JOURNAL OF APPLIED PSYCHOLOGY				
Authors	Smith-Jentsch, Kimberly A; Mathieu, John E.; Kraiger, Kurt			**Year**	2005
Abstract	Linkages between 2 types of shared mental models (SMMs)--that is, positional-goal interdependencies and cue-strategy associations--and effectiveness in an air traffic control environment were investigated. Two types of SMMs were expected to contribute uniquely, as well as interact, to predict tower safety and efficiency. Using SMM data from 306 air traffic controllers, and corresponding archival efficiency and safety measures for 47 airports, the authors found no significant linear relationships between SMMs and either outcome measure. However, the 2 SMMs interacted with one another to predict both outcomes. Results are discussed in terms of the importance of measuring multiple types of SMMs, the examination of complex relationships, and the importance of indexing decisions. (PsycINFO Database Record (c) 2016 APA, all rights reserved).				
Comments	*Study used data from 306 air traffic controllers; examined two shared mental models; no linear relationships between the shared mental models, but 2 interacted to predict the two measured outcomes.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://psycnet.apa.org/record/2005-05102-009				

Reference #	142	**General Area**	Airside Driving	**Specific Area**	Airport Markings
Title	*Development of Methods for Determining Airport Pavement Marking Effectiveness*				
Source/Agency	Federal Aviation Administration				
Authors	Cyrus, H M			**Year**	2003
Abstract	Paint markings on runways, taxiways, and ramps play an important role in preventing runway incursions. Paint markings, however, deteriorate in terms of their conspicuity and must be replaced over time. Presently, the conspicuity is determined by visual inspections of segments of these markings, but the validity of these inspections cannot always be confirmed. This study was undertaken to develop a method for a quick and accurate evaluation of paint markings. A manual method was required for eliminating subjectivity in the current method, and an automated method was developed for evaluation of larger surface markings over a vast airport area. In addition, the study also established a threshold pass/fail limit for white and yellow paint. It was found that for the manual method, three devices are required: a retro-reflectometer for determining retro reflectivity of the beads; a spectrophotometer is required to determine whether or not the paint marking has faded out of tolerance; and a transparent grid is used to determine coverage of the paint. If any one of these three tests fail, the pavement marking fails.				
Comments	*Study produces a manual and automated method for evaluating the tolerance of the quality of painted runway and taxiway markings.*				
Potential Gaps	*Unable to find full article to review.*				
Link	https://trid.trb.org/view/660370				

Reference #	143	**General Area**	Choose an item. N/A	**Specific Area**	Experiment
Title	*Development and Transfer of Higher Order Thinking Skills in Pilots*				
Source/Agency	*UND* THESES AND DISSERTATIONS				
Authors	Charles Robertson			**Year**	2005
Abstract	The aviation community recognizes a need for at least one order of magnitude improvement in general aviation safety. This improvement would virtually eliminate the primary cause of today's accidents—human factor errors. This study examined a method of teaching higher order thinking skills and compared it to the traditional method of instruction used in flight education. It used a pretest-posttest control-group experimental research design to compare an example of a blended problem-based learning (PBL) and non-PBL methods of instruction. The results of the experiment showed improvements in all measures and significant improvements in several measures of (a) pilot performance, (b) situational awareness, and (c) aeronautical decision- making for pilots transitioning to technically advanced aircraft (TAA). Additional research is needed to determine the value of this method for other aviation training.				
Comments	*Study conducted as a dissertation and examined for significant differences in two types of training: traditional and blended problem-based learning; results indicate that experimental group performed better in all measured categories.*				
Potential Gaps	*Not directly related to RIs but could relate to the earlier studies that found computer-based training was more effective than traditional training for airport workers.*				
Link	https://commons.und.edu/theses/359/				

Reference #	144	**General Area**	RSA and RPZ	**Specific Area**	Archival Research
Title	*Controller and Pilot Error in Surface Operations*				
Source/Agency	U.S. Department of Transportation				
Authors	Dr. Kim Cardosi			**Year**	2001
Abstract	This paper presents the results of an examination of controller and pilot errors in surface operations. Several different types of reports were analyzed, including: FAA reports of operational errors of controllers in air traffic control towers, FAA reports of pilot deviations, NTSB reports of accidents and incidents, and reports submitted by pilots and controllers to the Aviation Safety Reporting System (ASRS). All of these reports were analyzed for the following: type of pilot and controller error, factors contributing to, or coincident with, the error, and what could be done in the tower to help prevent these errors and increase the safety of surface operations. Controller errors were predominately attributable to a lapse in controller memory, an error in judgment of separation, failure to ensure that the runway was clear, and inadequate coordination between controllers. While the objective data on pilot errors is scarce, pilot errors were subjectively attributed to inadequate airport signage and markings and errors in communication between pilots and controllers. The paper concludes with recommendations for improving the safety of surface operations and for improving the quality of data related to pilot and controller errors.				
Comments	*Study examined controller and pilot errors in surface operations; reviewed a series of reports; controller errors mostly from memory lapse; pilots had issues with airport signs/markings, and communications.*				
Potential Gaps	*Looked at archival reports; most of the data was all pre-2000.*				
Link	http://www.atmseminarus.org/seminarContent/seminar4/papers/p_016_S.pdf				

Reference #	145	**General Area**	Choose an item. N/A	**Specific Area**	Archival Research
Title	*Test Scenarios for Rare Events*				
Source/Agency	ERAU and NASA Ames				
Authors	Richard L Newman; David C Foyle			**Year**	2003
Abstract	During testing of cockpit systems and displays, a frequent objective is to evaluate a system's ability to maintain the pilot's "situation awareness" (SA). That maintenance of situation awareness is critical to flight safety is a truism. While SA is, no doubt, required for pilots and other crewmembers to make correct operational decisions, it has been difficult to identify precise objective test criteria. The approach taken is to compare experimental studies over the past several years with various human error models. This review shows four different experimental approaches to rare event test and evaluation. These match up well with the various situation awareness and human error taxonomies. Several proposed test plans are reviewed and changes in the scenarios made to match the appropriate human error model. The goal is to develop experimental scenarios that will yield suitable data and, at the same time, make efficient use of experimental facilities.				
Comments	*Study not directly related to RIs, other than RIs are rare events; conducted an analysis of experimental approaches to rare event test and evaluation; goal of study was to develop experimental scenarios for future research.*				
Potential Gaps	*Study not directly related to RIs; old study (2003).*				
Link	https://humanfactors.arc.nasa.gov/groups/hcsl/publications/Newman_AvPsyc03.pdf				

Reference #	146	**General Area**	Airside Driving	**Specific Area**	Software/Technology
Title	*How Can a Future Safety Net Successfully Detect Conflicting ATC Clearances – Yet Remain Inconspicuous to the Tower Runway Controller? First Results from a SESAR Exercise at Hamburg Airport*				
Source/Agency	*International Conference on Engineering Psychology and Cognitive Ergonomics*				
Authors	Marcus Biella; Karsten Straube; Marcus Helms; Stephen Straub; Benjamin Weiß; Felix Schmitt; Heribert Lafferton; Stéphane Dubuisson; Roger Lane			**Year**	2013
Abstract	To increase runway safety a new safety net for Tower Runway Controllers was developed which detects if controllers give a clearance to an aircraft or vehicle contradictory to another clearance already given to another mobile. In a shadow mode validation exercise with eleven controllers at the operational environment of the airport Hamburg (Germany) operational feasibility was tested in order to clarify if operational requirements in terms of usability are fulfilled. At the same time operational improvements regarding safety were studied e.g. if the new safety net detects all conflicts and if nuisance alerts are suppressed.				
Comments	*Examined a new safety net which would detect if a controller issued conflicting clearances to multiple aircraft/vehicles; related to #170.*				
Potential Gaps	*Unable to find the full article for review; used only 11 controllers in an operational feasibility test.*				
Link	https://link.springer.com/chapter/10.1007/978-3-642-39354-9_8				

Reference #	147	**General Area**	SMS	**Specific Area**	Fatigue
Title	*Fatigue in aviation*				
Source/Agency	*Travel Medicine and Infectious Disease* *Volume 3, Issue 2, May 2005, Pages 85-96*				
Authors	John A.Caldwell			**Year**	2005
Abstract	Pilot fatigue is a significant, but often under-reported problem in both civilian and military aviation operations. Although estimates vary, official statistics indicate that fatigue is involved in at least 4–8% of aviation mishaps, and surveys of pilots and aircrew members reveal that fatigue is an important concern throughout today's 24/7 flight operations. Regulatory efforts aimed at limiting flight hours and ensuring at least minimal periods of crew rest have to some extent mitigated fatigue-related difficulties in the cockpit, but it is clear that much remains to be done about this insidious threat to air safety. Scheduling factors, sleep deprivation, circadian disruptions, and extended duty periods continue to challenge the alertness and performance levels of both short-haul and long-haul pilots and crews. Solutions for these problems are not straightforward, but they can be developed through the cooperative efforts of scientists, regulators, managers, and the pilots themselves. Over the past 20 years, scientific understanding of human sleep, fatigue, and circadian rhythms has expanded considerably. The thorough integration of this new knowledge into modern crew-resource management practices will facilitate the establishment of optimal crew scheduling routines and the implementation of valid aviation fatigue countermeasures.				
Comments	*Fatigue studies and mitigations abound for flight crew. Some of the concepts and programs can translate to the airport airside environment.*				
Potential Gaps	*Fatigue management programs for airport personnel and ground crew.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S1477893904001012				

Reference #	148	**General Area**	RSA and RPZ	**Specific Area**	Congressional Testimony
Title	*Observations on FAA's Oversight of Aviation Safety*				
Source/Agency	Before the Committee on Transportation and Infrastructure				
Authors	Todd J. Zinser			**Year**	2006
Abstract	This testimony was conducted in accordance with Generally Accepted Governmental Auditing Standards prescribed by the Comptroller General of the United States. The work supporting this testimony was based on prior and ongoing audits conducted by the Office of Inspector General.				
Comments	*Testimony before Congress on FAA aviation safety oversight; discusses RIs and ongoing safety risk; discusses new technological approaches to mitigate RIs such as ASDE-X.*				
Potential Gaps	*Summary of current issues related to RI and RI prevention; no new data or studies conducted; over 10 years old now; similar to #149.*				
Link	https://www.oig.dot.gov/sites/default/files/IG_Aviation_Safety_Testimony_9.20.pdf				

Reference #	149	**General Area**	RSA and RPZ	**Specific Area**	Congressional Testimony
Title	*FAA's Progress and Challenges in Advancing Safety Oversight Initiatives*				
Source/Agency	Before the Committee on Commerce, Science, and Transportation				
Authors	Jeffrey B. Guzzetti			**Year**	2013
Abstract	With an increasingly complex air system—one that relies on rapidly evolving technologies, specialized services, and expanding partnerships—maintaining a safe and viable NAS is a challenging mission. While FAA has taken noteworthy action to address safety concerns raised by Congress, our office, NTSB, and others, we have noted that further opportunities remain to mitigate safety risks. These include improving collection and analysis of air traffic safety data, establishing an effective risk-based approach for overseeing repair stations and manufacturers, and fully addressing provisions of the Airline Safety and FAA Extension Act of 2010 and the FAA Modernization and Reform Act of 2012. We will continue our work with FAA and the Department to ensure intended air safety improvements are realized.				
Comments	*Testimony from FAA to Congress on FAA oversight of aviation safety; highlights RIs and new technology such as ASDE-X; identifies RIs as a continuing safety threat.*				
Potential Gaps	*Summary of current issues related to RI and RI prevention; no new data or studies conducted; similar to #148.*				
Link	https://www2.oig.dot.gov/sites/default/files/Aviation%20Safety%20Testimony_4-16-13.pdf				

Reference #	150	**General Area**	RSA and RPZ	**Specific Area**	Editorial
Title	*Improving Patient Safety in the Operating Room: Lessons From the Aviation Industry*				
Source/Agency	*Nature Clinical Practice Urology*				
Authors	Douglas F Milam			**Year**	2008
Abstract	The need to reduce the frequency and impact of medical errors has generated much discussion. As part of this debate, we have asked how other industries have produced documented safety improvements. US domestic air carriers stand out as an industry that decreased the rate of fatal accidents by almost two-thirds from 1987 to 2006 through purposeful intervention and training.				
Comments	*Study is an editorial for the medical field and uses examples from aviation, such as runway incursions, on how to improve safety in the operating room.*				
Potential Gaps	*An editorial; primarily directed at the medical industry, but applies lessons learned from aviation.*				
Link	https://www.nature.com/articles/ncpuro1134				

Reference #	151	**General Area**	RSA and RPZ	**Specific Area**	Simulation and Modeling
Title	*An Agent-Based Approach for Accident Analysis in Safety Critical Domains: A Case Study on a Runway Incursion Incident*				
Source/Agency	*Transactions on Computational Collective Intelligence*				
Authors	Tibor Bosse; Nataliya M. Mogles			**Year**	2014
Abstract	This paper introduces an agent-based approach to analyze the dynamics of accidents and incidents in aviation. The approach makes use of a number of elements, including formalization of a real world scenario, agent-based simulation of variations of the scenario, and formal verification of dynamic properties against the (empirical and simulated) scenarios. The scenario formalization part enables incident reconstruction and formal analysis of it. The simulation part enables the analyst to explore various hypothetical scenarios under different circumstances, with an emphasis on error related to human factors. The formal verification part enables the analyst to identify scenarios involving potential hazards, and to relate those hazards (via so-called interlevel relations) to inadequate behavior on the level of individual agents. The approach is illustrated by means of a case study on a runway incursion incident, and a number of advantages with respect to the current state-of-the-art are discussed.				
Comments	*Paper focuses on using an agent-based approach to recreate the scenario and provide an analysis of an RI event; uses a case study to demonstrate.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://link.springer.com/chapter/10.1007/978-3-662-44994-3_4				

Reference #	152	**General Area**	RSA and RPZ	**Specific Area**	Data Mining
Title	*Recent Experiences with Data Mining in Aviation Safety*				
Source/Agency	The MITRE Corporation				
Authors	Earl Harris Jr.; Eric Bloedorn; Neal J. Rothleder			**Year**	1998
Abstract	While many data miners want to find "interesting" patterns, the definition of an interesting pattern is often unclear. This is a case study of data mining applied to the problem of improving aviation safety. To address the problem, we applied several methods to pertinent data; these methods achieved varying degrees of success. During the project, our notion of an interesting pattern evolved and our appreciation for a good working definition for interestingness grew.				
Comments	*Paper is interested in big data mining techniques; uses RIs for some examples, but it is not really the focus of this paper.*				
Potential Gaps	*Rather date study (1998).*				
Link	http://www09.sigmod.org/disc/disc99/disc/dmkd/earlharris.pdf				

Reference #	153	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Requirements Analysis for an Air Traffic Control Tower Surface Surveillance Enhanced Vision System*				
Source/Agency	*Proceedings Volume 5081, Enhanced and Synthetic Vision*				
Authors	John W. Ruffner; Dawne M. Deaver; Daniel J. Henry			**Year**	2003
Abstract	Tower controllers are responsible for maintaining separation between aircraft and expediting the flow of traffic in the air. On the airport surface, they also are responsible for maintaining safe separation between aircraft, ground equipment, and personnel. They do this by sequencing departing and arriving aircraft, and controlling the location and movement of aircraft, vehicles, equipment, and personnel on the airport surface. The local controller and ground controller are responsible for determining aircraft location and intent, and for ensuring that aircraft, vehicles, and other surface objects maintain a safe separation distance. During nighttime or poor visibility conditions, controllers' situation awareness is significantly degraded, resulting in lower safety margins and increased errors. Safety and throughput can be increased by using an Enhanced Vision System, based upon state-of-the-art infrared sensor technology, to restore critical visual cues. We discuss the results of an analysis of tower controller critical visual tasks and information requirements. The analysis identified: representative classes of ground obstacles/targets (e.g., aircraft, vehicles, wildlife); sample airport layouts and tower-to-runway distances; and obstacle subtended visual angles. We performed NVTherm modeling of candidate sensors and field data collections. This resulted in the identification of design factors for an airport surface surveillance Enhanced Vision System.				
Comments	*Study suggests need for controllers to have a surface surveillance enhanced vision system; did collect field data, but no operational testing; system would be beneficial at night and in low-visibility conditions, when "out-the-window" visibility is reduced.*				
Potential Gaps	*Conducted conceptual testing, but no operational tests.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5081/0000/Requirements-analysis-for-an-air-traffic-control-tower-surface-surveillance/10.1117/12.498997.short?SSO=1				

Reference #	154	**General Area**	Choose an item. N/A	**Specific Area**	Communication
Title	*Miscommunication Between Pilots and Air Traffic Control*				
Source/Agency	*Language Problems and Language Planning Journal*				
Authors	R. Kent Jones			**Year**	2003
Abstract	Language confusion is a frequent cause of pilot error. Although English was made the common language of world aviation in 1951, miscommunication and crashes in which communication was a contributing factor are common. Standard phrases used by air traffic controllers in the United States contain numerous confusing elements. These include ambiguities, misnomers and illogicalities. Phrases are not derivations of a master plan as they should be. The inability of English to express specific directions to pilots without confusion disqualifies it as a language for permanent use by aviation.				
Comments	*Paper discusses language confusion as a main cause of pilot error.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://www.jbe-platform.com/content/journals/10.1075/lplp.27.3.03jon				

Reference #	155	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Object-Based Attention and Cognitive Tunneling.*				
Source/Agency	JOURNAL OF EXPERIMENTAL PSYCHOLOGY: APPLIED				
Authors	Jarmasz, J.; Herdman, C. M.; Johannsdottir, K. R.			**Year**	2005
Abstract	Simulator-based research has shown that pilots cognitively tunnel their attention on head-up displays (HUDs). Cognitive tunneling has been linked to object-based visual attention on the assumption that HUD symbology is perceptually grouped into an object that is perceived and attended separately from the external scene. The present research strengthens the link between cognitive tunneling and object-based attention by showing that (a) elements of a visual display that share a common fate are grouped into a perceptual object and that this grouping is sufficient to sustain object-based attention, (b) object-based attention and thereby cognitive tunneling is affected by strategic focusing of attention, and (c) object-based attention is primarily inhibitory in nature. (PsycINFO Database Record (c) 2016 APA, all rights reserved).				
Comments	*Paper examines attentional tunneling with HUD displays.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://psycnet.apa.org/record/2005-02947-001				

Reference #	156	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Surface Operation Automation Research for Airport Tower and Flight Deck Automation*				
Source/Agency	*Proceedings. The 7th International IEEE Conference on Intelligent Transportation Systems*				
Authors	V.H.L. Cheng			**Year**	2004
Abstract	Air traffic growth has resulted in serious peak-traffic flight delays in our National Airspace System, and congestion at key airports has been recognized as one of the key factors contributing to the problem. Airport expansion plans designed to increase the airports' capacities cannot fully realize their potential benefits because they tend to increase the complexity of the airport configurations, thus reducing the efficiency of the system. The surface operation automation research (SOAR) concept was proposed in a previous article as a collaborative concept to provide automation for surface-traffic management and the flight deck to enhance the operational efficiency in complex airport environments. Development and evaluation of the SOAR concept is being pursued in a 5-year program. This work presents a progress update of the program.				
Comments	*Study does not deal directly with RIs; purpose of the study was to investigate how airport expansion could be planned to increase efficiency and reduce congestion; prevention of RI is an added benefit; systems contains both automation for surface-traffic management and the flight deck.*				
Potential Gaps	*Mostly conceptual in nature; dated (2004).*				
Link	https://ieeexplore.ieee.org/abstract/document/1398970				

Reference #	157	**General Area**	SMS	**Specific Area**	Trade Publication
Title	*Tackling Runway Incursions Eurocontrol and FAA Officials are Seeking a Common Definition and More Data to Target this Airport Safety Hazard*				
Source/Agency	*Aviation Week & Space Technology*				
Authors	Hughes David			**Year**	2003
Abstract	The International Civil Aviation Organization is moving to establish a standard definition of runway incursion so that comparable data can be collected and used to guide safety actions. Runway incursions and accidents are thankfully rare, but when collisions do occur, they usually result in fatalities - so the safety issue is considered significant. However, the lack of large enough databases to underpin the powerful statistical analyses that officials say they need has been a stumbling block. Before data can be compiled on a global basis, the 20 or more definitions used by various civil aviation authorities worldwide to track incidents must be winnowed to one. Europe counts an incursion anytime an aircraft enters a runway by mistake, even if there are no other aircraft on the runway or in the vicinity. In contrast, incursions are recorded in the US only when there's another aircraft or vehicle on the runway, or an aircraft about to land. The definition that has been chosen for review is closer to Canada's and Europe's than to the FAA's version.				
Comments	*Advocates for ICAO establishing a standardized definition of runway incursions so databases can be combined for statistical analysis.*				
Potential Gaps	*Unable to access full article for review; trade publication on RIs.*				
Link	https://elibrary.ru/item.asp?id=6164963				

Reference #	158	**General Area**	RSA and RPZ	**Specific Area**	Qualitative Study
Title	*An Analysis of Tower (Ground) Controller - Pilot Voice Communications*				
Source/Agency	National Transportation Systems Center Cambridge Ma				
Authors	John A Volpe			**Year**	1995
Abstract	This report is based on an analysis of over 48 hours of pilot-controller communications recorded from the ground-control frequency at twelve air traffic control towers. The analysis examined the complexity of controller instructions, that is, how many pieces of information a single controller transmission contains. It looked at how pilots respond to these instructions, and whether the type of response was affected by the complexity of the instructions. Particularly, it studied the effect of complexity of the instructions on communication problems, such as when pilots asked controllers to repeat their instructions or when they made an error in the readback. It also examined the incidence and possible causes of callsign confusions as well as of conceptual errors in pilot-controller communications. Lastly, it compared the incidence of communication problems with the transmission density (transmissions per minute) at a facility. It related these findings to what was observed in the en-route (Cardosi, 1993), terminal-radar (TRACON; Morrow, Lee, and Rodvold, 1993) and in the tower-local control (Cardosi, 1994) environment. In conclusion a series of recommendations is presented.				
Comments	*Study was conducted to listen to ATC-Pilot voice communications; based on listening, recommendations were provided such as controllers keeping instructions short, controllers verifying pilot readbacks, pilots seeking clarification when confused, etc.*				
Potential Gaps	*Qualitative analysis of pilot-voice communications; identified breakdowns, but recommendations are somewhat limiting; did not directly study RIs and V/PDs.*				
Link	https://apps.dtic.mil/docs/citations/ADA307868				

Reference #	159	**General Area**	RSA and RPZ	**Specific Area**	Archival Research
Title	*An Analysis of Runway-Taxiway Transgressions at Controlled Airports*				
Source/Agency	Transportation Systems Center Cambridge, MA				
Authors	Bellantoni, John; Kodis, Ralph			**Year**	1981
Abstract	The purpose of this study was to determine the cause of aircraft making inadvertent or unauthorized takeoffs and transgressions onto active runways during takeoff and landing operations. The study was conducted in four phases: (1) Prior studies by FAA, NASA and MITRE/METREK were reviewed; (2) Existing data bases containing information on accidents and incidents resulting from transgressions were examined and compared; (3) Investigations were carried out by the FAA Eastern, Great Lakes and Western regions of the occurrence of transgressions at selected airports within their jurisdictions; (4) A detailed analysis was carried out for 166 occurrences drawn from the Aviation Safety Reporting System (ASRS) and the National Transportation Safety Board (NTSB) data bases. A summary of the results includes some observations with respect to possible system improvements and suggestions for further work.				
Comments	*Study used a four-phased approach, focuses on various types of archival research such as prior studies, reviewing ASRS; suggest expert opinion and objective data as sources to help solve RI issues.*				
Potential Gaps	*Very dated study (1981).*				
Link	https://apps.dtic.mil/docs/citations/ADA099470				

Reference #	160	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Alternating Yellow and Green Taxiway Centerline as a Runway Safety Enhancement*				
Source/Agency	Federal Aviation Administration				
Authors	Patterson Jr, James W			**Year**	2005
Abstract	This research effort was conducted to investigate and validate the suitability of installing alternating yellow and green taxiway centerline lights on taxiway segments located between the runway hold position marking and the runway centerline in the direction approaching the runway. This lighting configuration is the same configuration frequently used to identify the centerline of a taxiway exiting a runway, except that it is viewed from the opposite direction. This lighting configuration would serve as a visual cue to pilots and vehicle drivers that they are about to enter the runway environment/runway safety area (RSA). The objective of this research effort was to determine how the proposed lighting configuration would appear to pilots approaching the hold line (runway environment/RSA), if presently available lighting fixtures are adequate for the purpose, if present spacing standards are adequate for the purpose, if pilots interpret the purpose of the alternating yellow and green taxiway centerline lighting configuration correctly, and the cost factors involved in making such a change. The alternating yellow and green taxiway centerline lighting configuration was found to be suitable for various reasons. Presently available fixtures, such as the L-852 taxiway centerline fixture, were found to be adequate in color, intensity, and alignment, for this purpose, as long as they are installed, aligned, and maintained as required in the appropriate Advisory Circulars. Subjects were unanimous in judging the spacing as satisfactory for this purpose. The results of this research effort showed that subjects were able to recognize that there was some kind of transition at the point at which the lighting changed from green to the alternating pattern. The cost to modify a taxiway/runway entrance to the alternating yellow and green taxiway centerline configuration is dependent on the length of the taxiway section, the complexity of the intersection, and the number of fixtures available. Price estimates for replacing the appropriate filters, as well as other serviceable parts, ranged from $50 to $200 per fixture, including labor and parts. This price makes the alternating yellow and green taxiway centerline lighting configuration one of the cheapest alternatives for potentially reducing runway incursions.				
Comments	*Suggestion of creating alternative yellow/green taxiway centerline lights before runways to alert pilots and drivers between the runway hold line and the runway centerline; study found that this was a cost-effective and easily deployable tool.*				
Potential Gaps	*Limited sample size (9), and data only collected on one night at one airport.*				
Link	https://trid.trb.org/view/1355548				

Reference #	161	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Overall Safety Performance of the Air Traffic Management System: Indicators and Analysis*				
Source/Agency	*Journal of Air Transport Management*				
Authors	Giulio Di Gravio; Maurizio Mancini; Riccardo Patriarca; Francesco Costantino			**Year**	2015
Abstract	Defining means to assess safety performance and delve into their causes is one of the current and future challenges of the ATM sector. Following the experiences of the Aerospace Performance Factor by FAA and EUROCONTROL, this research aims to apply the Analytic Hierarchy Process (AHP) in order to build synthetic and user-friendly safety-related indicators. Through the analysis and combination of the safety events over time (accidents, incidents and issues), this model will pinpoint critical situations and will address the interventions of the decision makers.				
Comments	*Paper discusses the development of a statistical model to identify the overall safety performance; RIs are not directly discussed, just as examples.*				
Potential Gaps	*Paper is conceptual in nature; proposes and discusses an overall safety performance metric.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0969699715000198				

Reference #	162	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Flight Testing an Integrated Synthetic Vision System*				
Source/Agency	*Proceedings Volume 5802, Enhanced and Synthetic Vision*				
Authors	Lynda J. Kramer; Jarvis James Arthur III; Randall E. Bailey; Lawrence J. Prinzel III			**Year**	2005
Abstract	NASA's Synthetic Vision Systems (SVS) project is developing technologies with practical applications to eliminate low visibility conditions as a causal factor to civil aircraft accidents while replicating the operational benefits of clear day flight operations, regardless of the actual outside visibility condition. A major thrust of the SVS project involves the development/demonstration of affordable, certifiable display configurations that provide intuitive out-the-window terrain and obstacle information with advanced pathway guidance for transport aircraft. The SVS concept being developed at NASA encompasses the integration of tactical and strategic Synthetic Vision Display Concepts (SVDC) with Runway Incursion Prevention System (RIPS) alerting and display concepts, real-time terrain database integrity monitoring equipment (DIME), and Enhanced Vision Systems (EVS) and/or improved Weather Radar for real-time object detection and database integrity monitoring. A flight test evaluation was jointly conducted (in July and August 2004) by NASA Langley Research Center and an industry partner team under NASA's Aviation Safety and Security, Synthetic Vision System project. A Gulfstream G-V aircraft was flown over a 3-week period in the Reno/Tahoe International Airport (NV) local area and an additional 3-week period in the Wallops Flight Facility (VA) local area to evaluate integrated Synthetic Vision System concepts. The enabling technologies (RIPS, EVS and DIME) were integrated into the larger SVS concept design. This paper presents experimental methods and the high-level results of this flight test.				
Comments	*Conducted flight testing and experiments of NASA's synthetic vision system; conducted flight tests over two 3-week periods in Nevada and Virginia; participants flew multiple scenarios to evaluate the SVS system; DVs were path control performance, mental workload & SA, information presentation, RI prevention, DIME performance, and voice and speech recognition; overall, SVS was shown to improve pilot SA without increasing workload.*				
Potential Gaps	*Limited to two test locations and only 10 pilots; not applied in an airside driving context.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5802/0000/Flight-testing-an-integrated-synthetic-vision-system/10.1117/12.601757.short?SSO=1				

Reference #	163	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Sparse Machine Learning Methods for Understanding Large Text Corpora*				
Source/Agency	UC Berkeley				
Authors	Laurent El Ghaoui; Guan-Cheng Li; Viet-An Duong; Vu Pham; Ashok Srivastava; And Kanishka Bhaduri			**Year**	2011
Abstract	Sparse machine learning has recently emerged as powerful tool to obtain models of high-dimensional data with high degree of interpretability, at low computational cost. This paper posits that these methods can be extremely useful for understanding large collections of text documents, without requiring user expertise in machine learning. Our approach relies on three main ingredients: (a) multi-document text summarization and (b) comparative summarization of two corpora, both using sparse regression or classification; (c) sparse principal components and sparse graphical models for unsupervised analysis and visualization of large text corpora. We validate our approach using a corpus of Aviation Safety Reporting System (ASRS) reports and demonstrate that the methods can reveal causal and contributing factors in runway incursions. Furthermore, we show that the methods automatically discover four main tasks that pilots perform during flight, which can aid in further understanding the causal and contributing factors to runway incursions and other drivers for aviation safety incidents.				
Comments	*Used advanced statistical modeling and sparse machine learning of ASRS reports to predict causal and contributing factors of RIs.*				
Potential Gaps	*Limited to archival data for model output.*				
Link	https://people.eecs.berkeley.edu/~elghaoui/Pubs/cidu2011_final.pdf				

Reference #	164	**General Area**	RSA and RPZ	**Specific Area**	Descriptive Research
Title	*Human Risk Factors Associated with Pilots in Runway Excursions*				
Source/Agency	*Accident Analysis & Prevention Volume 94, September 2016, Pages 227-237*				
Authors	Yu-Hern Chang; Hui-Hua Yang; Yu-Jung Hsiao			**Year**	2016
Abstract	A breakdown analysis of civil aviation accidents worldwide indicates that the occurrence of runway excursions represents the largest portion among all aviation occurrence categories. This study examines the human risk factors associated with pilots in runway excursions, by applying a SHELLO model to categorize the human risk factors and to evaluate the importance based on the opinions of 145 airline pilots. This study integrates aviation management level expert opinions on relative weighting and improvement-achievability in order to develop four kinds of priority risk management strategies for airline pilots to reduce runway excursions. The empirical study based on experts' evaluation suggests that the most important dimension is the liveware/pilot's core ability. From the perspective of front-line pilots, the most important risk factors are the environment, wet/containment runways, and weather issues like rain/thunderstorms. Finally, this study develops practical strategies for helping management authorities to improve major operational and managerial weaknesses so as to reduce the human risks related to runway excursions.				
Comments	*Study focused on runway excursions; used the SHELLO model to categorize human risk factors; conducted a survey of pilots and experts; structure of the study seems similar to a multi-stage Delphi technique; found that the Liveware portion of the SHELLO model was the most important and pilots could play the most important role in reducing runway excursions.*				
Potential Gaps	*Focus of the study and participants were from Taiwan.*				
Link	https://www.sciencedirect.com/science/article/abs/pii/S0001457516302032				

Reference #	165	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*A Runway Incursion Detection Approach Based on Multiple Protected Area and Flight Status Machine for A-SMGCS*				
Source/Agency	MATEC Web of Conferences				
Authors	Jing Li; Guo Qiang Wang; Pan Zhu; Xin Lu; Jian Su			**Year**	2016
Abstract	A-SMGCS is a modular system defined in the ICAO (International Civil Aviation Organization) Manual on Advanced Surface Movement Guidance and Control System (A-SMGCS). One of A-SMGCS goals is to provide enhanced safety and protection of the runway. This paper presents a novel runway incursion detection approach for A-SMGCS, in which a multiple protected area is proposed to decrease complexity of pre-treatment for incursion judgment, and a flight status machine is designed to specify the transitions of one flight from one target status to another. Additionally, an HMI (Human Machine Interface) independently developed by the Second Research Institute of CAAC (Civil Aviation Administration of China) was designed in order to validate the runway incursion detection approach, the result shows that the algorithm has the potential to significantly improve runway safety by early detection and alerting of runway incursions.				
Comments	*Discusses moving from event-based alerts, which has to occur before events happen to the development of an algorithm which triggers alert based on rules that define potential conflicts.*				
Potential Gaps	*Limited to conceptual simulation testing at one airport in China; preliminary findings suggest an increase in early detection.*				
Link	https://www.matec-conferences.org/articles/matecconf/abs/2016/07/matecconf_iceice2016_01084/matecconf_iceice2016_01084.html				

Reference #	166	**General Area**	RSA and RPZ	**Specific Area**	Network Modeling
Title	*Australian Airport Network Robustness Analysis: A Complex Network Approach*				
Source/Agency	Australasian Transport Research Forum 2013 Proceedings				
Authors	Murad Hossain; Sameer Alam; Tim Rees; Hussein Abbass			**Year**	2013
Abstract	An airport network is a fundamental component of an air transportation infrastructure and has to be designed in such a manner that failure of any of its arbitrary components should not cascade into a catastrophic event. Resilience analysis of the Airports Network can offer an insight into airport network readiness and response behaviour to any catastrophic event. A complex network analysis approach of such a network can offer an insight about its structure, performance and resilience under various levels of perturbation. In this paper, we present a complex network approach for measuring the performance and estimating the resilience of an airport network using the Australian Airports Network (AAN) as a case study. Real air traffic data for all domestic flights in the Australian airspace for the year 2011 is used to form the network. Resilience is then assessed under different failure scenarios. The complex network analysis reveals that the AAN can be classified as a scale free small-world network and that its structure is resilient to random failures of airports (e.g., shutdowns) and random disruptions of flight paths (e.g., airways unavailable due to bad weather). It also indicates that the AAN remains connected and incurs minimal increase in travel times and reduced 'reachability' when a majority of its nodes (airports) are removed or its edges (airways) become randomly unavailable. In the case of a targeted failure (a targeted isolated airport shutdown), the AAN is more sensitive to node failure by a descending order of degree as well as 'betweenness centrality'.				
Comments	*Proposes assessing the resilience of the air traffic system to random individual failures; findings indicate the system could tolerate individual failures well without leading to catastrophic outcomes.*				
Potential Gaps	*Case study limited to assessment using data from Australia; not directly related to RIs.*				
Link	https://www.researchgate.net/profile/Murad_Hossain3/publication/255971280_Australian_Airport_Network_Robustness_Analysis_A_Complex_Network_Approach/links/544c45220cf2d6347f43a514/Australian-Airport-Network-Robustness-Analysis-A-Complex-Network-Approach.pdf				

Reference #	167	**General Area**	RSA and RPZ	**Specific Area**	Cognitive Modeling
Title	*Cognitive Modeling as a Tool for Improving Runway Safety*				
Source/Agency	16TH INTERNATIONAL SYMPOSIUM ON AVIATION PSYCHOLOGY				
Authors	**Michael J. Schoelles; Wayne D. Gray**			**Year**	2011
Abstract	Runway incursions are low probability events resulting from complex combinations of cognitive and environmental factors, which can have deadly consequences. However, the development and evaluation of tools to reduce runway incursions are, ironically, hampered by the low incidence of such events. A possible path forward is the use of high-fidelity cognitive models to predict pilot performance under a wide variety of airport conditions and runway circumstances. We describe a fully embodied ACT-R 6.0 cognitive model, named SimPilot, of a pilot taxiing a simulated Boeing 737-800 aircraft. The goals of SimPilot are twofold. The first is automated testing of a new safety devices. The second goal is to show that modeling the multitasking inherent to taxiing in a cognitive plausible manner is an important step in predicting and preventing runway incursions.				
Comments	*Working to develop high-fidelity cognitive models of pilot performance, in this study looking at pilot taxiing.*				
Potential Gaps	*Used a low-fidelity simulator (X-Plane) for testing; very preliminary phases of development.*				
Link	https://corescholar.libraries.wright.edu/isap_2011/24/				

Reference #	168	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Data-Link and Surface Map Traffic Intent Displays for Nextgen 4DT and Equivalent Visual Surface Operations*				
Source/Agency	Society of Photo-Optical Instrumentation Engineers (SPIE)				
Authors	Kevin J. Shelton; Lawrence (Lance) J. Prinzel III; Jarvis (Trey) J. Arthur III; Denise R. Jones; Angela S. Allamandola; Randall E. Bailey			**Year**	2009
Abstract	By 2025, U.S. air traffic is predicted to increase 3-fold and may strain the current air traffic management system, which may not be able to accommodate this growth. In response to this challenge, a consortium of industry, academia and government agencies have proposed a revolutionary new concept for U.S. aviation operations, termed the Next Generation Air Transportation System or "NextGen". Many key capabilities are being identified to enable NextGen, including the concept of "net-centric" operations whereby each aircraft and air services provider shares information to allow real-time adaptability to ever-changing factors such as weather, traffic, flight trajectories, and security. Data-link is likely to be the primary source of communication in NextGen. Because NextGen represents a radically different approach to air traffic management and requires a dramatic shift in the tasks, roles, and responsibilities for the flight deck, there are numerous research issues and challenges that must be overcome to ensure a safe, sustainable air transportation system. Flight deck display and crew-vehicle interaction concepts are being developed that proactively investigate and overcome potential technology and safety barriers that might otherwise constrain the full realization of NextGen.				
Comments	*This paper provides a summary of tools that will be associated with part of NextGen to enhance the safety and efficiency of the air transportation industry to meet the growing demands.*				
Potential Gaps	*Conceptual and summative in nature.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/7328/73280C/Data-link-and-surface-map-traffic-intent-displays-for-NextGen/10.1117/12.818640.short				

Reference #	169	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Tower Operations Digital Data System – Concept Refinement and Description of New Features*				
Source/Agency	Federal Aviation Administration				
Authors	Truitt, Todd R			**Year**	2008
Abstract	Human factors researchers at the Federal Aviation Administration have developed new methods of operation for Air Traffic Control Specialists working in Airport Traffic Control Towers (ATCTs). The newly redesigned and enhanced Tower Operations Digital Data System (TODDS) provides a means to assist ATCT controllers with flight data management, communication, and coordination by reducing cognitive and physical taskload. The TODDS prototype designs include separate solutions for ATCTs either with or without surface surveillance capability. This report addresses the results of a recent usability test by providing a description of design changes and new features that compose the TODDS. The author also recommends the use of a touchscreen training protocol. Pending further investigation, the TODDS may help reduce the risk of runway incursions, ease the flow of surface operations, and support the Staffed Virtual Tower concept.				
Comments	*Usability testing of Tower Operations Digital Data System; system designed to assist with flight data management, and improvement on flight progress strips; some interface issues, recommendations for training on the use of the touchscreen.*				
Potential Gaps	*System is specific to controllers, but the enhancements of the system could lead to better detection or prevention of RIs.*				
Link	https://trid.trb.org/view/1307209				

Reference #	170	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Route-Based Detection of Conflicting ATC Clearances on Airports*				
Source/Agency	International Symposium on Enhanced Solutions for Aircraft and Vehicle Surveillance Applications (ESAVS 2013)				
Authors	Benjamin Weiß; Federico Centarti; Felix Schmitt; Stephen Straub			**Year**	2013
Abstract	Runway incursions are among the most serious safety concerns in air traffic control. Traditional A-SMGCS level 2 safety systems detect runway incursions with the help of surveillance information only. In the context of SESAR, complementary safety systems are emerging that also use other information in addition to surveillance, and that aim at warning about potential runway incursions at earlier points in time. One such system is "conflicting ATC clearances", which processes the clearances entered by the air traffic controller into an electronic flight strips system and cross-checks them for potentially dangerous inconsistencies. The cross-checking logic may be implemented directly based on the clearances and on surveillance data, but this is cumbersome. We present an approach that instead uses ground routes as an intermediate layer, thereby simplifying the core safety logic.				
Comments	*Continued testing of software to identify conflicting ATC clearances to detect possible RIs before they occur; related to #146.*				
Potential Gaps	*Paper mostly conceptual in nature.*				
Link	https://arxiv.org/abs/1304.6494				

Reference #	171	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Comparing the Tower Operations Digital Data System to Paper Flight Progress Strips in Zero-Visibility Operations*				
Source/Agency	Federal Aviation Administration				
Authors	Truitt, Todd R; Muldoon, Robert			**Year**	2009
Abstract	The current experiment used a high-fidelity, human-in-the-loop simulation to compare the Tower Operations Digital Data System (TODDS) to paper flight progress strips (FPSs) during zero-visibility Airport Traffic Control Tower operations. Sixteen current controllers participated in groups of two. Each group received touchscreen and TODDS training before completing eight practice and eight test scenarios. The participants worked at both the ground and local control positions under four experimental conditions. The participants used either the Integrated TODDS (electronic flight data integrated with surface surveillance, weather information, and digital-taxi communications), FPSs with Airport Surface Detection Equipment – Model X (ASDE-X), Perceptual-Spatial TODDS (electronic flight data integrated with weather information and digital-taxi communications, but no surface surveillance), or FPSs only, to control airport traffic. The participants had a Standard Terminal Automation Replacement System (STARS) display in all four conditions but did not have an out-the-window view. Dependent measures included the number and duration of airport operations, number and duration of communications, TODDS usability, and participant opinion. The data revealed advantages for surface surveillance and TODDS. The Integrated TODDS provided additional benefits that may help reduce the risk of runway incursions, ease the flow of surface operations, and support the Staffed Virtual Tower concept.				
Comments	*Further study looking at Tower Operations Digital Data System (TODDS); conducted experimental design which included touchscreen training; findings indicated advantages to using TODDS and surface surveillance; related to #169.*				
Potential Gaps	*Limited to small sample size (16 controllers).*				
Link	https://trid.trb.org/view/1307238				

Reference #	172	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Detection of Mobile Runway Obstacles Using Dual Airborne Laser Scanners*				
Source/Agency	IEEE/AIAA 27th Digital Avionics Systems Conference				
Authors	Mark Smearcheck; Ananth Vadlamani; Maarten Uijt de Haag			**Year**	2008
Abstract	This paper examines the use of airborne Light Detection and Ranging (LIDAR) for detection and velocity estimation of mobile obstacles in airport movement areas during landing and low altitude flight. Depending upon the operational conditions, obstacles may become hazards posing a threat to landing safety. In order to prevent runway incursions caused by runway obstacles, pilots must be made aware of all surface traffic. This traffic not only includes other aircraft, but also objects such as ground vehicles, wildlife, pedestrians, and debris. Current landing safety systems such as Automatic Dependent Surveillance-Broadcast (ADS-B) are limited to vehicles equipped with a transponder, while the Airport Movement Area Safety System (AMASS) is limited by factors including hazard size and communication latency with the pilot. A truly robust hazard monitoring system capable of operating in all scenarios and landing conditions must include the capability to detect all airport surface traffic, estimate the state of that traffic. This task would preferably be independent of information from monitoring systems external to the aircraft. The hazard monitor proposed in this paper makes use of two airborne laser scanners (ALS), an inertial measurement unit (IMU), and the Global Positioning System (GPS) to identify and accurately geo-locate all runway obstacles in addition to estimating the state of the hazard though velocity prediction. Flight-testing and data collection using this system has been performed at the Ohio University Airport (KUNI) in Albany, Ohio. Results indicate geo-referencing accuracy of approximately 2 m in most cases, along with successful hazard classification, and hazard velocity estimates accurate to within 2.8 m/s.				
Comments	*Evaluation of LIDAR system to provide information on aircraft and V/PD issues; results found good accuracy and classification of hazards/hazard velocities.*				
Potential Gaps	*Limited to testing at one airport in Ohio.*				
Link	https://ieeexplore.ieee.org/abstract/document/4702839/				

Reference #	173	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*An Improved Model for Estimating Runway Accident Cost in Nigeria*				
Source/Agency	IJTTE				
Authors	Akinyemi Olasunkanmi Oriola; Adebiyi Kazeem Adekunle			**Year**	2016
Abstract	This research proposes an improved model for estimating runway accident cost in the aviation industry in Nigeria. Bayesian Network was used to model the probability of consequences of runway accidents and subsequently the cost of the potential consequences. The Bayesian Network was also used to implement causal and diagnostic inference. Market interest rate which incorporates the effect of inflation was included to relax the assumption of constant economic value. The three classes of consequences of runway accidents identified in this study were fatal, serious, and minor. Domain experts were used to obtain relevant Bayesian causes and evidences related to the occurrence of consequence of runway accident. A mathematical equation was developed to solve the Bayesian Network influence diagram to obtain the probability of minor runway accident, serious runway accident and fatal runway accident as 0.7603, 0.1547 and 0.0850 respectively. Consequently, the estimated cost of runway accident (minor, serious and fatal) was $23, 813.52, $20, 052.64 and $772, 856.06 respectively. The Bayesian Network diagnostic inference reveals the close relation of runway accidents in Nigeria aviation sector with aircraft system failure, approach/takeoff procedures, human factors, weather conditions and collision risk.				
Comments	*Advanced statistical model developed to predict the cost of a runway accident in Nigeria; three categories of runway accidents: fatal, serious, and minor.*				
Potential Gaps	*Costs calculated by model would be specific to Nigeria, which limits the generaliability.*				
Link	https://www.researchgate.net/profile/Olasunkanmi_Akinyemi/publication/297679899_AN_IMPROVED_MODEL_FOR_ESTIMATING_RUNWAY_ACCIDENT_COST_IN_NIGERIA/links/5723458a08ae586b21d8802d.pdf				

Reference #	174	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Anticipatory Runway Incursion Prevention Based on Inaccurate Position Surveillance Information*				
Source/Agency	Part of the Lecture Notes in *Computer Sciencebook* series				
Authors	Kai Shi; Hai Yu; Zhiliang Zhu; Jingde Cheng			**Year**	2017
Abstract	To build a practical anticipatory runway incursion prevention system (ARIPS), it is necessary to predict runway incursions based on inaccurate position information of aircraft and vehicles. To this end, this paper proposes a series of improved methods to predict runway incursions based on inaccurate position surveillance information for ARIPSs. The evaluation shows that our system can handle different types of runway incursions based on inaccurate position information, deal with the momentary absence of surveillance data, and produce few false detections under non-runway incursion circumstances.				
Comments	*Work examined how to improve anticipatory runway incursion prevention system (ARIPS) based on inaccurate position information from aircraft and vehicles; conducted simulation experiments to test; findings indicate the revised system could handle momentary losses of surveillance data and produced few false detections.*				
Potential Gaps	*Study limited to preliminary experimental simulations and testing.*				
Link	https://link.springer.com/chapter/10.1007/978-3-319-54430-4_10				

Reference #	175	**General Area**	RSA and RPZ	**Specific Area**	Descriptive Research
Title	*Airport Signing: Movement Area Guidance Signs. In: The Human Factors of Transport Signs*				
Source/Agency	*Publisher: CRC Press*				
Authors	Carrick, K; Pfister, P; Potter, R; Ng, R			**Year**	2004
Abstract	The intervention programs in the United States, Canada, and Europe are broad-based approaches in dealing with the runway incursion problem; they address all users of airports and include attention to the provision of airport signage in accordance with ICAO recommendations. Australia is setting up a runway incursion task force within Airservices Australia to monitor and make recommendations with regards to runway incursions. The provision of signs at smaller regional airports in Australia is an issue for the individual airport owners and Airservices Australia. Other interventions, such as education and awareness, are being addressed through industry publications like Flight Safety Australia. The more high-tech interventions discussed earlier also appear to be high cost and may be out of reach for small operators and small airport owners. Many depend upon the airport's having an air traffic control tower or some other form of surface movement control; therefore, this type of intervention is going to be established only at larger, more traffic-dense airports where incursions are more likely. The main problem remains one of human factors; interventions may be present and working, but the context of aviation activity at the airport remains the same. Situational awareness and cognitive workload will still push individual pilots (and air traffic controllers) to the limits of their capacity. The issue seems to be not so much with the provision of signs and markings as with getting pilots and drivers of ground vehicles to look for and use the signs, follow instructions, and maintain situational awareness under high workloads.				
Comments	*Discusses Australia setting up a runway incursion task force; using signage at smaller airports; also, education and awareness; main issue remains human factors; SA and cognitive workload are issues for pilots; does consider drivers in their initiatives.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://trid.trb.org/view/702341				

Reference #	176	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Results of Human-In-The-Loop Simulation Evaluating an Enhanced Runway Safety System with Ground-Based Direct Pilot Warnings*				
Source/Agency	*MITRE*				
Authors	Kathleen A. McGarry; Dr. Peter M. Moertl			**Year**	2006
Abstract	This document describes a human-in-the-loop simulation evaluating the effectiveness of integrated ground-based warning systems for improved runway safety. The evaluated warning systems contained technologies to enhance pilot awareness, as well as warn pilots about runway safety risks. Pilots experienced simulation scenarios with warning systems that provided either visual or audio warnings about surface traffic. In addition, pilots experienced simulation scenarios in a baseline condition, with no warnings. The ground based warnings consisted of airport surface lights including Runway Entrance Lights, Takeoff Hold Lights, Arrival Warning Lights, and an Auditory Arrival Runway Incursion Alerting System. Eye tracking was used to examine where pilots focused their attention when they are taxiing, departing, and arriving. Results indicate significant safety benefits of ground-based pilot warnings by reducing the likelihood of runway safety incidents.				
Comments	*Human in the loop evaluation of integrated ground-based warning systems for runway safety; used either visual or audio warnings about surface traffic, compared to baseline with no warnings; findings indicate significant safety improvements with ground-based warnings.*				
Potential Gaps	*Small sample size (12 participants).*				
Link	https://www.mitre.org/sites/default/files/pdf/08_1075.pdf				

Reference #	177	**General Area**	Airside Driving	**Specific Area**	Software/Technology
Title	*Safe Airport Operation Based on Innovative Magnetic Detector System*				
Source/Agency	The Institution of Engineering and Technology				
Authors	H. Gao; Th. Heuer; K. Dimitropoulos; N. Grammalidis; M. Weinmann; M. Huhnold; Th. Astheimer; P. Kirrane; C. Stockhammer; A. Kurz; J. Pfister; U. Hartmann			**Year**	2009
Abstract	A novel magnetic sensing technology that forms the basis of an innovative system to monitor ground vehicle movements at airports is presented. The operating principle of this system is the detection of interaction of aircraft or ground vehicles with the earth's magnetic field using sensitive magnetic field detectors. After development and laboratory testing of the detectors, test sites have been set up at three European airports. Potential applications of the detectors were designed and demonstrated. Tests have shown that the system can be applied for ground movement surveillance. The approach can be used as a complementary surveillance system for existing and future advanced surface movement guidance and control systems (A-SMGCS) at large airports or as a cost-effective stand-alone solution for monitoring critical areas at medium and small airports. Furthermore, this system can be applied as well in road traffic and car park occupancy monitoring. Unaffected by weather conditions, interference and shadowing effects, the system provides reliable vehicle position, velocity and direction information without requiring any equipment in aircraft or ground vehicles and thus it increases airport operational safety.				
Comments	*Use of magnetic sensing technology for airport ground vehicles; preliminary testing at 3 European airports has shown favorable results.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://digital-library.theiet.org/content/journals/10.1049/iet-its_20080058				

Reference #	178	**General Area**	RSA and RPZ	**Specific Area**	Signs, Lights, and Markings
Title	*Evaluation of L-8O4 Elevated Runway Guard Light Fixtures.*				
Source/Agency	FAA				
Authors	Katz, Eric			**Year**	1996
Abstract	The number of inadvertent runway incursions has grown during recent years, increasing the importance of protective visual guidance systems for incursion prevention. One such visual system is the L-804 elevated runway guard light fixture. Also known as a wig-wag light, these fixtures contain two alternately flashing yellow lights and are used to help identify runway holding positions to pilots. Pilots, however, have indicated that the light intensity (600 candelas minimum average intensity) and flash rate (average of 35 flashes per minute per lamp) of the L-804s are inadequate. The L-804s were examined under day and night visual flight rules (VFR) and instrument flight rules (IFR) conditions from various distances and angles. Particular attention was paid to performance characteristics such as intensity, flash rate, vertical and horizontal aiming angle, lamp separation, and the usefulness of providing a hood over each lamp. As a result of the evaluation it was determined that the L-804 specifications needed to be modified. Flash rate should be increased to 45 to 50 flashes per minute per lamp. The light intensity of the Mode 1 (constant current) L-804 when energized at 6.6 amps and tested with one lamp in the steady burning mode and the other lamp masked out should be 4100 candelas. The light intensity of the Mode 2 (constant voltage) L-804 when energized at 120 volts and similarly tested should be 940 candelas.				
Comments	*Analysis of elevated runway guard lights; identified ideal conditions for illumination and frequency.*				
Potential Gaps	*Study is dated (1996).*				
Link	https://apps.dtic.mil/docs/citations/ADA307589				

Reference #	179	**General Area**	Choose an item. N/A	**Specific Area**	Safety
Title	*Aviation Deregulation and Safety*				
Source/Agency	*Journal of Transport Economics and Policy*				
Authors	Leon N. Moses; Ian Savage			**Year**	1990
Abstract	The popular press paints a bleak picture of contemporary aviation safety in the United States. The cover stories of Time (12 January 1987), Newsweek (27 July 1987), and Insight (26 October 1987) are of crashes and escalating numbers of near midair collisions, with allegations of improper maintenance. In the minds of the public, these allegations are confirmed by the recent record fines for irregularities imposed on airlines with household names. The popular belief, expressed for example by Nance (1986), is that the root cause is the economic deregulation of the industry in 1978. Deregulation, it is argued, has led to competitive pressures on air carriers to reduce expenditure on safety-related items, and allowed entry into the market by inexperienced new carriers. In addition, many believe that the congestion caused by the greater number of airline flights, occasioned by the substantial rise in demand since deregulation, has led to an increased probability of collision. This paper considers the evidence to date on the validity of these contentions. However, initially we will present a theoretical framework that links economic conditions and the safety performance of firms. This framework allows inferences to be drawn more easily from the various strands of evidence.				
Comments	*Summary and discussion of aviation safety in the 1980s and 1990s; provides a theoretical framework and economic conditions related to safety performance.*				
Potential Gaps	*Quite a dated study (1990); not primarily about RIs.*				
Link	http://faculty.wcas.northwestern.edu/~ipsavage/410.pdf				

Reference #	180	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*On the Application of Near Accident Data to Risk Analysis of Major Accidents*				
Source/Agency	*Reliability Engineering & System Safety, Volume 126, June 2014, Pages 116-125*				
Authors	Nima Khakzad; FaisalKhan; NicolaPaltrinieri			**Year**	2014
Abstract	Major accidents are low frequency high consequence events which are not well supported by conventional statistical methods due to data scarcity. In the absence or shortage of major accident direct data, the use of partially related data of near accidents – accident precursor data – has drawn much attention. In the present work, a methodology has been proposed based on hierarchical Bayesian analysis and accident precursor data to risk analysis of major accidents. While hierarchical Bayesian analysis facilitates incorporation of generic data into the analysis, the dependency and interaction between accident and near accident data can be encoded via a multinomial likelihood function. We applied the proposed methodology to risk analysis of offshore blowouts and demonstrated its outperformance compared to conventional approaches.				
Comments	*Advanced statistical modeling to use accident precursor data to identify risks of major accidents.*				
Potential Gaps	*Not directly related to RI research.*				
Link	https://www.sciencedirect.com/science/article/pii/S0951832014000258				

Reference #	181	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*An Assessment of Pilots' Concurrent Use of Runway Entrance Lights and Surface Movement Control System Guidance System Stop Bars*				
Source/Agency	*Proceedings of the Human Factors and Ergonomics Society Annual Meeting*				
Authors	Kathleen McGarry; Emily Stelzer			**Year**	2011
Abstract	Two Human-in-the-Loop (HITL) simulations were conducted to investigate the concurrent use of Runway Entrance Lights (RELs) and Surface Movement Guidance Control System (SMGCS) stop bars. The first study investigated use by 11 pilots who received training on the use of these lighting systems simultaneously, while the second study investigated use by 8 pilots who did not receive training. The commercial pilots were asked to taxi a mid-fidelity simulated aircraft under low visibility conditions. Results suggest that pilots who have not received the proper clearance from ATC are not likely to cross the illuminated stop bar, even when RELs extinguish indicating that the runway is not actively being used. In addition, RELs were found to generate stopping responses on 100% of trials for the trained pilots, and 67.5% of trials for the untrained pilots when they were erroneously cleared onto an active runway. While the lighting systems were effective in reducing the number of runway incursions, pilots ignored or did not respond to the RELs in 32.5% of trials in the untrained group. Though the performance data suggest that these lighting systems can enhance runway safety, some pilots' subjective reports indicate that the concurrent use of the systems could cause some confusion. Results point to the importance of an effective training program, and notification that the systems are concurrently being used in an airport environment to ensure their full effectiveness.				
Comments	*Two studies evaluated runway entrance lights and surface movement guidance control system stop bars; stop bars had a 100% rate of having pilots stop when they were given an erroneous clearance with training and only 67.5% of the time without training; 32.5% of pilots in the untrained group ignored the runway entrance lights; study highlights the importance of training and also highlights the possible confusion between having the two systems working together.*				
Potential Gaps	*Studies limited to a small group of participants (11 and 8).*				
Link	https://journals.sagepub.com/doi/abs/10.1177/1071181311551007				

Reference #	182	**General Area**	RSA and RPZ	**Specific Area**	Signs and Markings
Title	*Airborne Evaluation of Retro-Reflective Beads*				
Source/Agency	Federal Aviation Administration				
Authors	Previti, Anthony J; Cyrus, Holly; Gallagher, Donald W			**Year**	2010
Abstract	This project was undertaken by the Federal Aviation Administration (FAA) Airport Safety Technology Research and Development Sub-Team as part of an effort to determine the relative conspicuity, from an aircraft on approach, of Type I and Type III retro-reflective beads. Retro-reflective beads are designed to redirect and return light back to its source. The inclusion of retro-reflective beads in painted surface markings can increase their conspicuity. It has been suggested that Type III retro-reflective beads, which have a higher index of refraction (IOR) compared to Type I beads, will substantially increase the conspicuity of paint markings and could help prevent runway incursions. The FAA uses Federal Specification TT-B-1325D, "Beads (Glass Spheres) Retro-Reflective," to specify retro-reflective beads. Previous studies by the United States Air Force and the FAA have shown that in cases where the light source is not in close proximity to the observer's line of sight, the benefit of using higher IOR beads is negligible. Since 1994, all research on retro-reflective beads has been focused on surface markings from the ground to improve the conspicuity of taxiway hold position markings, which aid in the prevention of runway incursions. Due to advances in bead technology, it has been suggested that additional tests be conducted from the pilot's perspective on approach to a runway. Type I and Type III retro-reflective beads were installed on the same type of airport pavement markings at opposite ends of Runway 13/31 at Atlantic City International Airport (ACY) for a period of 8 months and side by side on Runway 10 at Savannah/Hilton Head International Airport (SAV) for a period of 2 months. Subjective data was collected in the form of questionnaires completed by test subjects from aircraft approaching the runway at both locations. The test subjects were queried concerning ease of marking detection and conspicuity. Objective measurements were taken at the beginning and the end of the evaluation. The majority of the test subjects involved in the tests at both ACY and SAV stated they do not use runway markings as a visual cue on approach to a runway at night. They focus on the runway lights. Of the subjects participating, all but one reported no difference in ease of detection between Type I and Type III bead markings. The chromaticity and retro-reflectivity characteristics of the bead markings were acceptable following initial application and throughout the evaluation period.				
Comments	*The study conducted a review of Type I and Type III reflective beads incorporated into the paint at two airports; objective and subjective measures were taken; pilots said they did not use the painted markings much while on approach, and there was minimal difference between the Type I and Type III reflective beads.*				
Potential Gaps	*While pilots did not use markings much while on approach (they prefer the runway lights); this seems like a tool that would be very useful for taxi and to airport drivers.*				
Link	https://trid.trb.org/view/1354997				

Reference #	183	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Airport Surface Surveillance with a Network of Mini Radars*				
Source/Agency	IEEE Transactions on Aerospace and Electronic Systems				
Authors	G. Galati; M. Naldi; M. Ferri			**Year**	1999
Abstract	A distributed system based on a network of short-range (1.5-3 km) radars, operating in the W-band (93-95 GHz), is proposed for the ground surveillance of airports. Both the architecture and the main features of each subsystem are described. The system can boast very high resolution, the elimination of shadowing, and the inclusion of image processing techniques in the track-while-scan (TWS) function.				
Comments	*Paper proposes a network of mini radar units to better track aircraft and objects at the airport.*				
Potential Gaps	*Paper mostly conceptual in nature and discussing specifications of system; says two operational tests were currently underway but fails to report any results.*				
Link	https://ieeexplore.ieee.org/abstract/document/745702				

Reference #	184	**General Area**	RSA and RPZ	**Specific Area**	Statistical Modeling
Title	*Taxiing Route Scheduling Between Taxiway and Runway in Hub Airport*				
Source/Agency	*Mathematical Problems in Engineering*				
Authors	Yu Jiang; Xinxing Xu; Honghai Zhang; Yuxiao Luo			**Year**	2014
Abstract	To guarantee the operation safety of airport, improve the efficiency of surface operation, and enhance the fairness of taxiing route scheduling, an optimizing model is established for the airport surface taxiing route scheduling. Reducing the total aircraft taxiing route length and reducing the waiting delay time are the goals of the model by controlling the initial taxiing time of aircraft and choosing the right taxiing route. The model can guarantee the continuous taxiing for all aircraft without conflicts. The runway scheduling is taken into consideration in the model to optimize the surface operation. The improved genetic algorithm is designed for simulation and validation.				
Comments	*Study creates an algorithm which predicts continuous taxiing for aircraft without conflicts; simulation predicts the model will reduce taxi distance and total taxi time.*				
Potential Gaps	*Limited to simulation environment only to assess the validity of the model; needs operational testing.*				
Link	https://www.hindawi.com/journals/mpe/2015/925139/abs/				

Reference #	185	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*High Resolution, Millimeter-Wave Radar Applications to Airport Safety*				
Source/Agency	8th International Conference on Ultrawideband and Ultrashort Impulse Signals				
Authors	Gaspare Galati; Emilio G. Piracci; Mauro Ferri			**Year**	2016
Abstract	A millimeter-wave (mmw: 3 mm wavelength, W-band) radar permits short-range, high-resolution detection and imaging of the airport movement area. The main safety-related applications, which have been tested in Marco Polo (Venice) and Urbe (Roma) airports respectively, are the prevention of runway incursions and the management of Foreign Object Debris (FOD). Other potential applications, to be studied, are bird-strike prevention and intruder detection.				
Comments	*Paper assesses the deployment of this technology at two airports in Italy; focuses on detecting foreign object debris and potentially bird strikes/wildlife.*				
Potential Gaps	*If the technology can detect FOD, it seems that it could be used for vehicles and pedestrians as well to prevent V/PDs.*				
Link	https://ieeexplore.ieee.org/abstract/document/7724144				

Reference #	186	**General Area**	RSA and RPZ	**Specific Area**	Taxonomy
Title	*Holistic Approach to Airport Surface Safety*				
Source/Agency	*Transportation Research Record*				
Authors	Sabine Wilke; Arnab Majumdar; Washington Y. Ochieng			**Year**	2012
Abstract	Airport surface safety is acknowledged worldwide as a key area to aviation safety. However, current methods for analyzing and mitigating surface safety occurrences are piecemeal in their approach and limited in scope and perspective. This paper emphasizes the need for a holistic approach to surface safety and introduces a new methodology for the development of a holistic taxonomy for critical factors underlying airport surface safety occurrences. The taxonomy incorporates findings from the relevant literature, safety data, airport surveys, and interviews with subject matter experts. It benefits from the viewpoints of all the relevant aviation stakeholders (regulators, air navigation service providers, airport authorities, airlines, ground handling companies, accident investigation boards) and derives its robustness from the combination of a number of research methods. The application of the taxonomy to support the safety risk management function within the context of safety management systems is proposed. Application of the taxonomy to a multinational data set (North America, Europe, Oceania) verifies that the databases complement each other and that a holistic picture can only be achieved through their combined use. In addition, the analysis indicates that differences in the data sets are a function of the national air traffic system and airport infrastructure, underlying regulations, reporting system and safety culture, and the viewpoint of the aviation stakeholder that is represented. Finally, the holistic approach proposed in this paper is shown to be transferable to other areas of aviation safety.				
Comments	*Study proposes a holistic approach to increase airport surface safety; moves away from the segmented and separate approaches currently used; reviewed almost 3,000 occurrences; suggests worldwide acceptance of a taxonomy would result in better mitigation and enhance runway safety.*				
Potential Gaps	*Future work needed to quantify the functional relationship between surface safety and underlying critical factors; need to access buy-in from worldwide users.*				
Link	https://journals.sagepub.com/doi/abs/10.3141/2300-01				

Reference #	187	**General Area**	RSA and RPZ	**Specific Area**	Airport Operations
Title	*Airport Technology Management*				
Source/Agency	*Emerging Dimensions of Technology Management*				
Authors	Dietmar P. F. Moeller			**Year**	2012
Abstract	Airports and airlines running their technology enhanced business within airports as unique entities and as a group of several and diverse stakeholders with the focus to guarantee cost-effective, on schedule, and safe civil air traffic. Thus, airport operators must conduct the necessary actions for a proactively airport technology management to minimize the potential for operational failures and facilitate collaboration between airport authorities, airlines, ground handling, and air traffic control within the airports. Moreover, airport operators have the managerial obligation to plan and forecast future airport operations to capitalize on revenue potential and enhance service and security quality.				
Comments	*Focus on the role that airports and airport operations management need to play in managing all the various airlines and users of their facilities.*				
Potential Gaps	*Unable to find full article for review.*				
Link	https://link.springer.com/chapter/10.1007/978-81-322-0792-4_8				

Reference #	188	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Runway Status Light System Demonstration at Logan Airport*				
Source/Agency	*Lincoln Laboratory*				
Authors	J. R. Eggert; R. J. Sasiela; M. P. Kastner; W. H. Harman; H. Wilhelmsen; T. J. Morin; H. B. Schultz; J. L Sturdy; D. Wyschogrod; P. M. Daly			**Year**	1995
Abstract	The Runway Status Light System is intended to help reduce the incidence of runway incursions and airport surface accidents. It will do so by providing a preventive, back-up system of automatically controlled lights on the airport surface that inform pilots when runways are unsafe for entry or takeoff, and by providing controllers with enhanced surface radar displays. This report documents a proof-of-concept evaluation of the RSLS at Boston's Logan Airport. It details the methods used to provide the necessary surface surveillance and safety logic to allow a computer to operate the runway status lights and associated controller displays without human assistance. The system was installed and tested off-line at Boston's Logan Airport using an inexpensive commercial marine radar as a primary surveillance source. The system operated live and in real time, but the runway status lights were not physically installed. They were displayed on a scale model of Logan Airport located in a demonstration room that had a good view of the airport. This allowed visual comparison between the actual aircraft and the resulting lights and displays. In addition to providing a convincing demonstration of the system, real-time viewing of the aircraft movement was an important aid in the development of the surveillance processing and safety logic software. Surveillance performance and runway status light operational performance were evaluated quantitatively. The probability of tracking an aircraft in movement areas with line-of-sight coverage was better than 98%. The false track rate was about four per bour, and the surveillance jitter was about 1-meter rms. From an operational point of view, had there been real lights on the field, it appears that they would have provided the intended safety back-up with little impact on airport capacity or controller and pilot workload. Only once in 15 minutes would the pilot population have observed a light in an incorrect state for more than four seconds. Specific suggestions for improvement are included in this document.				
Comments	*Demonstration of the runway status lights system (RSLS) at Boston Logan Airport; one of the original studies looking at this technology; results were good, high levels of detection and low number of false alarms.*				
Potential Gaps	*Proof of concept test; report from 1995.*				
Link	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.222.9531&rep=rep1&type=pdf				

Reference #	189	**General Area**	RSA and RPZ	**Specific Area**	Network Modeling
Title	*Network Analysis Reveals Patterns Behind Air Safety Events*				
Source/Agency	*Physica A: Statistical Mechanics and its Applications*				
Authors	Massimiliano Zanin			**Year**	2014
Abstract	Complex networks have been extensively used to study the topological and dynamical characteristics of transportation systems, although far less attention has been devoted to the analysis of specific problems arising in everyday operations. In this work, the use of a network representation is proposed for studying the appearance of Loss of Separation events, a kind of safety occurrence in which two aircraft violate the minimal separation while airborne. The topological analysis of networks representing the structure of traffic flows allows identifying situations in which the probability of appearance of such events is increased. Beyond these specific results, this work demonstrates the usefulness of the complex network approach in the analysis of operational patterns and occurrences.				
Comments	*Network analysis of loss of separation of airborne aircraft.*				
Potential Gaps	*Study did not focus on RIs, but suggested RIs as another possible application area.*				
Link	https://www.sciencedirect.com/science/article/pii/S0378437114000430				

Reference #	190	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Research Progress on an Automation Concept for Surface Operation with Time-Based Trajectories*				
Source/Agency	Integrated Communications, Navigation and Surveillance Conference				
Authors	Victor H. L. Cheng			**Year**	2007
Abstract	To address anticipated growth in air traffic demand, the surface operation automation research (SOAR) is a collection of research activities designed with the common goal to explore and develop automation technologies for enhancing surface movement efficiency at major airports. The concept features a tower automation system that counts on the availability of advanced surveillance data to plan the execution of timed surface operations to enhance movement efficiency and safety. Communication of the clearances will require the availability of digital data link for sending the data for executing the time-based trajectories - known to some as 4-dimensional (4D) trajectories. The concept also features a flight-deck automation system that counts on the availability of advanced navigation data to enable the flights to execute the 4D trajectories with high timing precision. The arrangement results in a collaborative concept where the tower and flight-deck automation systems count on each other's abilities to jointly deliver the efficient and safe surface traffic. Several publications have documented the SOAR concept and initial feasibility studies of the tower and flight-deck automation systems based on early experimental software prototypes of the automation functions. This paper serves as a progress update of the SOAR development effort. Specifically, it covers recent human-in-the-loop experiments to study procedures and controller roles and responsibilities involving the tower automation system, as well as development of the flight-deck automation system in terms of its guidance and control functions.				
Comments	*Paper provides an update on the surface operation automation research (SOAR) program; SOAR focuses on using surface and flight deck-based system to optimize the execution of timed surface operations to enhance efficiency and safety.*				
Potential Gaps	*Provides an update on this research; further research necessary, especially in the areas of determining responsibilities between humans and automation; initial feasibility has been demonstrated.*				
Link	https://ieeexplore.ieee.org/abstract/document/4272198				

Reference #	191	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Design and Testing of an Unlimited Field-of-Regard Synthetic Vision Head-Worn Display for Commercial Aircraft Surface Operations*				
Source/Agency	*Proceedings Volume 6559, Enhanced and Synthetic Vision 2007*				
Authors	J. J. Arthur III; Lawrence Prinzel III; Kevin Shelton; Lynda J. Kramer; Steven P. Williams; Randall E. Bailey; Robert M Norman			**Year**	2007
Abstract	Experiments and flight tests have shown that a Head-Up Display (HUD) and a head-down, electronic moving map (EMM) can be enhanced with Synthetic Vision for airport surface operations. While great success in ground operations was demonstrated with a HUD, the research noted that two major HUD limitations during ground operations were their monochrome form and limited, fixed field of regard. A potential solution to these limitations found with HUDs may be emerging Head Worn Displays (HWDs). HWDs are small, lightweight full color display devices that may be worn without significant encumbrance to the user. By coupling the HWD with a head tracker, unlimited field-of-regard may be realized for commercial aviation applications. In the proposed paper, the results of two ground simulation experiments conducted at NASA Langley are summarized. The experiments evaluated the efficacy of head-worn display applications of Synthetic Vision and Enhanced Vision technology to enhance transport aircraft surface operations. The two studies tested a combined six display concepts: (1) paper charts with existing cockpit displays, (2) baseline consisting of existing cockpit displays including a Class III electronic flight bag display of the airport surface; (3) an advanced baseline that also included displayed traffic and routing information, (4) a modified version of a HUD and EMM display demonstrated in previous research; (5) an unlimited field-of-regard, full color, head-tracked HWD with a conformal 3-D synthetic vision surface view; and (6) a fully integrated HWD concept.				
Comments	*Two ground simulations looked at the use of head worn displays (HWDs); study looked at six display concepts; HWD was better than using paper charts alone; no significant difference in path performance between HWD and HUD; HWD and HUD also rated same in terms of SA and workload, but there were twice as many taxiway incursions with HUD than with HWD.*				
Potential Gaps	*Study limited to simulations and use of small samples (16 flight crews and 12 flight crews); some issues noted with HWD alignment.*				
Link	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/6559/65590E/Design-and-testing-of-an-unlimited-field-of-regard-synthetic/10.1117/12.719695.short?SSO=1				

Reference #	192	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Synthetic Vision/Enhanced Vision System Implementation*				
Source/Agency	Conference Proceedings National Telesystems Conference 1993				
Authors	D. Ferguson; J. Radke			**Year**	1993
Abstract	There is an emerging requirement within the world's air transport network to improve safety and increase productivity by enabling aircraft to perform visual flight operations under low-visibility weather conditions. Currently, the commercial aviation industry has centered its efforts at achieving this requirement around a millimeter-wave imaging radar and/or imaging infrared (IR) sensor, a Global Positioning System (GPS)-aided inertial navigation system, and a heads-up-display (HUD) to enable a minimum set of low-visibility functions. Honeywell has flight tested a 35-GHz radar as part of the Synthetic Vision System Technology Demonstration (SVSTD) program, and the authors describe the system implementation, signal processing, and resulting flight test results. The focus is on the terminal area navigation and landing problem in adverse weather using existing avionics with appropriate sensor and navigation upgrades.				
Comments	*Evaluated Honeywell's synthetic vision system technology; provided a demonstration using an aircraft but did not operationally test the system.*				
Potential Gaps	*Rather old study (1993); future operational research needed for validation.*				
Link	https://ieeexplore.ieee.org/abstract/document/293003				

Reference #	193	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*The NASA Approach to Realize a Sensor Enhanced-Synthetic Vision System (SE-SVS) [Aircraft Displays]*				
Source/Agency	Proceedings. The 21st Digital Avionics Systems Conference				
Authors	S.D. Harrah; W.R. Jones; C.W. Erickson; J.H. White			**Year**	2002
Abstract	There exists a need by the cockpit crews for confirmation of runway location and detection of non-responding objects on or near the active runway. This is a major role for an onboard enhanced vision system (EVS). The NASA aircraft EVS configuration is composed of a visual (CCD) camera, a short-wave FLIR, a long-wave FLIR and a modified X-band radar. Inputs from externally-generated sensor sources are piped directly to the SVS processors and are merged to provide the pilot (on head-up or head-down displays) situational awareness in adverse weather and darkness for and during airport approach, approach and landing guidance, runway incursions/runway object detection, and taxiing. On smaller aircraft (commuter, business jets, and GA) where the proposed radar technology cannot be installed, FLIRs and low-light visible cameras are likely the only sensor candidates that perform these functions.				
Comments	*Provides a description of the necessary components required for the system; system installed on-board a NASA 757 aircraft; provides a summary of flight test results.*				
Potential Gaps	*Limited to mainly demonstration; needs further research and operational testing and evaluation of system.*				
Link	https://ieeexplore.ieee.org/abstract/document/1052970				

Reference #	194	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Design and Evaluation of the Closed Runway Operation Prevention Device*				
Source/Agency	Proceedings of the Human Factors and Ergonomics Society Annual Meeting				
Authors	Hunter Kopald; Shuo Chen			**Year**	2014
Abstract	The MITRE Corporation was asked by the Federal Aviation Administration to perform an initial operational feasibility analysis on a speech recognition-based concept called the Closed Runway Operation Prevention Device (CROPD). This paper describes the activities conducted as part of the design and evaluation of the CROPD and outlines how a human-centered perspective of the system and operational environment informs the specifications of user interface design and system functionality.				
Comments	*Device monitors controller speech and responds if a clearance is issued to takeoff or land on a closed runway; completed proof of concept demonstration and graphical user interface; SMEs discussed the negative impacts of false alerts from the system; results from a 2013 test showed system missed 5% of expected alerts and 16% of non-expected alerts.*				
Potential Gaps	*Further research needed to improve reliability of the system and reduce false alerts.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/1541931214581018				

Reference #	195	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*An Airborne Synthetic Vision System with HITS Symbology Using X-Plane for a Head Up Display*				
Source/Agency	24th Digital Avionics Systems Conference				
Authors	M.C. Ertem			**Year**	2005
Abstract	Highway-in-the-sky (HITS) trajectories and symbology were generated for GPS WAAS approach procedures developed for the NASA small aircraft transportation system (SATS) demonstration flights. Aircraft position and attitude data collected using an integrated IMU/GPS were used to render synthetic ground imagery and highway-in-the-sky (HITS) symbology using the X-Plane program in real-time. Flight testing showed that synthetic imagery using actual aircraft data can be used for aircraft guidance and for situational awareness, as well as for post flight playback and analysis. The availability of high-quality scenery and elevation data as well as the existence of a software development kit allowed use of the X-Plane flight simulation program as a high performance and inexpensive rendering platform. This proved the feasibility of building an inexpensive synthetic vision system to generate synthetic imagery on a low-cost head up display (HUD) designed for general aviation type aircraft.				
Comments	*Testing on the use of a HUD and synthetic vision system; used X-Plane along with real flight hardware to develop system; study shows feasibility of developing a similar, and cost-effective system for small general aviation aircraft.*				
Potential Gaps	*Not directly related to RIs, but technology could be applied for surface operations and vehicles.*				
Link	https://ieeexplore.ieee.org/abstract/document/1563432				

Reference #	196	**General Area**	RSA and RPZ	**Specific Area**	Software/Technology
Title	*Does a Head-Mounted Display Worsen Inattentional Blindness?*				
Source/Agency	Proceedings of the Human Factors and Ergonomics Society Annual Meeting				
Authors	Stas Krupenia; Penelope M Sanderson			**Year**	2006
Abstract	Head mounted displays (HMDs) can present visual information to operators at times when this would otherwise be difficult or impossible using standard visual displays. HMDs have been shown to benefit anesthetists in simulated medical environments. Operators, however, may have trouble extracting information from the HMD in dynamic environments. Operators may also fail to consciously perceive visual events that are important, meaningful, or bizarre if attending to other aspects of the visual scene. We investigated how attention manipulations (Focused, Divided, Just Watch) interact with display type (HMD, Standard Display) and found that participants were less likely to detect unexpected events using the HMD. We also found that unexpected event detection decreased from the Just Watch to Divided to Focused attention conditions. We suggest further testing be taken to ensure that HMDs to not result in failures to detect unexpected events in anesthesia monitoring.				
Comments	*Paper describes the flight-testing results head mounted displays (HUDs); used 155 participants from Australia; marginal support found that the HUD group performed better than the standard group; attention was found to play a major role; group testing using desktop computer.*				
Potential Gaps	*Findings marginally support the technology; further trials needed to verify the findings and evaluate in a more operational context.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/154193120605001626				

Reference #	197	**General Area**	SMS	**Specific Area**	NextGen
Title	*Safer Systems: A Nextgen Aviation Safety Strategic Goal*				
Source/Agency	2008 IEEE/AIAA 27th Digital Avionics Systems Conference				
Authors	Stephen Darr; Wendell Ricks; Katherine A. Lemos			**Year**	2008
Abstract	The Joint Planning and Development Office (JPDO), is charged by Congress with developing the concepts and plans for the Next Generation Air Transportation System (NextGen). The national aviation safety strategic plan (NASSP), developed by the Safety Working Group of the JPDO, focuses on establishing the goals, objectives, and strategies needed to realize the safety objectives of the NextGen integrated plan. The three goal areas of the NASSP are safer practices, safer systems, and safer worldwide. Safer practices emphasize an integrated, systematic approach to safety risk management through implementation of formalized safety management systems (SMS) that incorporate safety data analysis processes, and the enhancement of methods for ensuring safety is an inherent characteristic of NextGen. Safer systems emphasize implementation of safety-enhancing technologies, which will improve safety for human-centered interfaces and enhance the safety of airborne and ground-based systems. Safer worldwide encourages coordinating the adoption of the safer practices and safer systems technologies, policies and procedures worldwide, such that the maximum level of safety is achieved across air transportation system boundaries. This paper introduces the NASSP and its development, and focuses on the Safer systems elements of the NASSP, which incorporates three objectives for NextGen systems: (1) provide risk reducing system interfaces, (2) provide safety enhancements for airborne systems, and (3) provide safety enhancements for ground-based systems. The goal of this paper is to expose avionics and air traffic management system developers to NASSP objectives and safer systems strategies.				
Comments	*This paper focuses on a summary of concepts related to safety improvements through NextGen; 3 focal areas: provide risk reducing system interfaces, provide safety enhancements for airborne systems, and provide safety enhancements for ground-based systems.*				
Potential Gaps	*Conceptual and descriptive paper; not directly focused on RIs.*				
Link	https://ieeexplore.ieee.org/abstract/document/4702772				

Reference #	198	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Going Below Minimums: The Efficacy of Display Enhanced/Synthetic Vision Fusion for Go-Around Decisions during Non-Normal Operations*				
Source/Agency	14th International Symposium on Aviation Psychology; 23-26 Apr. 2007; Dayton, OH; United States				
Authors	Prinzel, Lawrence J., III; Kramer, Lynda J.; Bailey, Randall E			**Year**	2007
Abstract	The use of enhanced vision systems in civil aircraft is projected to increase rapidly as the Federal Aviation Administration recently changed the aircraft operating rules under Part 91, revising the flight visibility requirements for conducting approach and landing operations. Operators conducting straight-in instrument approach procedures may now operate below the published approach minimums when using an approved enhanced flight vision system that shows the required visual references on the pilot's Head-Up Display. An experiment was conducted to evaluate the complementary use of synthetic vision systems and enhanced vision system technologies, focusing on new techniques for integration and/or fusion of synthetic and enhanced vision technologies and crew resource management while operating under these newly adopted rules. Experimental results specific to flight crew response to non-normal events using the fused synthetic/enhanced vision system are presented.				
Comments	*Experiment looking at the combined use of synthetic vision and enhanced vision systems; systems did not help in RI detection in the experiment (vehicles blocked by display information).*				
Potential Gaps	*Limited sample size (24 pilots); findings did not help reduce RI threat.*				
Link	https://ntrs.nasa.gov/search.jsp?R=20070018289				

Reference #	199	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Automation and Inattentional Blindness in a Simulated Flight Task*				
Source/Agency	Proceedings of the Human Factors and Ergonomics Society Annual Meeting				
Authors	Kellie D. Kennedy; Chad L. Stephens; Ralph A. Williams; Paul C. Schutte			**Year**	2014
Abstract	The study reported herein is a subset of a larger investigation on the role of automation in the context of single pilot aviation operations. This portion of the study focused on the relationship between automation and inattentional blindness (IB) occurrences for a runway incursion. The runway incursion critical stimulus was directly relevant to primary task performance. Participants performed the final five minutes of a landing scenario in one of three automation conditions (autopilot, autothrottle, and manual). Sixty non-pilot participants completed this study and 70% (42 of 60) failed to detect the runway incursion critical stimulus. Participants in the partial automation condition were significantly more likely to detect the runway incursion when compared to those in the full automation condition. The odds of participant detection in the full automation condition did not significantly vary from the manual condition. Participants that detected the runway incursion did not have significantly higher scores on any component of the NASA-TLX compared to those who failed to detect. The relationship demonstrated between automation condition and IB occurrence indicates the role of automation in operational attention detriment.				
Comments	*Evaluated 3 levels of automation (autopilot, autothrottle, and manual); those who were moderately tasked were more likely to notice the RI vehicle than those who were over or under-tasked.*				
Potential Gaps	*Used non-pilots in the study; would be interesting to replicate with pilots.*				
Link	https://journals.sagepub.com/doi/abs/10.1177/1541931214581433				

Reference #	200	**General Area**	RSA and RPZ	**Specific Area**	Experiment
Title	*Pathway HUDs: Are They Viable?*				
Source/Agency	*Human Factors Journal*				
Authors	Steven Fadden; Patricia May Ververs; Christopher D. Wickens			**Year**	2001
Abstract	We describe two experiments that examine 3D pathway displays in a head-up location for aircraft landing and taxi. We address both guidance performance and pilot strategies in dividing, focusing, and allocating attention between flight path information and event monitoring. In Experiment 1 the 3D pathway head-up display (HUD) was compared with a conventional 2D HUD. The former was found to produce better guidance, with few costs to event detection. Some evidence was provided that attentional tunneling of the pathway HUD inhibits the detection of unexpected traffic events. In Experiment 2, the pathway display was compared in a head-up versus a head-down location. Excellent guidance was achieved in both locations. A slight HUD cost for vertical tracking in the air was offset by a HUD benefit for event detection and for lateral tracking during taxi (i.e., on the ground). The results of both experiments are interpreted within the framework of object- and space-based theories of visual attention and point to the conclusion that pathway HUDs combine the independent advantages of pathways and HUDs, particularly during ground operations. Actual or potential applications include understanding the costs and benefits of positioning a 3D pathway display.					
Comments	*Compared 2D and 3D HUDs; found 3D HUDs produced better guidance; however, some attentional tunneling was present, reducing detection of unexpected events; 3D heads up was determined to be better than 3D heads down display.*				
Potential Gaps	*Used a small sample of university pilots (20 and 26, respectively); however, study appears to be well done.*				
Link	https://journals.sagepub.com/doi/abs/10.1518/001872001775900841				

Reference #	201	**General Area**	RSA and RPZ	**Specific Area**	Runway Incursion Rulemaking
Title	*Opinion No 03/2019: Runway Safety*				
Source/Agency	EASA				
Authors	EASA			**Year**	2019
Abstract	The objective of this Opinion is to mitigate the safety risks associated with runway safety, from an aerodrome's perspective, focusing mainly on the prevention of runway incursions and on runway surface condition assessment and reporting, but also addressing issues such as ground collisions, runway configuration, foreign object debris(FOD)-related occurrences as well as runway pavements maintenance. This Opinion proposes amendments to existing organization and operational requirements of Regulation (EU) No 139/2014, as well as the introduction of new ones, which are based on ICAO provisions contained mainly in International Civil Aviation Organization (ICAO) Annexes 14 and 15, recommendations contained in the European Action Plans for the Prevention of Runway Incursions and Excursions (EAPPRI, EAPPRE), as well as safety recommendations addressed to EASA by the Accident Investigation Boards of Norway and Sweden, and also safety recommendations which are not addressed to EASA. It is also provides for alignment with ICAO Annex 14 Volume I 'Aerodrome Design and Operations' 8th Edition and ICAO Doc 9981 'Procedures for Air Navigation Services – Aerodromes' 2nd Edition, as regards runway surface condition assessment and reporting which will be applicable worldwide by November 2020. Furthermore, the Opinion proposes consequential amendments to Regulation (EU) 2017/373 and Regulation (EU) No 923/2012. In particular, the Opinion proposes amendments to the framework for the operation of vehicles at aerodromes, including the authorization of drivers and the conformance of vehicles operating on the maneuvering area with certain safety prerequisites, in order to ensure runway safety. The proposed amendments are expected to improve safety by reducing the number of runway-safety-related occurrences from an aerodrome's perspective. In addition, it is expected that some of the amendments will improve harmonization as a result of the introduction of new common requirements that do not currently exist. The proposed amendments will ensure alignment of the current EU aerodrome regulatory framework with the relevant aerodrome-related ICAO provisions of Annexes 14 and 15, PANS-ATM and PANS-Aerodromes and support the rules proposed by Opinion No 02/2019 in regard to aeroplane performance requirements for commercial air transport operations.				
Comments	*Stage 3 (of 5) of EASA rulemaking process; use of multidisciplinary approach; focus on V/PDs.*				
Potential Gaps	*A rather comprehensive proposal, but not binding and could change before final rule issued.*				
Link	*https://www.easa.europa.eu/sites/default/files/dfu/EASA%20Opinion%20No%2003-2019.pdf*				

Reference #	202	**General Area**	SMS	**Specific Area**	SMS implementation
Title	*Legal Issues Related to Implementation and Operation of SMS for Airports*				
Source/Agency	*ACRP Legal Research Digest, Issue 36, 2018, 33p*				
Authors	Kirsch, Peter; Clabbers, Nicholas M.			**Year**	2018
Abstract	Discusses legal issues associated with starting an SMS program as well as benefits experienced.				
Comments	*None.*				
Potential Gaps	*Accident/incident statistics before and after implementation of an SMS program.*				
Link	https://trid.trb.org/view/1575342				

Reference #	203	**General Area**	Emergency Mgmt Training	**Specific Area**	Communication Planning
Title	*Emergency Communications Planning for Airports*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 73, 2016, 100p*				
Authors	Smith, James F; Kenville, Kimberly A; Sawyer, John M; Garcia, Ricardo E.			**Year**	2016
Abstract	This report is on emergency communications planning. It is specifically designed for use by airport senior management, public information officers, first responders, and emergency managers. Includes a checklist designed to assist airport managers, emergency managers, and planners in the development, implementation, and evaluation of effective communications plans or crisis communications plans.				
Comments	*There is one reference that says good communication planning leads to better human adaptation and decision making.*				
Potential Gaps	*One reference in the checklists on responders having food/water on hand. However, nothing said about making sure responders are safe to respond.*				
Link	https://trid.trb.org/view/1417904				

Reference #	204	**General Area**	Terminal Incidents	**Specific Area**	IROPS
Title	*Guidebook for IROPS Stakeholder Communication and Coordination*				
Source/Agency	*ACRP Report, Issue 153, 2016, 229p*				
Authors	Cogliandro, Barbara; Kicinger, Rafal; Masterson, Ed; O'Keeffe, Giles; Agnew, Rose; Nash, J Michael; Coverdell, Christina; Anderson, Tim; Marchi, Richard; Phy, Justin; Callister, Tim			**Year**	2016
Abstract	Guidebook to assist communication and coordination to airports and airlines to implement Irregular Operations (IROPS) contingency plans to reduce their impact on passengers.				
Comments	*The report has guidance for fostering good situational awareness between stakeholders using collaboration, communication, and coordination.*				
Potential Gaps					
Link	https://trid.trb.org/view/1406441				

Reference #	205	**General Area**	Movement Area Safety	**Specific Area**	Snow Removal
Title	*Airside Snow Removal Practices for Small Airports with Limited Budgets*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 67, 2015, 112p*				
Authors	Quilty, Stephen M.			**Year**	2015
Abstract	Information on the challenges and successful strategies that airport operators snow removal techniques used at small airports with significant budget and other constraints.				
Comments	*Chapter 4 discussed airport operator duty to report conditions (NOTAM system). Chapt. 4 goes on to talk about preventing runway incursions and surface incidents due to reduced friction from snowy conditions. Starting on page 44 human factors for winter operations and snow equipment operators is discussed.*				
Potential Gaps					
Link	https://trid.trb.org/view/1368287				

Reference #	206	**General Area**	SMS	**Specific Area**	SRM/SRA
Title	*A Guidebook for Safety Risk Management for Airports*				
Source/Agency	*ACRP Report, Issue 131, 2015, 212p*				
Authors	Neubauer, Kenneth; Fleet, Dave; Ayres Jr, Manuel			**Year**	2015
Abstract	Guidance on conducting the safety risk management (SRM) process. It provides information on conducting safety risk assessments (SRA) and tailors this information so that it can be scaled for smaller airports with fewer resources.				
Comments	*The "5 why's" are introduced for the identification of hazards in which you ask why something is the way it is to 5 degrees of separation. Could be used to identify why incursions and V/PD's still occur.*				
Potential Gaps					
Link	https://trid.trb.org/view/1356800				

Reference #	207	**General Area**	Emergency Mgmt Training	**Specific Area**	Post Event Recovery
Title	*Airport Emergency Post-Event Recovery Practices*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 60, 2015, 87p*				
Authors	Smith, James F; Kenville, Kim; Sawyer, John M.			**Year**	2015
Abstract	Emergency management theory and practice focused on post event recovery best practices and guidance.				
Comments					
Potential Gaps					
Link	https://trid.trb.org/view/1354193				

Reference #	208	**General Area**	Movement Area Safety	**Specific Area**	Winter Operations
Title	*A Guidebook for Airport Winter Operations*				
Source/Agency	*ACRP Report, Issue 123, 2015, 139p*				
Authors	McGormley, Robert; Arendt, Timothy; Seal, Devon; Fisher, Elizabeth; Sichko, Paul; Rea-Gaubert, Vesta; Anderson, Tim; Tolton, Eric; Marchi, Richard			**Year**	2015
Abstract	Report serves to help managers, operators, and users of small to large airport facilities prepare for, operate during, and recover from disruptive winter events as well as manage airport user expectations.				
Comments	*Runway Incursion mitigation is discussed. Also, training and pre-season dry-runs incorporate sleep disorder and circadian rhythm training as well as factors that affect human performance and situational awareness.*				
Potential Gaps	*These were noted for snow removal crews but do other airside personnel receive this training as well?*				
Link	http://www.trb.org/Publications/Blurbs/171976.aspx				

Reference #	209	**General Area**	SMS	**Specific Area**	SRS
Title	*Safety Reporting Systems at Airports*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 58, 2014, 73p*				
Authors	Landry, Joanne; Bannard, David Y; Stockon, Chase; English, Colin			**Year**	2014
Abstract	Safety reporting methods and systems for Title 14 Code of Federal Regulations Part 139 (Part 139) certificated airports. Evaluates current practices, processes, and systems employed.				
Comments	*Article talks about how safety reporting quality is diminished by actual or perceived legal implications instilled on reporters. Reporting needs to be non-punitive to work. It also explains that there is no centralized repository for most types of incidents. There are only for certain types, runway incursions, and certain airborne incidents.*				
Potential Gaps					
Link	https://trid.trb.org/view/1316322				

Reference #	210	**General Area**	Movement Area Safety	**Specific Area**	
Title	*Best Practices Manual for Working in or Near Airport Movement Areas*				
Source/Agency	*ACRP Report Issue 101, 2014, 61p*				
Authors	Ricondo & Associates, Incorporated; Aviation Safety and Security Education Training, LLC; GSS Creative; Kimley-Horn and Associates Incorporated			**Year**	2014
Abstract	Provides guidance to airports, tenants, and contractors in identifying best practices for airport activities. Includes a best practices database, training tools, training aids, and checklists on eliminating/mitigating risks while working in or near the airport movement area.				
Comments					
Potential Gaps					
Link	https://trid.trb.org/view/1311852				

Reference #	211	**General Area**	SMS	**Specific Area**	Training
Title	*Helping New Maintenance Hires Adapt to the Airport Operating Environment*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 49, 2013, 60p*				
Authors	Quilty, Stephen M.			**Year**	2013
Abstract	This report presents information on locating information for training new hires, identifying current practices and challenges, documenting core training elements and resources, and identify resources that may help raise knowledge and understanding on the airport campus and its operating environment. Written primarily for GA airport operators.				
Comments	*In the literature review it explains desirable skills for an airport employee as well as knowledge requirements for entry level personnel.*				
Potential Gaps					
Link	https://trid.trb.org/view/1262840				

Reference #	212	**General Area**	Non-Mov. Area Safety	**Specific Area**	Ramp Safety
Title	*Ramp Safety Practices*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 29, 2011, 67p*				
Authors	Landry, Joanne; Ingolia, Shane			**Year**	2011
Abstract	Intended to inform airport operators, ground handlers, and airlines about the current state of ground handling practices. Focus is on safety measures and training.				
Comments	*Table 19 lists many products used for ground tracking of A/C and Vehicles.*				
Potential Gaps					
Link	https://trid.trb.org/view/112272				

Reference #	213	**General Area**	SMS	**Specific Area**	FOD
Title	*Current Airport Inspection Practices Regarding FOD (Foreign Object Debris/Damage)*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 26, 2011, 94p*				
Authors	Prather, C Daniel			**Year**	2011
Abstract	Details the components of a comprehensive FOD management program. Includes current practices, techniques, and lists of tools available for use, or those currently being used, by airports for FOD inspections.				
Comments	*Chapter 6 discusses training and promotion of an effective FOD program. Lists the dirty dozen human factors, poor business culture, and lack of effective training as negative influences to a healthy program. Much of this applies to other evolutions on the airfield plagued with human errors.*				
Potential Gaps					
Link	https://trid.trb.org/view/1116338				

Reference #	214	**General Area**	SMS	**Specific Area**	Self Assessment
Title	*Airport Self-Inspection Practices*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 27, 2011, 121p*				
Authors	Prather, C Daniel			**Year**	2011
Abstract	This report provides insight into common airport self-inspection practices and may be useful to airports in benchmarking their self-inspection program to peer airports and practices considered successful by regional FAA personnel.				
Comments	*In chapter 6 human factors are discussed as distractors to quality control. The most significant of them complacency during routine airfield inspections. Fatigue and a macho attitude were also discussed as factor for a decrease in quality. Figure 43 lists factors that negatively impact self-inspections by the degree of impact they have.*				
Potential Gaps					
Link	https://trid.trb.org/view/1118295				

Reference #	215	**General Area**	SMS	**Specific Area**	How-to guide
Title	*Safety Management Systems for Airports. Volume 2: Guidebook*				
Source/Agency	*ACRP Report, Volume 2, Issue 1, 2009, 174p*				
Authors	Ayres Jr, Manuel; Shirazi, Hamid; Cardoso, Samuel; Brown, Jeffrey; Speir, Richard; Selezneva, Olga I; Hall, Jim; Puzin, Tara; Lafortune, Jeff; Caparroz, Fernando; Ryan, Robert; McCall, Edward			**Year**	2009
Abstract	Comprehensive reference of what constitutes an airport SMS; describes its components and their interactions; and offers guidance in the planning, implementation, and operation of an airport SMS.				
Comments					
Potential Gaps					
Link	https://trid.trb.org/view/905132				

Reference #	216	**General Area**	Airside Driving	**Specific Area**	Requirements/ Training
Title	*Identification of the Requirements and Training to Obtain Driving Privileges on Airfields*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 15, 2009, 51p*				
Authors	Castellano, Benedict			**Year**	2009
Abstract	Report provides airport operators with information on the requirements and training required to obtain driving privileges on airport airfields. Also contains information on the types of training programs available to airport employees based on where they are authorized to drive.				
Comments	*Literature Review shows a pie chart from 2004-2007. Pilot deviations accounted for more runway incursions than vehicle, pedestrian, and operational errors combined. Table 10 Enforcement Measures: Suspend/Revoke and Remedial training are most often used in response to infractions where fines and penalties are used the least. Training for movement areas seem to be more involved than for non-movement areas however there seemed to be some confusion on the limitations of where non-movement area drivers can go.*				
Potential Gaps					
Link	https://trid.trb.org/view/891647				

Reference #	217	**General Area**	SMS	**Specific Area**	
Title	*Safety Management Systems for Airports. Volume 1: Overview*				
Source/Agency	*ACRP Report, Issue 1, 2007, 40p*				
Authors	Ludwig, Duane A; Andrews, Cheryl R; Jester-ten Veen, Nienke R; Laqui, Charlotte			**Year**	2007
Abstract	This report explains what a safety management system (SMS) is and how a systems approach to safety management will benefit both the safety and business aspects of airports.				
Comments	*Section 3 includes SMS approaches/examples from industries other than aviation such as Petroleum, Nuclear, Railway, Marine, and Chemical industries. Looking at other industries for Human Factor issues and mitigation techniques would be beneficial.*				
Potential Gaps					
Link	https://trid.trb.org/view/825928				

Reference #	218	**General Area**	SMS	**Specific Area**	
Title	*General Aviation Safety and Security Practices*				
Source/Agency	*ACRP Synthesis of Airport Practice, Issue 3, 2007, 52p*				
Authors	Williams, Craig			**Year**	2007
Abstract	Identifies current practices in safety and security at general aviation airports, resources used by the general aviation community, funding sources, and issues that determine the amount of money spent on such programs.				
Comments	*The most common training topics for new hires at interviewed airports are driving on the airport, air traffic control tower communications, and security awareness. Later FIGURE 2 lists Topic areas in a typical general aviation airport safety plan. I did not see anywhere that human factors that affect each of these subject areas are being discussed. Page 11 tells of an airport that brought runway incidents and incursions to zero by ENFORSING rules to airfield driving. The interviewee states, "successful implementation of a program that links airfield safety and security is only as good as the Airport Manager's desire to enforce those rules."*				
Potential Gaps					
Link	https://trid.trb.org/view/814609				

Reference #	219	**General Area**	SMS	**Specific Area**	
Title	*Application of Enterprise Risk Management at Airports*				
Source/Agency	*ACRP Report Issue Number: 74 Publisher: Transportation Research Board*				
Authors	Marsh Risk Consulting; HNT B Corporation; Direct Effect Solutions, Inc			**Year**	2012
Abstract	Discusses implementation of the iterative ERM process including roles and responsibilities from the governing board to all staff members. ERM help catalog identified risks in a risk register with expected likelihood of occurrence and expected severity of impact on the airport to generate a risk score and a risk map.				
Comments	*When establishing an ERM at an airport most of the FAQs tend to lean around why it has to be done. It is seen (at least in this list of FAQs) as an unnecessary addition to workload. In thinking about HF, cultural beliefs are often the most difficult hurdle to overcome.*				
Potential Gaps	*Using an ERM to include human factor risks (ie. Cognitive function deterioration, fatigue factors, biological factors of aging).*				
Link	http://www.trb.org/Publications/Blurbs/167515.aspx				

Reference #	220	**General Area**	Airport Losses	**Specific Area**	
Title	*Evaluating Impacts of Sustainability Practices on Airport Operations and Maintenance*				
Source/Agency	*ACRP Report Issue Number: 110 Publisher: Transportation Research Board*				
Authors	Jennifer Salerno; Greg Raiffa; Carol Lurie			**Year**	2014
Abstract	This report provides an evaluation process and cost–benefit tool to evaluate lifecycle costs of sustainability practices being considered by airport operators. These are designed to evaluate sustainability practices in water conservation, energy conservation, waste management, consumables and materials, and alternative fuels.				
Comments					
Potential Gaps					
Link	http://www.trb.org/Publications/Blurbs/170580.aspx				

Reference #	221	**General Area**	Airport Losses	**Specific Area**	
Title	*Guidance for Planning, Design, and Operations of Airport Communications Centers*				
Source/Agency	*ACRP Report Issue Number: 182 Publisher: Transportation Research Board*				
Authors	Kipp, D; Nessi, D			**Year**	2017
Abstract	There are different ways to organize a call center. Some have separate centers for each department such as emergency response calls and monitoring of airport surveillance systems. Other airports combine these into one call center. This report can be used by all sizes of airports to determine which type of airport communications center best meets each airport's operational needs.				
Comments	*Talks about how to use ACCs to improve SA. Section 5.2 addresses human factors challenges in information absorption. Although written towards ACCs, much of this section can be inferred about other operations with human involvement.*				
Potential Gaps					
Link	http://www.trb.org/main/blurbs/177052.aspx				

Reference #	222	**General Area**	Non-Mov. Area Safety	**Specific Area**	Vehicles
Title	*FAA National Part 139 CertAlert No. 14-02*				
Source/Agency	FAA				
Authors	Brian Rushforth			**Year**	2014
Abstract	CertAlert issued by the FAA due to an increase in the numbers of vehicles and/or equipment inadvertently hitting and damaging airplanes in the ramp/gate areas. Includes recommendations to airport operators as well as a short list of best practices. FAA called for a review of training programs.				
Comments					
Potential Gaps					
Link	https://www.faa.gov/airports/airport_safety/certalerts/media/cert1402.pdf				

Reference #	223	**General Area**	Movement Area Safety	**Specific Area**	Closed Runways
Title	*Aircraft Departing/Landing on Closed Runways CertAlert No. 02-01*				
Source/Agency	FAA				
Authors	Benedict D. Castellano			**Year**	2002
Abstract	At the time this CertAlert was issued there was in increase to aircraft landing and taking off on closed runways.				
Comments					
Potential Gaps					
Link	https://www.faa.gov/airports/airport_safety/certalerts/media/cert0201.rtf				

Appendix 3 – MLB Site Visit Agenda and Interview Questions

ACRP 06-08 – Phase I Research

Orlando Melbourne International Airport Site Visit (29-30 January 2020)

- Itinerary
    - Jan. 29th
        - 1000-1100 Meet with Director of Ops and/or Ops Mgr (Cliff/ Patrick | Conf. Rm.)
        - 1100-1200 Meet with Ops & Mx supervisors (Conf. Rm.)
        - 1200-1300 Lunch
        - 1300-1430 Observe daytime ramp ops/turn (1313ARR of AA5621 (CRJ900) / 1405ARR DL0995 (B717))
        - 1430-1600 Meet with Airport Ground Services Manager and GSP (fuel/above wing/below wing) (Amanda/Chris | Conf. Rm.)
        - 1600-1815 Meet with FBO (Kyle | APEX EJC)
        - 1815-1930 Observe night ramp ops/turn (1844ARR DL2944 (B717))
    - Jan. 30th
        - 0800-0900 ATCT Visit (Charlie | ATCT)
        - 0900-1000 Meet with Mx personnel (Florida Room)
        - 1000-1100 Meet with Delta (Chris Sorensen | Florida Room)
        - 1100-1200 Meet with Airport Operations Officer and Airport Safety and Training Coordinator (Stephanie/Stan | Florida Room)
        - 1200-1230 Outbrief (Cliff/ Patrick | Florida. Rm.)

Interview Questions

- Line Personnel
  - Individual Information
    - Organization, position, duties, time on the job at MLB, other experience
    - Qualifications (airside driving, aircraft taxi, etc.)
  - What helps you to perform at your best on the job?
  - What hinders you in performing your best on the job?
  - What training did you receive to be able to work on the flight line?
    - Initial training
    - Recurring training
    - Driver training
  - Are airport rules and regulations understandable, up to date, and applicable to your work activities?
  - Describe a close call you have had on the flight line
    - Factors that contributed to the event
    - Follow-up or investigations
  - How are airside operations monitored?
    - Safety observers?
    - Supervisors?
  - Are you familiar with risk management? If so, describe.
  - Describe how you communicate on the flight line.

- Supervisors
  - Individual Information
    - Organization, position, duties, time on the job at MLB, other experience
    - Qualifications (airside driving, aircraft taxi, etc.)
  - Describe the requirements you have for your people who work airside (training, experience, fitness for duty, etc.)
  - What characteristics make a person well suited to work airside? Drive airside?
  - What helps your people perform at their best on the job?
  - What hinders your people from performing at their best on the job?
  - Are airport rules and regulations understandable, up to date, and applicable to your work activities?
  - How is performance of airside operations monitored? Measured?
  - Describe a close call your organization has had on the flight line
    - Factors that contributed to the event
    - Follow-up or investigations
    - Organizational changes that resulted