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A Guidebook for Safety Risk Management for Airports

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A Guidebook for Safety Risk Management for Airports

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FOREWORD

By Marci A. Greenberger
Staff Officer
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ACRP Report 131: A Guidebook for Safety Risk Management for Airports provides guidance on conducting the safety risk management (SRM) process, one of the four components of a Safety Management System (SMS). The guidebook is organized to allow readers who are new to SMS and its components to understand where the SRM process falls within an overall SMS; those familiar with the SMS concepts and ready to specifically learn more about the SRM process can go directly to the relevant material.

The guidebook provides information on conducting safety risk assessments (SRA) and tailors this information so that it can be scaled for smaller airports with fewer resources. Tools and templates are provided as appendices and typical accident and incident rates are provided to help airport operators understand some potential airport risks.

Although a final regulation has not been issued by the FAA to airport operators on establishing an SMS, the industry has been preparing for this eventuality. There have been airport pilot studies and those lessons learned have been published. It is also believed that many airports currently conduct safety risk assessments; however, the formality expected to be required will be new to airports. Futron Aviation, as part of ACRP Project 04-16, developed this guidebook to assist airports of all sizes in navigating the safety risk management process. Airport directors, safety managers, and operations, maintenance, and public safety employees will benefit from understanding the SRM process and its application to the daily operation of the airport and unique events, including construction.

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Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

PART I

Using the Guidebook

This guidebook has five parts. Part I will help readers become familiar with Safety Management System (SMS) and safety risk management (SRM) terms and definitions. Part I identifies key terms and how they relate to one another and explains how to use the guidebook. Readers will also learn how the guidebook can benefit all airports, regardless of size or complexity.

CHAPTER 1

Glossary

One reason for this guidebook is to promote consistency in the use of safety and risk management terms. To do this, the authors compared FAA and International Civil Aviation Organization (ICAO) references to non-aviation industry references to identify inconsistent nomenclature. When the authors found multiple terms with common meanings and uses, they identified the most commonly accepted terms.

Terms used by the FAA Office of Airports (ARP) and ICAO are preferred; where terms from other industries or organizations are used, sources are noted. The glossary will help airport staff use the terms more uniformly, thus reducing confusion and setting up consistency across the industry. Although some of the terms defined are not used in this guidebook, they are included because they are commonly used in industry or by regulators.

1.1 Acronyms

AAS	FAA Office of Airport Safety and Standards
ACM	Airport Certification Manual
ACRP	Airport Cooperative Research Program
ARFF	Aircraft Rescue and Fire Fighting
ARP	FAA Office of Airports
ATCT	Air Traffic Control Tower
ATO	FAA Air Traffic Organization
AVS	FAA Office of Aviation Safety
FAA	Federal Aviation Administration
FBO	Fixed-Base Operator
FOD	Foreign Object Damage or Foreign Object Debris
FOIA	Freedom of Information Act
ICAO	International Civil Aviation Organization
KPI	Key Performance Indicator
PIREP	Pilot Report
SA	Safety Assurance
SAS	Safety Assessment Screening
SME	Subject Matter Expert
SMS	Safety Management System
SOP	Standard Operating Procedure
SRA	Safety Risk Assessment
SRM	Safety Risk Management
SRMD	Safety Risk Management Document

1.2 Definitions

Accountable Executive—a single identifiable person responsible for the effective and efficient performance of the airport's SMS. (ICAO Doc 9859, 3rd edition Safety Management Manual—SMM)

Aircraft Accident—an occurrence, associated with the operation of an aircraft, that occurs between the time any person boards the aircraft with the intention of flight and until all such persons have disembarked; and in which any person suffers death or serious injury, or the aircraft receives substantial damage. (NTSB, Part 830)

Aircraft Incident—an occurrence, other than an accident, that is associated with the operation of an aircraft and that affects or could affect the safety of operations. (NTSB, Part 830)

Airport Project—an airport construction project that affects the physical characteristics of the airport, airport layout plan approvals, or review of construction safety phasing plans. (FAA Order 5200.11)

As Low As Reasonably Practicable (ALARP)—describes a safety risk reduced to a level that is as low as reasonably practicable; that is, any further risk reduction is either impracticable or grossly outweighed by the cost. (ICAO Safety Management Manual) *Note: in the latest version of ICAO Safety Management Manual (3rd Edition, 2013) ALARP was removed. It is provided here for reference only.*

Common Cause Failure—a failure that occurs when a single fault results in the corresponding failure of multiple system components or functions. (FAA Order 5200.11)

Comparative Safety Assessment (CSA)—a safety analysis that provides a list of hazards associated with a project proposal, along with a risk assessment of each alternative-hazard combination. A CSA is used to compare alternatives from a risk perspective. (FAA SRM Guidance for System Acquisitions, 2007)

Construction Safety and Phasing Plan (CSPP)—a document that outlines procedures, coordination, and control of safety issues during construction activity on an airport. (FAA AC 150/5370-2)

Control—see Risk Control.

FAA Office of Airports (ARP)—provides leadership in planning and developing a safe and efficient national airport system. The office is responsible for all programs related to airport safety and inspections and standards for airport design, construction, and operation (including international harmonization of airport standards). The office also is responsible for national airport planning and environmental and social requirements and establishes policies related to airport rates and charges, compliance with grant assurances, and airport privatization. (http://www.faa.gov/about/office_org/headquarters_offices/arp/)

FAA Air Traffic Organization (ATO)—the operational arm of the FAA. It is responsible for providing safe and efficient air navigation services to 30.2 million square miles of airspace. (http://www.faa.gov/about/office_org/headquarters_offices/ato/)

FAA Office of Aviation Safety (AVS)—responsible for the certification, production approval, and continued airworthiness of aircraft; and certification of pilots, mechanics, and others in safety-related positions. (http://www.faa.gov/about/office_org/headquarters_offices/avs/)

Hazard—A condition that could foreseeably cause or contribute to an accident. (FAA Order 8040.4A) *Note: Section 1.3 discusses this in further detail.*

Hazard Assessment—a systematic, comprehensive evaluation of a change, operation, system, or safety issue. (DRAFT FAA AC 150/5200-37A)

Incident—an occurrence, other than an accident, associated with the operation of an aircraft, that affects or could affect the safety of operations. (49 CFR 830.2)

Injury Severity (ICAO Annex 13)

- **Minor—**any injury that is neither fatal nor serious.
- **Serious—**an injury that (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.
- **Fatal—**fatal injuries include all deaths determined to be a direct result of injuries sustained in the accident, and within 30 days of the date of the accident.

International Civil Aviation Organization (ICAO)—a specialized agency of the United Nations, the ICAO promotes the safe and orderly development of international civil aviation throughout the world. (http://www.icao.int/about-icao/Pages/default.aspx)

Key Performance Indicator (KPI)—a set of quantifiable measures that a company or industry uses to gauge or compare performance in terms of meeting strategic and operational goals. Within the context of SRM, the KPI will be safety related. (Various sources)

Likelihood—the estimated probability or frequency, in quantitative or qualitative terms, of a hazard's effect. (FAA Order 5200.11)

Material Change—any change, relating to a construction project, that is a result of the environmental or design process and/or alternative selection that changes the physical layout. Such changes could introduce safety risks. (FAA Order 5200.11)

National Airspace System (NAS)—the common network of U.S. airspace; air navigation facilities; equipment and services; airports or landing areas; aeronautical charts and information services; rules, regulations, and procedures; technical information; and labor and material. The NAS includes system components shared with the military. (FAA Pilot/Controller Glossary, 2014)

Operational Risk Management (ORM)—a decision-making tool used by personnel at all levels to increase effectiveness by identifying, assessing, and managing risks. By reducing the potential for loss, the probability of a successful mission increases. (Chief of Naval Operations Instruction 3500.39C)

Outcome—a specific system state and sequence of events supported by data and expert opinion that clearly describes the outcome. The term implies that it is reasonable to expect the assumed combination of conditions may occur within the operational lifetime of the system. (FAA Order 5200.11) *Note: Other terms used in risk management as substitutes for outcome include consequence, effect, and result. Outcome is used throughout the guidebook.*

Preliminary Hazard Assessment (PHA)—an overview of the hazards associated with an operation or project proposal consisting of an initial risk assessment and development of safety-related requirements. (FAA ARP Desk Reference)

Preliminary Hazard List (PHL)—a list of anything that the analyst can think of that can go wrong, based on the concept, its operation, and implementation. (FAA System Safety Handbook, 2000) *Note the FAA System Safety Handbook, 2000, is no longer in use by the FAA and is only used as a resource because it cross references some FAA ATO documents.*

Qualitative Risk—level of risk based on subjective measures, rather than quantitative metrics. (Various sources)

Quantitative Risk—level of risk based on objective data and metrics. (Various sources)

Risk—see Safety Risk.

Risk Analysis—the process during which a hazard is characterized for its likelihood and the severity of its effect or harm. Risk analysis can be either quantitative or qualitative; however, the inability to quantify or the lack of historical data on a particular hazard does not preclude the need for analysis. (DRAFT FAA AC 150/5200-37A)

Risk Assessment—the process by which the results of risk analysis are used to make decisions. The process combines the effects of risk elements discovered in risk analysis and compares them against acceptability criteria. A risk assessment can include consolidating risks into risk sets that can be jointly mitigated, combined, and then used in making decisions. (FAA Order 5200.11)

Risk Assessment Code (RAC)—the ranking of risks based on the combination of likelihood and consequence (severity) values. A widely used SRM term throughout DoD and governmental agencies. (DoD MIL-STD-882E)

Risk Control—reduction of risk severity and/or likelihood, via the application of engineering and/or administrative hazard controls. Risk control can also be anything that mitigates or ameliorates the risk. (FAA System Safety Handbook) *Note: In this guidebook, risk mitigation is used instead of risk control.*

Risk Matrix—table depicting the various levels of severity and likelihood as they relate to the levels of risk (e.g., low, medium, or high). (FAA Desk Reference)

Risk Mitigation—any action taken to reduce the risk of a hazard's effect. (DRAFT FAA AC 150/5200-37A) *Note: Further definition is provided in Section 1.3.*

Root Cause Analysis—analysis of deficiencies to determine their underlying root cause. (FAA AC 120-79A)

Safety—the state in which the risk of harm to persons or property damage is acceptable. (FAA Order 8000.369A); The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management. (ICAO Doc 9859, Safety Management Manual—SMM)

Safety Assessment—completion of the applicable SAS, the SRM 5-step process of identifying and analyzing hazards and documentation of the SRA panel's findings, as applicable. (FAA ARP Desk Reference)

Safety Assessment Screening (SAS)—an FAA form (5200-8, 5200-9 or 5200-10) used to document the ARP Safety Assessment process. Specifically, the SAS form is used to document the appropriate level of assessment, the five steps of SRM, and the final signatures and approvals. (FAA ARP Desk Reference)

Safety Assurance—the process and procedures of management functions that evaluate the continued effectiveness of implemented risk mitigation strategies, support the identification of new hazards, and function to systematically provide confidence that an organization meets or exceeds its safety objectives through continuous improvement. (FAA AC 150/5200-37)

Safety Evaluation—procedures to monitor performance with respect to safety objectives, SMS requirements, and/or safety initiatives. (FAA AC 150/5200-37)

SMS Manual—an airport-developed document that describes the SMS components and how they will be established and will function. An SMS manual may resemble the Airport Certification

Manual (ACM). Whereas an ACM describes how an airport operates, an SMS Manual describes how the SMS functions. (FAA AC 150/5200-37)

Safety Management System (SMS)—a formal, top-down, organization-wide approach to managing safety risk and ensuring the effectiveness of safety risk controls. An SMS includes systematic procedures, practices, and policies for managing safety risk. (FAA Order VS 8000.369A)

Safety Objective—a measurable goal or desirable outcome related to safety. (FAA AC 150/5200-37)

Safety Performance Indicator (SPI)—a data-based safety parameter used for monitoring and assessing safety performance. (ICAO Doc 9859, Safety Management Manual—SMM)

Safety Policy—defines the fundamental approach to managing safety that is to be adopted within an organization. Safety policy further defines the organization's commitment to safety and overall safety vision. (AC 150-5200-37)

Safety Promotion—the combination of safety culture, safety training, and communication activities that support the implementation and operation of the SMS in an organization. (AC 150-5200-37)

Safety Risk—the composite of predicted severity and likelihood of the potential effect of a hazard. (FAA Order 8040.4A)

- **Initial—**the predicted severity and likelihood of a hazard's effects or outcomes when it is first identified and assessed; includes the effects of pre-existing risk controls in the current environment.
- **Current—**the predicted severity and likelihood at the current time.
- **Residual—**the remaining predicted severity and likelihood that exists after all selected risk control techniques have been implemented.

Safety Risk Assessment—assessment of a system or component, often by a panel of system subject matter experts (SMEs) and stakeholders, to compare an achieved risk level with the tolerable risk level. (Various sources)

Note: during the FAA SMS Pilot Studies multiple airports adopted the term SRA to describe the 5-step process, defined within SRM: (1) define the system, (2) identify the hazards, (3) assess the risks, (4) analyze the risks, and (5) mitigate the risks. In this guidebook, safety risk assessment is used exclusively when describing the 5-step process and the conduct of that process with a panel of SMEs.

Safety Risk Control—anything that mitigates the safety risk of a hazard. Safety risk controls necessary to mitigate an unacceptable risk should be mandatory, measurable, and monitored for effectiveness. (FAA AC 150/5200-37)

Safety Risk Management—a standard set of processes to identify and document hazards, analyze and assess potential risks, and develop appropriate mitigation strategies. (FAA ARP SMS Desk Reference)

Safety Risk Management Document (SRMD)—an ATO-specified description of the safety analysis for a given proposed change. An SRMD documents the evidence to support whether or not the proposed change to the system is acceptable from a safety risk perspective. SRMDs are maintained by the organization responsible for the change for the lifecycle of the system or change. (FAA Order 5200.11)

Safety Risk Management Panel—a group formed to formalize a proactive approach to system safety and a methodology that ensures hazards are identified and unacceptable risk is mitigated before the change is made. An SRM Panel provides a framework to ensure that, once a change is made, the change will be tracked throughout its lifecycle. (FAA Order 5200.11)

Note: this term is synonymous with Safety Risk Assessment (SRA) Panel. This guidebook uses SRA Panel as the common term.

Severity—the measure of how severe the results of a hazardous condition's outcome are predicted to be. Severity is one component of risk. The safety risk of a hazard is assessed on the combination of the severity of and the likelihood (probability) of the potential outcome(s) of the hazard. (FAA Order 8040.4A)

Single Point Failure—a failure of an item that would result in the failure of the system and is not mitigated by redundancy or an alternative operational procedure. (FAA Order 5200.11)

Small Airport—a non-primary airport with less than 20 employees working full time. (defined by the author for this guidebook)

System—an integrated set of constituent pieces combined in an operational or support environment to meet a defined objective. Elements include people, hardware, software, firmware, information, procedures, facilities, services, and other support facets. (FAA Order 8040.4) *Note: See the 5M Model.*

System State—an expression of the various conditions, characterized by quantities or qualities, in which a system can exist. (FAA ATO SMS Manual)

Triggers for SRM—the requirements, precursors, or organizational plans that lead to initiation of the SRM process. *Note: Triggers are explained in more detail in Part V, Chapter 16.*

Validation—the process of proving the functions, procedures, controls, and safety standards are correct and the right system is being built (that is, the requirements are unambiguous, correct, complete, and verifiable.) (FAA Order 5200.11)

5M Model—A model often used to help define an operational system, composed of five elements: **M**ission, hu**M**an, **M**achine, **M**anagement, and environ**M**ent (also called **M**edia). (Various sources)

1.3 Key Terms and Standardization

Some safety and risk management terms are commonly used when addressing the subject. A few key terms are defined further to ensure consistent understanding in the airport industry and to minimize misuse or interchanging of terms.

Safety

A well understood definition of the term *safety* is necessary given that the SRM process deals predominately with safety risks. Three definitions of safety follow:

- **Safety—**freedom from harm or danger: the state of being safe; the state of not being dangerous or harmful. (Merriam-Webster)
- **Safety—**freedom from unacceptable risk. (FAA)
- **Safety—**the state in which the risk of harm to persons or property damage is reduced to, and maintained at or below, an acceptable level throughout a continuing process of hazard identification and risk management. (ICAO)

From an airport perspective, any of the definitions can suffice. The FAA's definition is the simplest, while ICAO's definition is the most complete. All definitions address that which can do harm within the organization. Airports should develop or adopt a definition for safety that is compatible with their safety policies and objectives. For this guidebook, the FAA definition is the accepted definition.

Hazard

Airport personnel must have a clear, consistent understanding of the term *hazard.* Many airports in the early stages of SRM implementation use *hazard* synonymously with the term *risk*; however, these are different although related terms. A hazard must exist for the airport to be at risk. A hazard is defined as any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment. A hazard is a condition that is a prerequisite of an accident or incident. A hazard might or might not result in a situation of high risk. (Various sources)

Airport personnel need to learn the difference between a hazard and the risks posed by a hazard. The SRM process functions effectively only when the organization actively identifies conditions or potential conditions that can result in undesirable or harmful outcomes; the airport identifies hazards, then assesses and mitigates the risks.

Risk

Hazards present risk. Risk is the composite of predicted severity and likelihood of the potential outcome of a hazard.

Risks may be categorized as follows:

- **Initial—**the severity and likelihood of a hazard's risk when it is first identified and assessed, including the effects of pre-existing risk controls in the current system.
- **Current—**the predicted severity and likelihood of a hazard's risk at the current time.
- **Residual—**the risk that remain after all risk mitigations have been implemented or exhausted and all risk mitigations have been verified.

Outcome

An outcome is the potential undesirable result of a hazard or the ill effects potentially resulting from exposure to a hazard. In this guidebook, *outcome* is used rather than *consequence* or *effect.*

Safety Risk Assessment (SRA)

According to the FAA and as defined in the ARP Desk Reference Guide, an SRA is one element of SRM and involves the SRM 5-step process by identifying hazards and analyzing, assessing, and mitigating risks and documenting findings. An SRA may be developed and conducted by a single person or a panel of SMEs and stakeholders with a facilitator.

The SRA and SRM processes differ as follows. SRM is the component of SMS that deals directly with safety hazards, their potential outcomes, and the risks associated with them. SRM defines the management tools and responsibilities and the triggers that cause an SRM action to happen. SRA is the act of conducting the 5-step process and addressing the hazardous conditions of a system or planned event.

Risk Mitigation

Mitigating airport risks is the result of a proactive SRM process. The FAA ARP defines risk mitigation as follows:

> **Risk Mitigation**—an airport operator-developed option or an alternative strategy to modify or reduce the risk of an identified hazard. Mitigations can be used to reduce the hazard's effects on the system. Risk mitigation is also referred to as a risk control. Most risk management strategies address medium and high-risk hazards. Low-risk hazards may be accepted after considering risk.

Risk management activities should identify feasible options to manage risk according to the following categories:

- **Avoidance—**selecting a different approach or not participating in, or allowing, the operation or procedure.
- **Acceptance—**accepting the likelihood, probability, and consequences associated with the risk.
- **Control—**developing options and alternatives that minimize or eliminate the risk.
- **Transfer—**shifting the risk to another area.

In this guidebook, *mitigation* and *mitigate* are used instead of *control.*

Baseline Safety

An airport uses an SMS to improve safety performance. In order to measure change, airport management must establish a safety performance baseline. Safety performance cannot be measured daily like the number of departures or gallons of fuel pumped into aircraft. Safety performance is assessed over extended periods.

The baseline level of safety performance is established before SMS implementation. Airport management should review and analyze past safety performance measures and identify a period when performance was judged acceptable. This could be for a 3-month period, a 6-month period, or as long as a year. The longer the selected period, the more patient the organization must be in assessing the success of SMS initiatives.

Key decisionmakers should receive regular updates on safety performance compared with baseline safety. These updates help decisionmakers make informed decisions on the use of resources. Current safety data enhances discussions on whether safety resources are being used effectively and where resources should be otherwise allocated.

CHAPTER 2

Introduction

The U.S. aviation system is one of the safest in the world. This is the result of decades of examining and reviewing incidents and accidents and making improvements based on the findings. After-action efforts—in response to aircraft incidents and accidents, ground movement incursions (by vehicles, equipment, or pedestrians), and incidents that have hampered the safe operation of aircraft—have resulted in regulations and guidance to reduce the likelihood of incidents, accidents, and incursions occurring. For airports, 14 CFR Part 139 is, in many ways, a proactive and systematic approach to managing risks. The FAA developed the regulations based on the lessons learned by airports over time. The result is processes, procedures, and physical requirements to reduce the likelihood of incidents, accidents, and incursions occurring.

Airport operators deal with risk every day and in everything they do. The risk is sometimes within their control, and sometimes it is not. Regulations and guidance developed and enforced by the FAA are a way to manage the risk inherent in the National Airspace System (NAS). Although this approach has been successful for more than 50 years, as air traffic increases, safety performance needs to improve. With traffic growth, the number of accidents tends to increase if the level of safety remains constant. To preserve public confidence, the aviation industry, using new technologies and approaches like SMS, needs to further reduce the chances of accidents. The implementation of NEXTGEN technologies and processes over the coming decade will bring changes to the NAS and require airports to adapt accordingly. SMS is a way to adapt current safety programs and methods to meet the requirements of these changes. Safety Risk Management, the key operational component of an SMS, is a creative method that looks into the future, rather than solely reacting to past events as the catalyst for improving safety.

As the industry becomes more complex and aircraft become more sophisticated, demands on airports will increase. If public confidence in the safety of the air transportation system is to be maintained, everyone involved must play a role. Simply following regulations will not be enough. Regulations too often are developed in reaction to past events. Managing risk needs to be proactive and consider the specific characteristics of each airport. This guidebook gives airport operators the means and methods to perform SRM and considers the wide spectrum of airport characteristics. Airport owners and operators will benefit from regular use of this guidebook, regardless of airport size or complexity.

2.1 Background

The FAA is developing regulations to require 14 CFR Part 139 certificated airports to develop and implement SMS. This is a result of the International Civil Aviation Organization (ICAO) requirement for all member states (the United States being one) to develop and implement SMS for the regulator and the international airports of member states.

The airport industry knows that SMS will become a regulatory requirement. SMS will require more knowledge and training for airport staff and stakeholders. SMS references that provide objective and practical guidance specifically addressing airport needs are needed. The need for SRM guidance became clear during the FAA pilot studies on SMS. Given this situation combined with a desire to address pending regulation, the industry identified the need for this guidebook.

In developing this guidebook, the authors used many lessons learned from the FAA-sponsored SMS Pilot Studies. Key information about SRM learned during the pilot studies helped to identify tools and support data that were missing and that should be developed to help airports run their SRM processes. The guidebook also reflects experiences from other countries and other industries that have adopted SMS. The guidebook presents concepts that are important to proper implementation and application of SRM, but many of these concepts (such as SRM and SRA triggers) can be difficult to understand or apply correctly. Questions about when the SRM process can and should be applied, and what considerations go into the decision to convene a panel and conduct an SRA arise often during early SMS implementation efforts. The guidebook provides explanations and examples for important concepts like these.

The guidebook also consolidates information on the resources available, uses research and experience to fill the gaps, and provides guidance and examples to help the industry move forward with SMS to improve the managing of safety.

2.2 Guidebook Audience

This guidebook was developed for airport staff responsible for SMS. The person or team responsible for an airport's safety should have in-depth knowledge of SMS and SRM; however, everyone working at an airport is responsible for safety. This guidebook can help anyone—airport staff, consultant or stakeholder—better understand SRM concepts, their practical application in dealing with airport issues that affect safety, and how SRM can enhance job performance.

The guidebook provides airports with tools to develop, set up, and perform SRM. Airports are the link between aircraft operators, the FAA, and the traveling public. With the right resources to manage safety risks, airports can improve the overall safety of the aviation industry and specifically improve safety for their airport users. SRM used by one airport positively affects not only the airport staff, but everyone involved with, working on, or traveling from that airport and can even reach outside the immediate airport environment and improve the safety for the surrounding community and its activities.

Regardless of past or pending regulations, SRM is a proven way to manage safety—determining hazards and their associated risks and mitigating them, *before* accidents occur, thus improving the overall safety performance of the National Airspace System (NAS).

SRM processes are not restricted to managing safety risk. The techniques can be used in every line of business. Other airport lines of business, such as environmental management, use similar approaches to manage the risk of their activities. Risk management, through use of the methods and tools in this guidebook, can be applied to all aspects of the airport, including property development, concessions, and Fixed-Base Operator (FBO) operations. Using a common risk management approach is helpful from a standardization perspective. A common approach will reduce confusion among organizational divisions and increase understanding and acceptance of risk management throughout the airport community.

CHAPTER 3

Using the Guidebook

The guidebook provides tools, examples, and guidance to help airports manage safety risks using the SRM process. Airport operators can use the guidebook to develop scalable SRM processes and procedures.

The guidebook provides sections and chapters that can standalone. An airport manager need not need absorb all contents to start using SRM. For example, Appendix B, which provides the basics for a handbook to conduct a safety risk assessment (SRA), is effective as a standalone tool. If theory and background behind process and tools are needed, users can easily find and extract such material for education and training when necessary.

All readers, regardless of their knowledge of SMS and SRM, should become familiar with the overall content and structure and then review applicable chapters more thoroughly.

This guidebook is a resource—for ideas, examples, lessons learned, methods, techniques, templates, and tools for use at their airport—airports should not consider it as required or prescriptive doctrine. This guidebook reflects input from various industries and can provide the foundation for how the airport management conducts its daily business, rather than SRM being just part of safety business.

3.1 Guidebook Organization

The guidebook has five major parts. Each part has several chapters, as shown in Figure 3-1. Each part builds on the previous part and provides the user with information and tools necessary to develop and set up SRM. The appendices have additional material, such as tools, templates, and information on baseline risks, to help airports carry out SRM processes.

- **Part I** discusses the guidebook's structure (see Figure 3-1). Part I presents key terms and explains how key ideas, hints, and concepts are highlighted.
- **Part II** presents basic SRM concepts. Part II helps the reader understand SRM, where it fits within the airport SMS, and its relationships with other SMS components. Part II also addresses how SRM improves airport systems and projects.
- **Part III** explains how to apply SRM. Part III also describes (1) how to use the five steps of the SRM process to address hazards and identify actions to mitigate risks and (2) the continual interaction between SRM and Safety Assurance (SA).
- **Part IV** presents SRM processes in the operational sense. Part IV describes how routine hazards are dealt with every day and how they are documented for further analysis. When non-routine hazards are present, such as those associated with airfield construction or special events, Part IV helps the user recognize SRM triggers and when to gather a team to conduct an SRA. Part IV also describes the decision and implementation processes for risk mitigations.

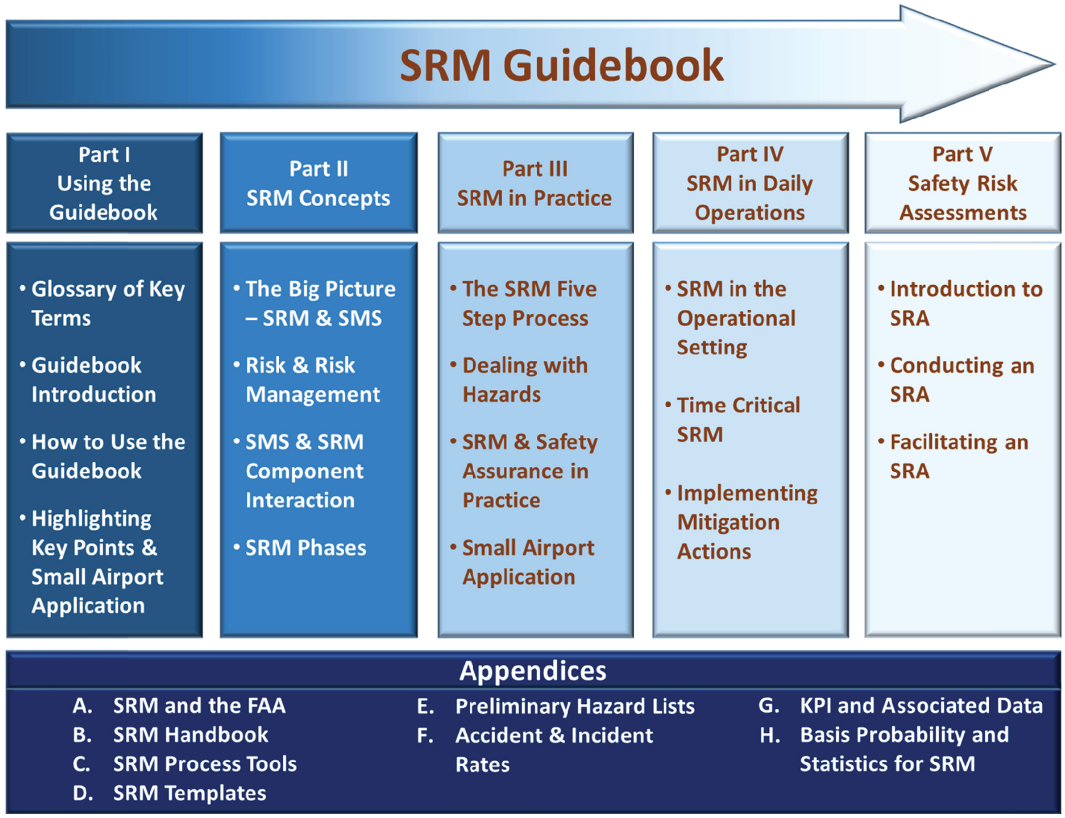


Figure 3-1. Guidebook outline.

- **Part V** focuses on procedures for evaluating more complex hazards using SRA techniques and templates. Part V addresses SRA planning, facilitation, and reporting, including specific facilitation techniques and support material available in the appendices, such as preliminary lists of hazards and baseline risks.

3.2 Key Concepts

The guidebook is organized so that important concepts are easily located. The Contents and Figure 3-1 tell where to find parts, chapters, and key concepts. The appendices include various tools, templates, and samples. For example, there is a sample SRM handbook that can be removed, reproduced, and used to guide the formal application of SRM.

To direct the user to key SRM aspects and identify where and when they apply, the guidebook uses text boxes with icons as indicators. They are as follows:

This icon and text box point out **Key Aspects** of the guidebook.

This icon and text box point to important concepts and how they **Apply to Small Airports**.

This icon and text box point out **Potential Bottlenecks** and practical alternatives to overcome such bottlenecks.

This icon and text box point to **Examples and Practical Recommendations**.

CHAPTER 4

Small Airports

For this guidebook, a small airport is non-primary and has fewer than 20 employees working full time. Most small airports have limited resources and staff to manage an SMS and to run SRM processes. Despite these limits, small airports can benefit from using SRM concepts and applying the templates and tools presented in this guidebook.

At the end of each part, a section is devoted to helping small airports set up SRM using available resources. The Small Airport icon points out guidance for small airports throughout the guidebook.

Regardless of pending regulatory requirements, small airports can use the SMS and SRM concepts described in this guidebook to manage safety issues at the airport actively and effectively.

PART II

Safety Risk Management Concepts

Part II presents key concepts about SRM and identifies where it fits within an airport SMS. Those leading the SMS and SRM efforts at an airport must fully understand these elements and educate airport personnel on the aspects relevant to their safety roles and responsibilities.

CHAPTER 5

The Big Picture—SRM and SMS

An SMS enables an airport to (1) anticipate and manage safety risks before system failures occur and (2) find out how to improve safety after accidents and incidents have happened. Airports have been pursuing these goals since long before SMS was introduced to the industry. With SMS, airports can move from sporadic and isolated safety initiatives to a systematic process in which the entire airport works in a coordinated, more effective manner.

The success of an airport's SMS hinges on identifying potential hazards and deciding the likelihood of accidents occurring and then using this information to make decisions in time to lessen unacceptable risk. SRM also includes monitoring mitigations to find out their effectiveness and to start future hazard mitigation plans. This is what SRM does and the reason that SRM is considered the "heart" of an SMS.

Even with the importance of SRM, its effective use cannot improve safety performance by itself. Effective SRM application works in coordination with the other three components of SMS: Safety Policy, Safety Assurance, and Safety Promotion. The four SMS components work in concert and continuously. None exists as a standalone element and each component provides inputs to and supports the others.

SRM is the primary operational component of the airport SMS. SRM is used by every airport function to manage risks at the airport every day. Effective SRM needs the active participation of all personnel at the airport (that is, airport staff, airlines, tenants, business partners, and other stakeholders). For SRM to work to benefit the airport, those involved in flight operations, emergency response, ground handling, and facility maintenance must constantly watch for conditions that could disrupt aircraft operations and the flow of people and cargo or cause damage to the assets needed to promote air transportation.

To explain how the four components of a Safety Management System (SMS) integrate, an example of an airport considering how to manage an increasing birdstrike rate follows.

A study identified the top ten airports with the highest rates of birdstrikes in the country; the sign was the number of birdstrikes causing adverse effect on flights. The example airport was one of the top ten airports. Adverse effects of a birdstrike can range from damage to aircraft to aborted takeoffs and delays.

Examples for each component of SMS in relation to the scenario for birdstrike rates follow:

- **Safety Policy:** The airport management decided to act to lessen the number of birdstrikes. The goal was to reduce the birdstrike rate by 20% every year, for 3 years. A special meeting with the SMS Accountable Executive, the Director of Operations, the wildlife management staff, and the SMS Coordinator was scheduled for once a month.
- **Safety Risk Management:** With the goal set by the airport management, airport personnel conducted an SRA to identify hazards and develop actions to lessen the number of birdstrikes at the airport. The SRA was conducted with the help of a panel composed of airport staff members, two SMEs on birdstrikes from outside the airport staff, and an SRA facilitator. During the SRA, a statistical summary of birdstrike data showed the species with the highest number of birdstrikes and the periods of the year with the highest frequencies and ranked the species causing the highest number of birdstrikes with adverse effects. The SRA used the SRM 5-step process recommended by the FAA. Some actions were identified and approved to reduce the attraction of hazardous species and to harass or deter those species. It was thought that performing these actions would lessen the rate of birdstrikes to achieve the goal set by airport policymakers.
- **Safety Assurance:** The SMS Coordinator defined the number of birdstrikes with adverse effects as a new safety performance indicator for the airport. Data on birdstrikes was collected monthly to record the total number of birdstrikes, the number of birdstrikes with an adverse effect, and the birdstrikes associated with the species with the highest risk identified during the SRA. Data were collected in coordination with all tenant airlines and the general aviation community. During the monthly meetings, the SMS Coordinator, with the wildlife management staff, presented trends to the Accountable Executive and the Director of Operations.
- **Safety Promotion:** In the SRA, incorporating a risk-based approach to wildlife management was identified as an airport gap. The SMS Coordinator developed and delivered a special training program on SMS for wildlife staff. Operations inspectors and maintenance staff were asked to report to wildlife management when certain species of birds were on the airside and posters with birdstrike hazard themes were prepared to remind staff to report. The airport bought and used new tools for harassing and deterring hazardous species. At the beginning of project implementation, and throughout the effort, the airport manager communicated with personnel and explained the actions taken and the reasons for the actions, as well as periodic progress reports on the success of the actions in reaching the airport's goal.

Conclusions drawn from this example follow. The airport management *policy* decisions set a goal to lessen birdstrikes, to support the effort by keeping track of results, and to allocate resources for equipment needed to carry out risk mitigation actions, which set the stage for the SRM process to be successful. Keeping track of birdstrike data and trends is an important *assurance* element that shows the actions defined by the SRM process are working to meet the goal. If trends show the rate of birdstrikes is not decreasing, or the decrease will not meet the goal set by the airport's management, these results might trigger another SRA to identify more actions. The training developed for airport stakeholders and the messages from the airport manager helped *promote* awareness, understanding, acceptance, and support for the safety improvement initiatives. The approach to reducing the risk of birdstrikes was anchored by SRM activities and supported by actions that fall under the other SMS components.

Safety Risk Management (SRM) will not be effective without the safety policy, safety assurance, and safety promotion components supporting SRM outputs.

Risk mitigation actions arising from SRM processes may require new tools and equipment, more training, and improved awareness. Without safety promotion and management commitment to use resources to control hazards, neither the SRM outcome nor SMS performance will be effective.

CHAPTER 6

Risk and Risk Management

This chapter presents basic concepts of risk and how it is managed. The terms hazard and risk are explained in detail, how hazards and risk relate is outlined, how risk is classified is described, and how SRM interacts with the other SMS components is further clarified.

6.1 Hazards

In addition to the definitions provided in Sections 1.2 and 1.3, ICAO and the FAA clearly define a hazard. According to ICAO, a hazard is a "condition or object with the potential of causing injuries to personnel, damage to equipment or structures, or reduction of ability to perform a prescribed function." The FAA uses this definition—"a condition that could foreseeably cause or contribute to an accident."

Some hazards are obvious, like a worn out tire. When driving, a flat tire may cause loss of directional control or braking capability, which may lead to an accident. Other hazards are more intangible. A passenger bridge operated by personnel with inadequate training may cause damage to an aircraft arriving at the gate.

Some hazards are common to all airports—jet blast or rotating propellers, and hazardous materials like fuel, oil and hydraulic fluid. The existence of these materials and equipment by themselves does not set up a hazard; but when humans are exposed to them, or operations are conducted contrary to normal procedures, these materials and equipment can become hazards.

> The materials and equipment common to the airport industry are not in themselves hazards. When they become part of a dangerous condition, like the rotating propeller example that follows, they are considered hazards.

Rotating propellers are not hazardous when the aircraft is taxiing on a taxiway with no personnel or equipment nearby. However, when the aircraft is parked at a loading gate, with one engine running (rotating propellers) and ground crews and equipment are servicing the aircraft, then the rotating propeller presents a hazardous condition. Harm to a person or damage to equipment could occur if contact is made with the spinning propeller.

Each individual airport will also have unique hazards based on their configuration and procedures. Airport personnel recognize and understand many of these unique conditions. These well-known hazards may affect many systems or situations in different ways and, therefore, are routinely identified during the SRM process. Developing a *preliminary hazard list (PHL)* is a timesaving SRM technique. The PHL can be a catalyst for proper hazard identification. Appendix E lists some common airport hazards.

> Airports should be wary of relying too heavily on a PHL. It can become a crutch and be considered as a definitive source that includes all airport hazards. The SRM process can start with the preliminary list, but then staff need to dig deeper into the system under consideration and anticipate more hazards. New hazards can then be reviewed and considered for addition to the list.

Ways to identify hazards at an airport follow:

- **Checklists:** checklists prepared for self-inspections may include the presence of FOD, pavement deterioration, and faults in the lighting system and signs.
- **Observation and experience:** an operations inspector is continuously searching for anything that may pose a safety risk to airport operations, even when not listed in the self-inspection checklists. Examples of hazards in this category include vehicles speeding on the ramp and equipment parked outside designated areas.
- **Brainstorming:** this is the most common method used during SRAs. A group of stakeholders meet to identify hazards and analyze risks. During the brainstorming session, the group develops a list of hazards associated with the issue being assessed. Brainstorming is a common basis for Preliminary Hazard Analysis (PHA), Comparative Safety Assessment (CSA) and Operational Safety Assessment (OSA).
- **Accident/incident investigations:** when studying the causes of accidents and incidents, the hazards and contributing factors to the event are identified. For example, an airside driver struck an aircraft causing minor damage during a ground handling operation. The accident investigation revealed the brakes failed when approaching the aircraft, which resulted in a collision. Improper vehicle maintenance and a violation of standard procedures were identified as hazards leading to the incident.
- **Job hazard analyses:** this is a technique that uses job tasks to identify hazards. A job hazard analysis explores how the worker, the specific task, the required tools, and the work environment relate. For example, an airport maintenance worker using a chipping hammer to break concrete pavement during repair work is subject to flying particles. The job hazard analysis identifies flying concrete particles as a hazard that can cause injuries.
- **Preliminary hazard lists (PHLs):** based on the safety issue or activity, preliminary lists of hazards can be prepared using a PHA (see the example in Appendix E).

6.2 Risk

Before understanding how risk can be managed, it is necessary to fully understand what risk is and how it relates to hazards. Risk combines two components: likelihood (or probability) and severity. Under the SMS approach, risk is the probability of an undesirable event occurring.

Although risk is sometimes represented as a mathematical equation (risk = likelihood × severity of outcome), risk is not calculated using this formula to come up with a quantitative value. The "risk formula" is a simple representation that the parameter (risk) has two components (likelihood and severity).

> The terms **hazard** and **risk** are often used synonymously. This is incorrect. A hazard is a condition that can present risk to the airport. The risk is the likelihood that the hazard will cause an undesirable outcome and the potential severity of that outcome. This is a key point for all airport personnel to understand. An airport with strong SRM processes in place has all airport personnel identifying and reporting **hazards**.

The analysis of risk is one of the steps of the SRM 5-step process and is addressed in detail in Chapter 9. For the discussion herein, the two components of risk can be illustrated by an example of how risk is analyzed for issues facing an airport. Suppose an airport has experienced two runway excursions in the past 6 months and wants to find out the risk of future excursions occurring. Several hazardous conditions can result in a runway excursion—the outcome.

> To explain the two components of risk, severity and likelihood, runway excursions at an airport are used here as an example.

6.2.1 Severity of Outcomes

The outcome is the effect of a hazard and the undesirable result the airport wants to avoid or control. Describing the outcome is always the first step in defining the risk. In this case, the outcome can be defined as "an aircraft accident resulting from a runway excursion." According to NTSB, an aircraft accident is "an occurrence in which any person suffers death or serious injury, or the aircraft receives substantial damage." If the event results in no death or serious injury and the aircraft receives no substantial damage, the event is considered an aircraft incident.

The difference between accident and incident is important because the outcome and its severity are related. The severity of an incident, by definition, is lower than that of an accident. It is also important to know that within the "accident" and "incident" categories are many possible outcomes. One possible outcome is a runway excursion incident with the aircraft staying in the

> Airports should resist the temptation to predict that all hazards will result in a fatality or major damage to assets, such as an aircraft hull loss. Although a fatal accident may happen, these are rare events and may not be considered likely outcomes. For example, a wingtip collision may lead to catastrophic outcome if fuel is spilled and ignited; however, historically no such accidents have occurred in the United States with commercial aircraft and, therefore, a more believable outcome for aircraft wingtip collision is aircraft structural damage or a delay in operations.

paved areas off the runway—on the runway shoulders, for example. In this example, the severity of the outcome is considered minor because no damage to the aircraft or injury to crew members or passengers occurred. The range of outcomes associated with a hazard is normally classified according to the severity of each possible outcome.

6.2.2 Likelihood

The likelihood component of risk is the estimated probability or frequency, in quantitative or qualitative terms, of a hazard's outcome. In other words, how often does or could the undesirable outcome happen? The airport safety data records can be the source of likelihood information if such an event has occurred at the airport. If the airport has never experienced a potential outcome of a hazard, other airports may have had such an event or agencies may have estimated based on historical data. Occasionally, the likelihood will need to be estimated based on the experience of airport personnel.

Continuing the runway excursion example, the likelihood of an aircraft leaving the runway will vary depending on the hazard leading to the outcome. If one of the excursions occurred because the runway was wet from a heavy rainstorm prior to landing and the airport is in Arizona, the likelihood may be determined as highly unlikely for such an outcome to reoccur in the next year or more. However, if the excursion happened because of ice on the runway and the latest event occurred in December in Minnesota, the likelihood may be determined to be likely to occur during the winter; thus the airport may need to consider actions related to the snow removal plan. Chapter 9 presents more detailed discussions of likelihood.

Appendix F presents some likelihood values based on historical data from accidents and incidents and associated with common airport risks. Appendix H presents basic concepts about probability that should help airport staff in finding out outcome likelihood. Appendix H also explains the basic notation used to characterize probability values.

6.3 Risk Management

This section discusses the overall concept of risk management; this discussion is separate and in more general terms that cover the SRM 5-step process presented in following sections of this guidebook.

The SRM component of SMS comprises five steps: (1) describing the system, (2) identifying the hazards, (3) analyzing the risk, (4) assessing the risk, and (5) mitigating the risk. The SRM process is used for all identified issues affecting safety, regardless of airport complexity or size. A safety issue could be simple (some debris found on the runway during a daily inspection that can be immediately fixed) or complex (a construction project needing a more detailed SRM analysis).

Not all risk can be removed; the goal in most cases is to lessen the risk (by either reducing the **likelihood** of an undesirable outcome or reducing the **severity** of the outcome) to an acceptable level. Managing risk is to take actions to control unacceptable risks and use available resources to improve the overall safety of airport operations.

Risk management is a decision-making process applied to control risks associated with a single or multiple hazards. An airport always has multiple hazards to control and the risk management process involves assessing and classifying each risk, defining control measures, and allocating the resources needed to implement the controls. These actions are carried out so risks can be compared and ranked to make the best use of limited resources to control the risks.

Sometimes a single risk is identified during self-inspections or perhaps by means of a pilot (weather) report (PIREP) and is immediately assessed as unacceptable (for example, FOD on the runway). In such cases, the airport takes immediate actions to control the risk (for example, remove FOD).

In other situations, a project is planned (for example, taxiway construction), new equipment (for example, passenger bridge) will be installed, or a new SOP is developed. Some new hazards can be expected for each project plan. Most of the hazards, at least the most critical ones, should be identified and risk mitigation measures performed to control the risks to acceptable levels. Figure 6-1 shows the concept of multiple hazards that may exist and should be managed across multiple airport functions.

The large shapes represent airport functions, assets, and projects. To each of these components a series of hazards (represented by the small triangles) can be associated and some of these hazards may be common to two or more functions, assets, or projects. Personnel must realize that an airport deals with multiple hazards and the resources available may not be enough to remove every risk at the airport. Therefore, the best way to deal with airport risks is to use risk management tools to identify and rank the control of higher level risks.

To identify and rank the risks for control, personnel can use specific techniques and processes. This guidebook presents these techniques and processes. The basic tool used in risk management is the 5-Step SRM process recommended by the FAA.

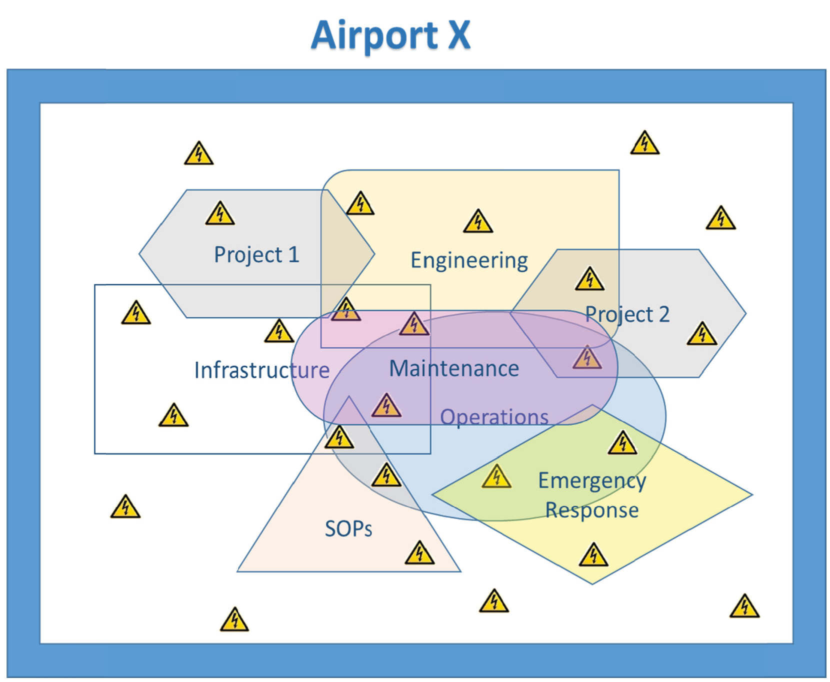


Figure 6-1. Concept of airport hazards.

6.4 Risk Classification

One key task in risk management is to classify the risks. Risk classification allows one to rate the risks according to acceptability and use a consistent reference to compare risks—a reference that is relevant no matter which airport function or project is being addressed. Using the same "measure" for every risk allows for comparisons, prioritization, and effective management.

A **risk matrix** is a tool used to assess the risks associated with a particular hazardous condition. A risk matrix provides a way to decide where a risk fits into an airport's predetermined levels of risk tolerance. The risk matrixes found in the FAA and ICAO guidance reflect five levels of severity and five levels of likelihood, also referred to as a 5x5 (five-by-five) matrix. Regardless of the number of levels for either severity or likelihood, the definitions for each level need to represent the local conditions and risk tolerance of the individual airport. A 5x5 risk matrix is the most common matrix structure used in aviation.

Each airport should adopt a matrix that fits its needs and complexity. Appendix D provides examples of risk matrixes.

6.5 SRM and SMS Component Interaction

In Chapter 5, the role of SRM within the airport SMS was presented. SRM is one of the **operational** components of an SMS. This section explains the relationships and interactions between SRM and the three other SMS components.

6.5.1 SRM and SA

SRM and SA are considered the operational components of the SMS. They are directly linked and work together; the output of one directly supports the other. The SA component encompasses the monitoring and measuring functions of the SMS. For the SRM process to fully support operations and safety performance improvement at an airport, the mitigations must be monitored and measured to decide their effectiveness.

Figure 6-2, from FAA Order 8040.4A, shows how SRM and SA relate. There are two flows in the diagram, one relates to the SRM process and the other is associated with SA. The information created by SRM feeds the SA process, and the information produced by SA feeds the SRM process. To clarify this idea, we return to the birdstrike hazard example presented earlier.

How SRM and SA relate is explained here by returning to the birdstrike example presented earlier.

An airport found the number of birdstrikes per 10,000 aircraft movements causing damage to aircraft was high compared to the rate found in other Part 139 airports. The airport then decided to carry out the SRM process to discover the reasons for the higher rates and how to mitigate future risk. During the SRM exercise, made easy by the SMS Coordinator and with the participation of airport staff involved with wildlife management, data from the FAA Wildlife

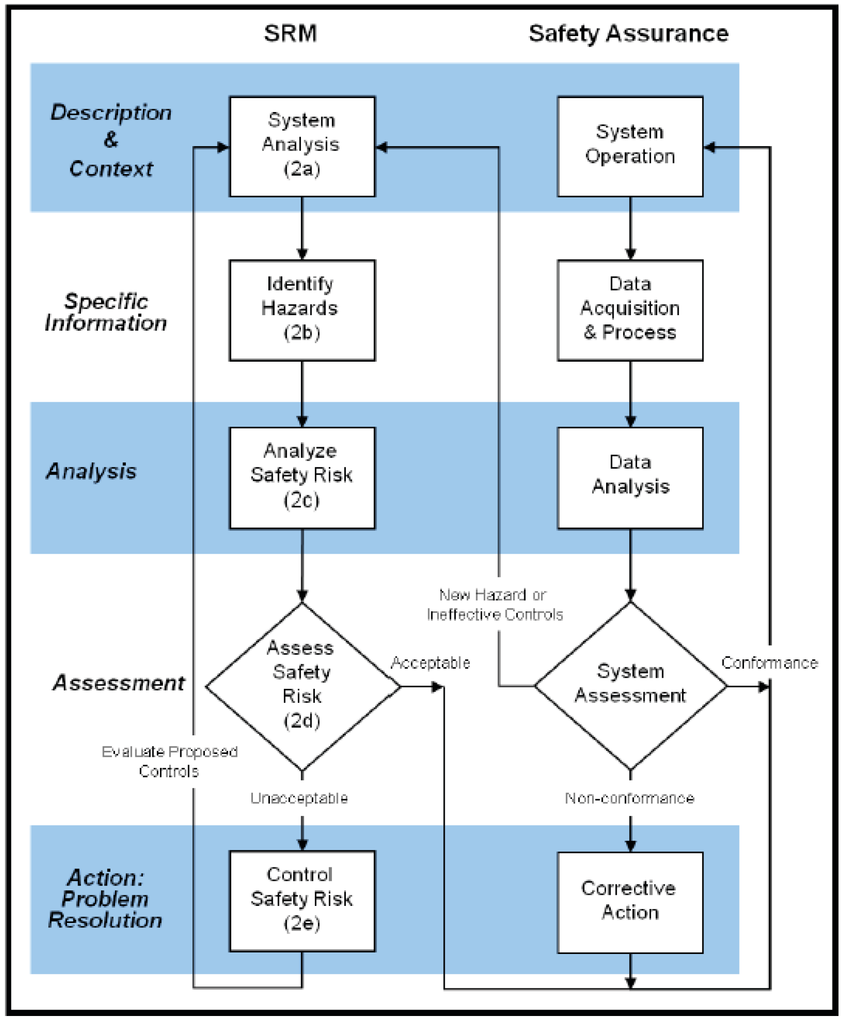


Figure 6-2. SRM and safety assurance processes (FAA Order 8040.4A, 2012).

Strike Database showed that five bird species were responsible for 92% of birdstrikes causing damage to aircraft and the risk was classified as high. With the exercise complete, the wildlife team proposed new actions to target the presence of those five species in the airport area. The actions were approved by the Director of Operations and were implemented over 6 months. All these actions were part of the first SRM cycle for the safety issue.

A parallel SA process was created to monitor the number of birdstrikes associated with the five bird species identified during the SRM. Data were collected monthly, and a performance indicator was defined as the number of birdstrikes associated with the five species identified. Data were analyzed for every month and the performance indicator was calculated and compared to the baseline rate calculated during the SRM. Trends were noted and after 1 year, the number of birdstrikes had decreased but not significantly. Because results were not considered satisfactory, a new SRM exercise was scheduled to find alternative control actions that could be more effective.

The risk assessment step generated the need to monitor birdstrike data and check for trends. Monitoring or system assessment is part of the SA component of SMS. When the monitoring and assessment of trends revealed unsatisfactory results during the SA cycle, the process led back to SRM and the need for a new SRM cycle associated with the same hazard. Thus, the two SMS components support each other and eventually lead to improved safety performance.

Some airports involved in early SMS development designed their SRM process with six steps versus five; the sixth step being to monitor mitigation actions. Other high-risk organizations using SRM include monitoring (or supervision) as part of the fifth process step. Regardless, the mitigations selected to decrease the risk need to be monitored to assess effectiveness. The audit and metrics monitoring functions of SA all work to support the continuous process of SRM. Feeding back the monitoring data from SA allows airport personnel to reassess risk, find out the residual risk that follows from mitigation, and, perhaps, identify new hazards with the SRM process starting a new cycle.

6.5.2 SRM, SA, Safety Promotion, and Safety Policy

The relationships among the components of an SMS resemble a wheel, with SRM as the hub. SRM supports **safety policy, safety assurance**, and **safety promotion**. A key SMS responsibility for airport management is to set safety objectives and goals for the airport. These performance targets are part of the airport safety policy. The ability to find out or measure the success of risk mitigation actions stemming from the SRM process depends on the existence of data and measures that can be tracked and analyzed by SA processes. Thus, the airport safety policy sets up the metrics by which the success of SRM is determined. If satisfactory metrics do not exist at the airport, then the SRM process actions may trigger a review of safety policy and modifying of airport goals and objectives. The mitigation actions defined during the SRM process will undergo an approval process by management. That approval and the resulting allocation of resources help prove airport management's support for the SMS and their safety policy, as well as their commitment to improve airport safety. The commitments of resources for improvement, coupled with feedback from airport management, are parts of safety promotion at the airport. Additionally, when performing the SRM and SA processes, some risk mitigation actions adopted fall under the umbrella of the safety promotion component. For example, when a new SOP is developed, the SRM process is used to ensure the safe implementation of new procedures. Recommended mitigation actions may include developing a training program for operators of new equipment or displaying posters to improve safety awareness when new equipment is introduced. These actions, while performed because of effective SRM, are also safety promotion initiatives that double as risk mitigation actions so that the SMS wheel continues to revolve around the SRM hub (see Figure 6-3).

Figure 6-3. The SMS wheel.

CHAPTER 7

SRM Phases

Earlier chapters explained the importance of risk management for airports. Every airport has multiple hazards to control. Some hazards are specific to certain airport activities and functions, while others are common to two or more activities. Many activities will involve different phases. For example, a construction project always includes planning and design phases, a preparation phase, and the construction or execution phase. Another example is a special event like the Super Bowl, or a popular college game in a small town. Again, the airport must plan for the changes in operations the event will bring, prepare the airport before the event, and then carry out the plan to help the event go off smoothly.

A construction project and a special event present major changes to an airport's operation and SRM should be used to identify and address any new hazards that such changes introduce. However, hazards associated with each phase can be different and the best approach is to conduct the SRM process for each project or event phase.

Often, an SRM approach can be helpful to deal with unanticipated hazards to daily activities as well. Imagine that a large fuel spillage from an aircraft has occurred on the ramp. Several hazards surface in a situation like this. During the response to the event, there is little time to use a formal planning/preparation/execution approach. However, this type of incident can be expected to occur on occasion and emergency response crews plan and prepare ahead so that the airport response crew is ready to execute appropriate mitigation plans.

The application of SRM during the three phases differs in the time allotted to process execution, the effort and detail put into each of the process steps, and the experience of the people using the process. The three basic phases of SRM thus mirror the project phases: the planning phase, the preparation phase, and the execution phase.

7.1 Planning Phase

The planning phase of SRM is the most disciplined phase—there is enough time to examine fully the system involved and the hazards associated with the system. In other high-risk organizations (such as the oil and gas industry) this phase is referred to as the In-Depth Level of risk management.

Safety risk assessment (SRA) techniques described in later chapters are commonly used during the planning phase. In the planning phase, SMEs are consulted, and all appropriate stakeholders in the system are involved. As with an SRA, this level is often carried out by gathering a panel so those involved can brainstorm and discuss the issues face to face.

Planning and designing a new terminal is used here as an example.

As an example, an airport decides to build a new terminal. During the planning and design phases, the location and the size of the terminal are defined, and any impacts to the airfield. Many potentially, permanent hazard conditions can be avoided through an effective planning phase SRM—line-of-sight limits on the ATCT personnel, airspace impacts, potential interference with existing and/or proposed surveillance equipment are just a few.

In the planning phase, time is usually not a constraint. This phase typically addresses large projects and complex evolutions that involve many parties, both inside and outside the airport organization. Time is available to research and gather the data needed to assess the risks fully and accurately.

Conducting an SRA is perhaps the best known technique applied to this SRM phase and it can become a valuable component of any airport planning evolution. The best decisions are made in a risk-informed manner. Applying the SRM process in all airport planning evolutions will improve the overall effectiveness and thoroughness of the plan.

In the planning phase, the SRM process is often revisited on multiple occasions. As assignments to research issues and gather information are completed, panels can be reconvened to review the SRM process results and update the outputs of the process. This keeps the process alive and relevant. The effectiveness of updating risk information can be increased during large projects with extensive periods of execution through the regular meeting of stakeholders, or *risk reviews.*

7.2 Preparation Phase

The preparation phase of SRM is performed immediately before a planned special or even a routine event. In other high-risk organizations, this level is known as the *deliberate phase* of risk management. The preparation phase can begin a few weeks before a special event, or a day before a complex but reoccurring operation. In this phase, the SRM process is used to (1) ensure that all hazards and risks identified in the planning phase are still relevant and (2) identify and assess any new hazards and risks that may have surfaced or can be anticipated during the execution.

The preparation phase occurs between planning and execution and is often applied immediately before implementation of the proposed change. This time frame may not allow for the research and data gathering performed in the planning phase, however, it still gives the responsible party the opportunity to ensure that appropriate stakeholders are involved in preparation. It also should provide time for pre-event briefings to address the risks faced and how such risks are to be mitigated. Finally, it allows opportunity to address environmental conditions and human performance issues that cannot be foreseen far in advance.

Middle managers and team leaders are particularly involved in the preparation phase. The results of the preparation level SRM can keep senior leaders informed, but the true value is in keeping the executing team's thinking focused and aware of the risks involved.

To show the difference between the planning and preparation phases, consider an airside construction project. Before starting the project, a Construction Safety and Phasing Plan (CSPP) is prepared and pre-construction meetings take place to define construction phasing and how hazardous situations will be managed. Examples of safety issues considered during the planning phase and the development of the CSPP include FOD control, definition of haul routes and escorting procedures, potential impacts on operations, coordination, and interference with NAVAIDs.

During the days just before the start of project work is the preparation phase—there is still enough time to work through the 5-Step SRM process, and management should ensure the team is disciplined and uses the process to improve the evolution. The SRM process is used to evaluate the risks posed by the latest weather forecasts, recent changes in personnel, and the potential performance levels of those who will carry out the project. Preparation phase SRM is still active

A common pitfall is to assume that all hazards have been effectively assessed and mitigated before operational execution and simply run through the steps as a formality—in other words, "check-the-box." A way to avoid the hasty, cursory use of the process at the preparation phase is for the responsible party to ask his or her team, "What has changed since we first planned this event?" This question can reengage the team's thinking and invigorate risk-based decision making.

in nature and enables leaders to focus project planners, supervisors, and workers on the hazards and levels of risk they will face.

7.3 Execution Phase

The execution phase of SRM involves the techniques used to manage safety risks during the execution of an event or task. In other high-risk industries, this phase is known as *time-critical risk management.* In the planning and preparation phases of SRM, management and leadership are at the forefront of ensuring proper application of the SRM process. At the execution phase, all participants should have a working knowledge of SRM and all involved must be aware and attuned to unanticipated hazards presenting new, often unmitigated risks to the success of the operation.

Often, the outcomes of hazards are realized because of the actions of the most junior personnel or those performing the task. During task execution there is little time to run through all SRM process steps formally. In the execution phase, those involved may be able to take time to evaluate, identify, and assess the new risk. At other times, they may have to act in the moment and need to be able to recognize and act to control risk. In the latter case, having an easy way to remember and act on processes can be of great value to the individuals involved.

In most cases, hazards produce losses and undesirable outcomes during the execution phase of airport activities. Those performing airport tasks must understand SRM and effective risk management tools to manage the risks they face in execution.

In the example of fuel spillage, an SOP can help the emergency response crew remember the sequence of actions to control the issue safely. There is little to no time to use a formal SRM during execution to control fuel spillage.

CHAPTER 8

SRM at Small Airports

The SRM concepts presented in this part are equally applicable to small airports and to large, complex airports. Many small airports may not have the resources to implement a formal SMS with staff that has full-time responsibility to coordinate an SMS; however, despite the seeming difficulty of having the right resources to perform an SMS, coordination and communication at a small airport are more direct, with frequent face-to-face discussions during the day. The number of hazards identified during daily inspections or PIREPs is low and hazards may be more manageable as compared with larger airports because there are fewer layers in the decision-making process.

Hazards may be identified during routine tasks if the airport has a positive safety culture and SMS and SRM concepts are known by both senior and front line staff at the airport. For small airport operators, a wide understanding of the general concepts presented in this guidebook may be more important than using formal SRM processes. In many situations, the manager of a small airport will see an unsafe situation that is not so obvious and take intuitive actions to eliminate the hazard. However, if the manager is familiar with SRM concepts, a brief, informal brainstorming session with his or her staff will help identify and control other hazards that were not on the manager's "intuitive" list. These types of SRM exercises will continually improve safety awareness and help to instill a positive safety culture in the staff of the small airport.

The effective use of SRM processes is explained here using the towing of aircraft as an example.

Consider a small airport that had a few incidents and minor accidents while towing aircraft from the ramp to hangars. Besides the monthly briefings to improve safety awareness, the airport manager met with the Supervisor of Operations and Safety and the individuals responsible for the towing operations. The airport manager used the SRM approach and identified the ramp and hangar areas, personnel and equipment involved with the coordination and processes associated with the towing operation. The incidents were reviewed and a "5-Why" approach was used to identify the hazards or root cause of the incidents. The towing operation was divided into different tasks and hazards and things that could go wrong were identified for each task. In a couple of hours, the group decided to develop an SOP for towing, use a wing-walker for each towing operation, and prepare posters to remind the crew of the basic procedures. This example explains how the SRM approach helped a small airport operator improve the safety of a routine evolution and enhance the operational performance of the airport.

PART III

The SRM Process and Application

Part III presents the 5-Step SRM process and how to apply it in daily operations. Understanding the SRM process is the first step to understanding the many ways it can be applied. Part III includes examples of when SRM is applied and a chapter specific to small airports.

CHAPTER 9

SRM 5-Step Process

Having a collective understanding by all airport personnel of SRM concepts and using a common risk management process can increase the likelihood of successfully managing safety and other organizational risks. Managing safety risk can take various forms, both formal and informal. Using airport SRM methods based on a disciplined, systematic process can promote understanding of foundational SRM techniques; this makes application easier to accept and more successful. This chapter discusses an FAA-recommended 5-Step SRM process used by many airports carrying out an SMS. The 5-Step SRM process follows this sequence:

1. Describe the System
2. Identify Hazards
3. Analyze Risks
4. Assess Risks
5. Mitigate Risks

9.1 Step 1—Describe the System

To manage risk effectively and prevent undesirable outcomes, personnel must understand the system under review. The **system** consists of parts, components, organizations, functions, and personnel interacting to produce a desired outcome. The system may be the airport as a whole, as is often the case with a major construction project. Alternatively, it may be a smaller part or subsystem of the airport, such as the runway lighting system or the system to move people through the terminal (for example, elevators, moving walkways, passenger carts, and airport ambassadors) or a defined hazardous area on the airside (e.g., the aircraft parking ramp).

Many industries use the **5M Model** to describe a system. The model offers an effective way to identify the parts of the system at risk. The model breaks the system down into five interacting components:

- **M**ission
- **M**an (or the hu**M**an component)
- **M**achine
- **M**anagement
- **M**edia (or environ**M**ent)

By walking through the 5M Model when reviewing the system, SRM users can better ensure that all aspects of the system are considered and that all stakeholders in the system are involved. Figure 9-1 illustrates the 5M Model.

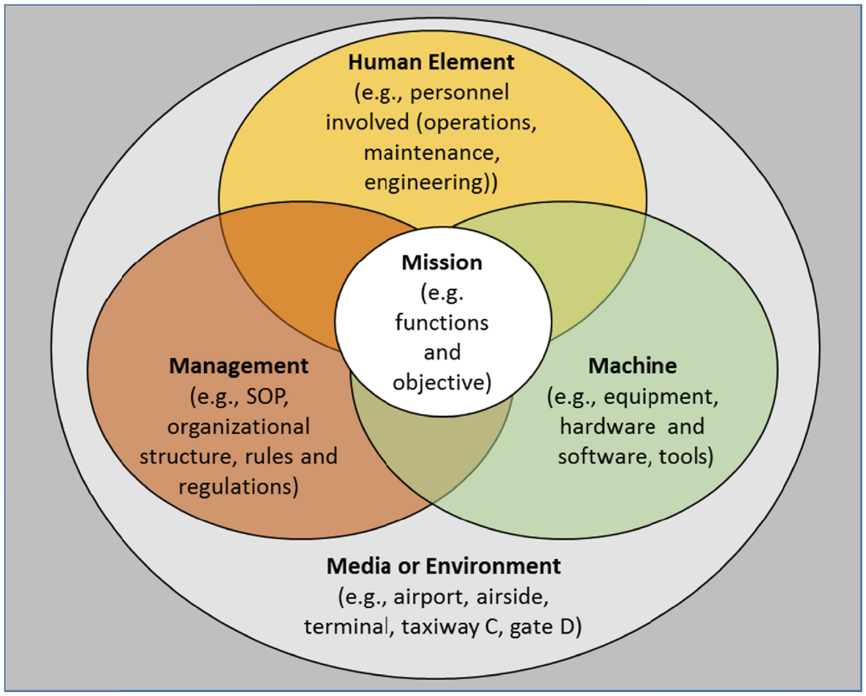


Figure 9-1. Relationships of the 5M Model.

New practitioners of SRM must remember not to exclude key people or organizations affected by the at-risk system in the SRM process.

Examples of such organizations for the airport environment include local organizations outside the airport property and all airlines and flying organizations that work from the airport. Using the 5M Model lessens the potential for unintended omissions.

Using the 5M Model to describe the system means those looking at the system describe it in terms of the mission to be performed, the media or environment in which it operates, the people who work in the system, the machines involved, and the management that ensures proper operation and output. In addition, while examining the system, users must "bound" the system, that is, they must also consider and exclude aspects that are not included in the system and parts that may be influenced by but are not part of the system. Bounding the discussion is important in focusing the SRM effort.

Here an airside construction project example is used to show how to use the 5M Model.

To show how to use the 5M Model to describe the system, the guidebook presents an airside construction project to rehabilitate a taxiway as an example. To carry out the construction project, construction equipment, personnel, and materials will be on site. Also work must be carried out so airport operations can continue safely and construction workers will be protected from harm during the entire project. In this example, the 5M Model would describe the system as follows:

- ***M**ission*: The safe movement of aircraft on the ground from runway to ramp area and vice versa. The project is described as follows: The work is to regain the functionality of the taxiway being rehabilitated and any activity needed to perform the work is included in the mission. Examples of activities are securing and marking construction area and haul routes; coordinating with ATC; coordinating with operations and engineering; transporting equipment, workers and materials; escorting trucks and vehicles; milling old pavement and making repairs; stockpiling material; controlling FOD; repaving and compacting; placing new markings; cleaning up; and reopening the taxiway.
- ***M**an*: Any person involved with the construction project who may affect construction activities. Many of the people involved are not construction workers. For example, ATC personnel who coordinate with airport operations staff and construction workers are part of this category. Airport staff securing a special "construction gate" where trucks may enter the airside are also in this category.
- ***M**achine*: Any equipment and tools involved with the construction activities defined in the ***M**ission.* This includes trucks, pavers, compactors, milling machines, escorting and inspection vehicles, communication equipment, barricades, aircraft, airfield lighting and other systems, navigational aids, and communication equipment.
- ***M**anagement*: Any coordination and communication activities associated with the ***M**ission.* Coordination and communication within the construction crew, between ATC and aircraft, and operations, between operations and contractors, and so forth.
- ***M**edia (environ**M**ent)*: The media represents the physical area involved in the project, including the weather and conditions that activities are subject to during construction. The physical area includes the taxiway being rehabilitated and adjacent areas, haul routes, plant and stockpile areas, and equipment parking areas. Operational conditions may include potential low visibility, strong wind, high temperatures, and snow—all conditions when construction activities might be suspended.

9.2 Step 2—Identify Hazards

This step is critical to the SRM process and should take a significant amount of the time allotted to applying the process. As defined earlier, a hazard is

> Any existing or potential condition that can lead to injury, illness, or death to people; damage to or loss of a system, equipment, or property; or damage to the environment. A hazard is a condition that is a precondition to an accident or incident.

As stated above, a hazard must exist for an accident or an undesirable incident to take place. A hazard is the origin of risk to the airport. Airport stakeholders must make every effort to identify the hazards associated with the system or evolutions they are considering. Identifying and mitigating hazards may lessen and potentially remove the chances for loss.

When considering hazards, personnel may find it helpful to break down the discussions into categories. Similar to using the 5M Model for describing the system, categorizing hazards can help ensure all hazards are acknowledged. Examples of hazard categories include the following:

- **People**: Could the condition lead to injuries or fatalities?
- **Assets**: Could the condition result in losses of property, equipment, and/or operating funds for which the airport could be liable?

- **Environment**: Could the condition lead to damage to the environment or local pollution?
- **Reputation**: Could the condition lead to damage to the image of the airport or cause a loss in public confidence about travel to or from the airport?
- **Mission**: Could the condition hinder the airport's ability to move people and cargo to and from desired destinations?

These hazard categories will be revisited in Step 3 of the SRM process, given that this technique can also be used to analyze the severity of the hazardous condition.

Often an identified hazard is simply the result or outcome of a hazard. Personnel must not take a first suggestion for a hazard to be analyzed and assessed as the last word. As an example, one member of a group exercising the 5-step process might suggest that a vehicle colliding with an aircraft in the non-movement area is a hazard because such a collision could result in injuries to people and/or damage to airport and airline assets. While accepting this as a hazardous condition may serve the airport's purposes, an underlying cause, or true hazard, may be uncovered by asking "why?"—Why did the collision occur? Was the vehicle operator distracted, and if so, why? Was the ramp wet or icy, and if so, why? And so on.

A rule of thumb when identifying hazards is to ask "why" five times before settling on the hazard. Although there may not be five "whys" to ask, the answer to the final question will uncover the hazard that needs to be addressed.

It is common to confuse hazards with their outcome or consequences.

Example: "runway incursion" is an outcome or consequence, not a hazard. In contrast, "unclear pavement markings" is a hazard that may lead to runway incursions. (*ACRP Report 1*, Vol. 2, 2009)

Another method to identify hazards is to use the proposed condition in a "risk statement." For example

Given that (state the condition or hazard), it is possible that (state the undesirable outcome or consequence).

If that statement makes sense when read aloud, then the hazard inserted in the statement is likely valid and should be assessed. The risk statement technique is also useful in moving from Step 2 of the SRM process, identify the hazards, to Step 3 where the potential outcomes of the hazards are determined.

Continuing with the example of the Vehicle to Aircraft Collision on the ramp, the 5 Why's and the risk statement techniques can be explained. Those looking at the potential event could ask "why might a collision occur?" The answer might be that a collision could be caused during night operations because of low visibility. A follow-on "why" might be: "Why will visibility on the ramp be degraded?" The answer might be there is inadequate lighting on certain segments of the ramp area where a collision might occur. Another "why" might be "why is there insufficient lighting?" The answer might be that funding is not available or the Airport Master Plan does not call for extra lighting for certain areas, which may lead to deciding the hazard is "insufficient ramp lighting." (Figure 9-2 illustrates the preceding example.)

Using the risk statement technique with this example, such a statement might read as follows:

Given there is no funding for more lighting, it is possible a collision will occur that causes significant aircraft damage.

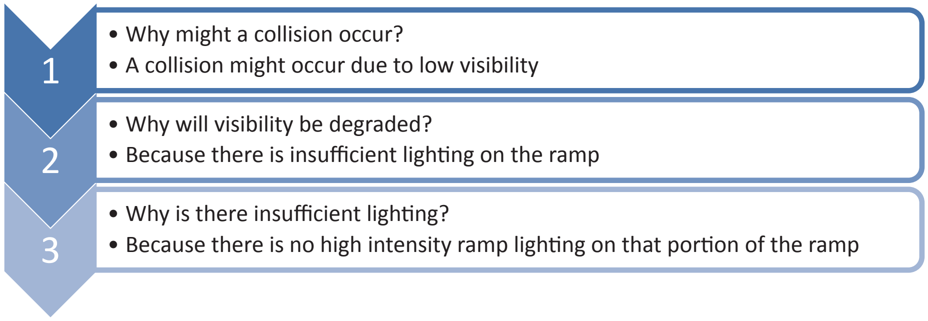


Figure 9-2. An illustration of the 5 whys.

In this example, the statement reads as if the lack of funding for improved lighting is the hazard. Although this statement may support the airport's assessment, the statement may not fully highlight a condition that poses risk that can be mitigated. This determination could lead to further dissection of the condition to better define the cause of the potential incident or hazard. This further consideration might lead to insufficient lighting being the hazard. When that condition is inserted in the risk statement, it would read as follows:

Given the insufficient lighting on select areas of the ramp, it is possible a vehicle could collide with an aircraft.

This statement makes sense when read aloud, confirms that "insufficient lighting on the ramp" is a hazard to be addressed, and is a hazard that likely gives the airport multiple mitigation options. Appendix E lists common airport hazards for various categories of activities. The lists can help readers become familiar with common airport hazards.

9.3 Step 3—Analyze the Risks

In Step 3, users analyze the elements that decide the level of risk, and the SRM process continues toward actionable risk information for decision making. There are three parts to this step:

- Decide the potential **outcome** of the hazards
- Decide the potential **severity** of the outcome
- Decide the **likelihood** of the outcome

To reiterate, the terms hazard and risk often are used synonymously, but this is incorrect. A hazard is a condition that can present risk to the airport. The risk is the likelihood that the hazard will cause an undesirable outcome and the potential severity of that outcome.

Likelihood can only be estimated after the outcome is defined.

9.3.1 Anticipating Potential Outcomes

Finding the potential undesirable outcomes of an uncontrolled hazard is the first step in analyzing the components of the risk. As suggested in using the risk statement method in SRM Step 2, identifying a potential outcome can help settle the validity of the identified hazard. But hazards can have some potential outcomes.

To continue with the "insufficient lighting" example, personnel concluded that the possibility of a collision between a vehicle and an aircraft was a potential outcome. However, other possible undesirable outcomes could result from this condition:

- Injury to personnel because of a trip or fall
- Damage to a vehicle from hitting an unseen obstacle
- An unnoticed fuel leak or spill

When deciding the outcomes of a hazard, the analysis should focus on making reasonable assessments based on credible outcomes. Many areas on an airport are host to many dangers. Working around aircraft and equipment is hazardous work. Although catastrophe is **possible** with many hazards, safety statistics show and reason backs the fact that fatalities and/or destroyed aircraft and equipment are rare. The goal is to discover **credible** outcomes—the outcomes most likely to occur. Personnel can base decisions about credible outcomes on experiences at the airport or historical events and statistics at other airports.

As discussed in Step 2, it can be valuable to consider potential outcomes according to the aspect of the airport they may affect. Potential outcomes could be categorized as follows:

- **People**: Could the hazard lead to serious injuries or fatalities?
- **Assets**: Could the hazard result in losses of property, equipment, or operating funds for which the airport could be liable?
- **Environment**: Could the hazard lead to negative effects on the environment or to increased local pollution?
- **Reputation**: Could the outcome of the hazard degrade the image of the airport or reduce public confidence about travel to and from the airport?
- **Mission**: Could the hazard degrade the airport's ability to move people and cargo to and from the desired destinations?

9.3.2 Determining the Severity

The next step in analyzing the risk is to assess the severity for each potential, credible outcome. Personnel should base the severity classification on predetermined definitions set up during the development of the airport SMS (or standalone SRM). The individual airport's management should develop these definitions so as to represent the airport's risk tolerance level—this is critical for making SRM scalable to the size and complexity of the individual airport.

Two similar methods can be used to analyze the risk. Given that a single hazard could produce multiple outcomes, one way to analyze the risk is to consider all potential outcomes and determine the severity of each. As an alternative, the analysis can be done on the **worst credible outcome**. When the most severe outcome is determined, the risk associated with the single hazard will reflect a single level of severity, followed by a single determination of likelihood.

9.3.3 Determining Likelihood

The **likelihood** of the hazard resulting in an undesirable outcome is the second of the two risk components. Given that accidents are rare at most airports, the likelihood of one occurring

For certain hazards, using the worst credible outcome and determining risk mitigation actions will also address less severe outcomes; however, often it is important to analyze a range of outcomes. For example, when dealing with birdstrikes, control actions to address large birds causing damage to aircraft may not mitigate risks associated with smaller species.

could be once in a month, once in a year, or even once in the history of the industry. Personnel can consult safety databases to research the number and frequency of occurrences for many outcomes. The most commonly referenced accident database is kept and provided by the NTSB. The NTSB is responsible for investigating all U.S.- registered aircraft accidents (among other transportation accident investigation duties).

The definitions of likelihood to be used during the SRM process should be developed during the development of the airport SMS (or standalone SRM). These definitions should reflect the history of the airport or the history of airports of similar size and complexity. Appendix D has examples of likelihood definitions used by early SMS adopters.

For small airports, researching safety databases for undesirable events at other airports may be the most productive way to determine credible outcomes. Because limited numbers of operations reduce exposure to hazardous conditions, an airport may never have experienced a certain undesirable outcome. That fact may or may not be an indication of a low level of risk.

Small airports may find the NTSB database helpful. The NTSB keeps records for all aircraft accidents investigated in the United States and its territories and for aircraft registered in the United States. From January 2008 to April 2014, there were more than 7,800 GA aircraft accidents in the United States; presumably, most of the aircraft involved were operating to and from GA airports. (NTSB aircraft accident database)

9.4 Step 4—Assess the Risks

The fourth step is to assess the risk. In this step, the likelihood and severity for each hazard are compared to the levels of acceptable risk determined during development of the SMS (or standalone SRM). This is an *initial* assessment of the risk associated with each hazard. The assessment may determine that the risk is too high or unacceptable for airport management to accept.

Tools are available to the industry to help estimate the likelihood of certain outcomes. These include the Collision Risk Model (CRM) to evaluate the probability of an aircraft colliding with an obstacle during instrument approaches, and the method presented in *ACRP Report 50* to estimate the risk of accidents during runway excursions. A risk matrix is a simple, effective, and often used tool to analyze airport risks.

9.4.1 Risk Matrix

The tool most commonly used to analyze risks is the risk matrix. A risk matrix is a simple table whose columns represent the levels of severity and the rows represent the levels of likelihood. The FAA, across multiple lines of business, has determined that a five-by-five (5 × 5) risk matrix is suitable to characterize safety risk in their varied regulatory roles in aviation, that is, five categories of severity and five categories of likelihood. The 5x5 risk matrix is the tool currently presented in the FAA advisory circulars for airports. Figure 9-3 shows the current FAA matrix. The different colors help the user identify the risk level: high risk (red), medium risk (yellow), and low risk (green). Appendix D contains more risk matrix examples to help guidebook users select or create a risk matrix that best fits their operational and safety needs.

Each level of likelihood and severity is defined so as to help the user select the most suitable combination of severity and likelihood. These defined levels reflect the risk tolerance of the airport. The definitions for risk levels adopted by the FAA in Order 5200.11 (Change 2, 2013) are presented below, followed by the definitions of severity and likelihood in Tables 9-1 and 9-2:

- **High Risk—**High risk is unacceptable within the FAA ARP SMS. If a hazard presents a high-initial risk, the proposal cannot be carried out, unless hazards are further mitigated so that risk is reduced to medium or low level and the ARP Safety Review Board recommends that ARP-1 approve the mitigations. Tracking and management of high-risk hazards and controls are required.
- **Medium Risk—**Medium risk is acceptable within the FAA ARP SMS. A medium risk is the minimum acceptable safety objective. With medium risk, the proposal may be carried out, as long as the risk is tracked and managed.

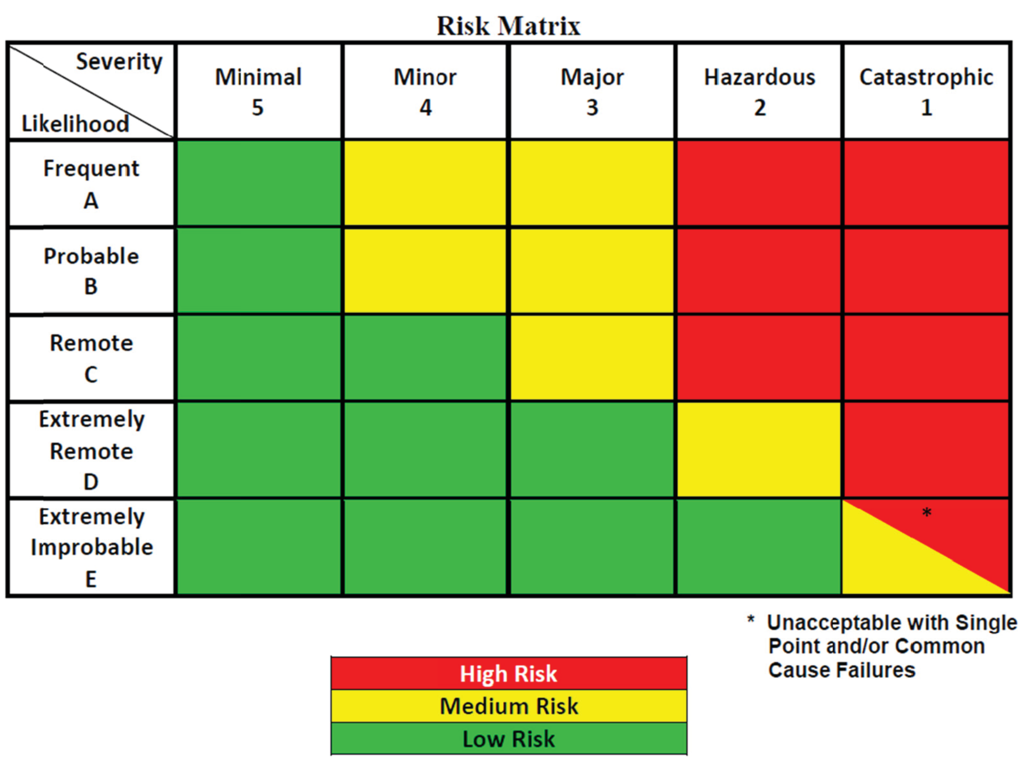


Figure 9-3. FAA ARP Risk Matrix as of July 22, 2013 (Order 5200.11, Change 2).

Table 9-1. **Definitions for severity from the FAA ARP Order 5200.11.**

	Minimal-5	Minor-4	Major-3	Hazardous-2	Catastrophic-1
ATC Services	-Conditions resulting in a minimal reduction in ATC services, or -A loss of separation resulting in a Category D Runway Incursion (RI), or -An Operational Deviation (OD), or -A Proximity Event (PE)	-Conditions resulting in a slight reduction in ATC services, or -A loss of separation resulting in a Category C RI, or Operational Error (OE)	-Conditions resulting in a partial loss of ATC services, or -A loss of separation resulting in Category B RI or OE	-Conditions resulting in total loss of ATC services (ATC Zero), or -A loss of separation resulting in a Category A RI or OE	Conditions resulting in a collision between aircraft, obstacles or terrain
Flight Crew	-Flight crew receives TCAS Traffic Advisory informing of nearby traffic or, -Pilot Deviation (PD) where loss of airborne separation falls within the same parameters of a Category D OE or PE, or -Minimal risk on operation of aircraft	-Potential for PD due to TCAS Preventive Resolution Advisory (PRA) advising crew not to deviate from present vertical profile, or -PD where loss of airborne separation falls within the same parameters of a Category C OE, or -A reduction of functional capability of aircraft but does not impact overall safety (e.g. normal procedures per AFM)	-PD due to response to TCAS Corrective Resolution Advisory (CRA) issued advising crew to take vertical action to avoid developing conflict with traffic, or -PD where loss of airborne separation falls within the same parameters of a Category B OE, or -Reduction in safety margin or functional capability of the aircraft requiring crew to follow abnormal procedures per AFM	-Near mid-air collision (NMAC) results due to proximity of less than 500 feet from another aircraft or a report filed by pilot or flight crew member that a collision hazard existed between two or more aircraft; or -Reduction of safety margin and functional capability of the aircraft requiring crew to follow emergency procedures as per AFM	-Conditions resulting in a mid-air collision (MAC) or impact with obstacle or terrain resulting in hull loss, multiple fatalities, or fatal injury
Flying Public	Minimal injury or discomfort to passenger(s)	-Physical discomfort to passenger(s) (e.g. extreme braking action; clear air turbulence causing unexpected movement of aircraft causing injuries to one or two passengers out of their seats) -Minor injury to greater than zero to less than or equal to 10% of passengers	-Physical distress on passengers (e.g. abrupt evasive action; severe turbulence causing unexpected aircraft movements), or -Minor injury to greater than 10% of passengers	Serious injury to passenger(s)	Fatalities or fatal injury to passenger(s)
Airport	No damage to aircraft but minimal injury or discomfort of little risk to passenger(s) or workers	-Minimal damage to aircraft, or -Minor injury to passengers, or -Minimal unplanned airport operations limitations (i.e. taxiway closure), or -Minor incident involving the use of airport emergency procedures	-Major damage to aircraft and/or minor injury to passenger(s)/worker(s), or -Major unplanned disruption to airport operations, or -Serious incident, or -Deduction on the airport's ability to deal with adverse conditions	-Severe damage to aircraft and/or serious injury to passenger(s)/worker(s); or -Complete unplanned airport closure, or -Major unplanned operations limitations (i.e.. runway closure), or -Major airport damage to equipment and facilities	-Complete loss of aircraft and/or facilities or fatal injury in passenger(s)/worker(s); or -Complete unplanned airport closure and destruction of critical facilities; or -Airport facilities and equipment destroyed

Table 9-2. Qualitative criteria for risk probability from the FAA ARP Internal Order 5200.11.

	NAS System & ATC Operational	NAS Systems		ATC Operational		Flight Procedures	Airports
		Individual Item/ System	ATC Service/NAS Level System	Per Facility	NAS-Wide		Airport-Specific
Frequent A	Probability of occurrence per operation/operational hour ≥ $1x10^{-3}$	Expected to occur about once every 3 months for an item	Continuously experienced in the system	Expected to occur more than once per week	Expected to occur more than every 1-2 days	Probability of occurrence per operation/operational hour ≥ $1x10^{-5}$	Expected to occur more than once per week or every 2,500 departures, whichever occurs sooner
Probable B	Probability of occurrence per operation/operational hour ≥ $1x10^{-5}$	Expected to occur about once per year for an item	Expected to occur frequently in the system	Expected to occur about once every month	Expected to occur about several times per month		Expected to occur about once every month or 250,000 departures, whichever occurs sooner
Remote C	Probability of occurrence per operation/operational hour is ≤ $1x10^{-5}$ but ≥ $1x10^{-7}$	Expected to occur several times during the lifecycle of an item	Expected to occur numerous times in a system's lifecycle	Expected to occur about once every year	Expected to occur about once every 3 years	Probability of occurrence per operation/operational hour ≤ $1x10^{-5}$, but ≥ $1x10^{-7}$	Expected to occur about once every year or 2.5 million departures, whichever occurs sooner
Extremely Remote D	Probability of occurrence per operation/operational hour ≤ $1x10^{-7}$ but ≥ $1x10^{-9}$	Unlikely to occur, but possible in an item's life cycle	Expected to occur several times in a system's lifecycle	Expected to occur once every 10-100 years	Expected to occur about once every 3 years	Probability of occurrence per operation/operational hour ≤ $1x10^{-7}$ but ≥ $1x 10^{-9}$	Expected to occur once every 10-100 years or 25 million departures, whichever occurs sooner
Extremely Improbable E	Probability of occurrence per operation/operational hour < $1x10^{-9}$	So unlikely that it can be assumed that it will not occur in an item's lifecycle	Unlikely to occur, but it is possible in system lifecycle	Expected to occur < every 100 years	Expected to occur < every 30 years	Probability of occurrence per operation/operational hour < $1x10^{-9}$	Expected to occur ≤ every 100 years

- **Low Risk—**Within the ARP SMS, low risk is the target. Low risk is acceptable without restriction. Low-risk hazards do not need to be managed actively, but must be recorded in the SRM documentation.

When personnel use a risk matrix, they need to set priorities. Which risks are the most critical? Which risks can the airport mitigate? What risks deserve having airport resources assigned to mitigate them? If a risk is assessed as unacceptable or high risk, it is understood and required that the risk must be mitigated. But, most of the assessed risks probably will fall into the acceptable regions of the matrix, either medium or low risk. For these risks, mitigation may be desirable but not be required to continue operations. Also, because an airport may not have the resources to mitigate all assessed risks, airport decisionmakers can benefit from risk prioritization.

For medium and low risks, using the matrix can lead to questions about which risk is more important to treat. Which poses the highest risk, if there are two different medium-level risks? Is it the hazard with the higher severity or the one more likely to result in an undesirable outcome? Personnel can use a *Risk Assessment Code* or *RAC* to help with prioritization. The RAC is a code developed by the airport to signify a level of importance within the risk matrix and even within the individual levels of risk (high, medium, and low). There is no set RAC system and the airport should use a code that is easily understood and reflects the priorities of the airport. Appendices B and D present an example of a risk matrix with a built-in RAC. The RAC in the example relates to the severity categorization (e.g., as the severity increases so does the RAC #).

Personnel can develop the RAC by simply numbering each box within the matrix, in ascending order based on the level of severity. A 5X5 matrix has 25 boxes. The airport could start with RAC number 1 in the lower left box of the matrix and finish with the box in the upper right corner of the matrix assigned RAC 25. Several airports that participated in the FAA SMS Implementation study used this method.

9.5 Step 5—Mitigate the Risks

The fifth step is to mitigate the assessed risks. In this step, resources or operational approaches are applied to treat or control the risk. The goal is to reduce the likelihood of the outcome occurring, reduce the severity of the outcome, or both.

The FAA requires, within their internal SMS, that high-level risks be mitigated to a lower or acceptable level of risk. Individual airports may determine that high-level risks are acceptable, if certain requirements are met. High-level risks are not acceptable according to the FAA; therefore, during the SRM processes required by the FAA of an airport operator, high-level risks must be mitigated to a lower level. Appendix A has more information on FAA-required SRM.

Strategies to handle the assessed risks can include the following:

- **Accept**: When the risk is sufficiently low and further mitigation is not feasible or practical, the airport may opt to accept the risk.
- **Avoid**: The event or operation can be canceled or postponed until hazardous conditions change or resources become available to control the risk.
- **Reduce**: Steps are taken to (1) reduce the likelihood of the undesirable outcome affecting operations or (2) reduce the severity of the undesirable outcome.

- **Transfer**: The airport can notify and reassign accountability and responsibility to another stakeholder willing to accept the risk (buying insurance is an example of transferring financial risk).
- **Monitor**: The airport can monitor the activity, operation, or environment for changes to hazardous conditions.

Accept A night inspection identified that two taxiway lights were off. No actions were taken to stop operations because the risk was considered low and maintenance could do the repair the next day.

Avoid Thunderstorms were approaching. The airport stopped all ramp activity and cleared the ramp when the lightning detection/prediction system indicated severe weather within 2 miles of the airport.

Reduce On construction projects, use of personal protective equipment (PPE) is mandatory so as to reduce the severity of injuries. Also, the airport expanded safety areas between construction zones and aircraft movement areas and used barricades to identify construction areas so as to reduce the likelihood of damage to aircraft.

Transfer The airport measured runway friction. Given the low friction levels, the airport planned to remove rubber within 15 days. Meanwhile, a NOTAM was issued to warn pilots that poor runway friction was expected under wet conditions. In this case, the airport transferred the responsibility for the risk of operating on the runway to the pilot and the airline.

Monitor Pilots operating on the runway report runway conditions during periods of rain, snow, or ice to the tower. The tower passes the information to airport operations and to other pilots. If hazardous conditions are identified, the approaching aircraft pilot may opt not to use the runway or the airport may clear or close the runway.

Regardless of the strategy, mitigations should be practical and achievable. All possible mitigations should be identified. The mitigation that best addresses the hazard, does not introduce added risk, and best fits the airport's capabilities should be identified and implemented whenever possible.

Risk mitigation may challenge smaller airports having limited financial and personnel resources, especially if engineering changes are judged to be the most effective mitigation. Alternate mitigation strategies, or a combination of strategies, may be required to continue operations.

When the most effective strategies are not practical, alternate risk strategies need to be used to continue operations. These strategies could include delaying certain types of operations, transferring the risk or mitigation responsibilities to other agencies with greater means to deal with the risk, or compensating for the risk through redundant procedures or equipment.

A vital component of effective mitigation strategies is assigning responsibility for the mitigations. Someone must be designated to organize and monitor the effectiveness of the strategies. The responsible person should be able to make real-time decisions and influence those with resource allocation authority. The responsible person is a key link between safety risk management and safety assurance. (See Chapter 14 for further information on carrying out risk mitigations.)

> When assigning responsibility for risk mitigation actions, the responsible person should be able to make real-time decisions about how the actions are accomplished and have influence on those with resource allocation authority.

CHAPTER 10

Applying the SRM Process

When airports use SRM processes, common questions arise. When should SRM be used? Who performs it at the airport? How are hazards identified? Which mitigation actions should be performed? Who makes the risk decisions on the airport? This chapter provides examples of when and how SRM is applied.

The SRM process can be applied whenever a hazard or a hazardous situation is identified. Table 10-1 presents some hazard identification techniques available for use by airports.

Table 10-1. Hazard identification techniques used by airports.

Technique	Example
Observation and reporting	Anyone working at the airport or using airport facilities should be able to report hazards that they see. The process can be more effective when airport staff has received training on how to identify and report hazards, and a system or tool is available for reporting, like a hotline or intranet based reporting system.
Daily inspections	Daily inspections are effective in identifying airside hazards. The procedure can be more effective if inspectors have received training to identify types of hazards, not covered by the routine list of Part 139 requirements.
Accident and incident investigations	The hazards contributing to accidents or incidents are often difficult to identify. A thorough investigation can discover the causes and contributing factors, particularly those hazards that are not obvious (for example deficient training), and investigation reports can communicate the identified hazards to airport decision makers for SRM action.
SRM triggers	Some common safety issues and hazardous situations can signal the need to put the SRM process in action, or the need to convene a formal SRA. A list of common SRM triggers is presented in Chapter 16. The FAA uses a technique called a Safety Assessment Screening (SAS) to identify situations when SRM is required.
Hazard identification tools	There are some common tools used by multiple industries to identify hazards. Examples include Functional Hazard Analysis (FHA); Change Analysis; Job Hazard Analysis (JHA); Job Safety Analysis (JSA); Failure Modes and Effects Analysis (FMEA), and “What-If…” tools.
Functional brainstorming	Brainstorming is a tool that systematically identifies hazards, often using hazard identification tools previously described. The airport may use this technique whenever multiple airport functions or stakeholders are impacted by the hazardous situation. It consists of gathering a group of people to discuss the issue and identify hazards. A facilitator will make the process more effective.
Preliminary lists of hazards	When available, preliminary lists of hazards can be helpful to streamline the SRM process, and to identify main categories of hazards, including specific hazards associated with unique situations at airports. Appendix E presents several example lists of hazards. A preliminary list of hazards is by definition not comprehensive, nor does it address special cases. The lists should be used carefully and as a prelude to in-depth hazard identification.
Trend analysis	Monitoring of safety performance indicators and statistics improves SRM by identifying undesirable trends associated with certain hazards like birdstrikes, runway incursions, and injuries to personnel.
Audits	Safety and SMS audits, like accident investigations, are effective tools to identify hazards that are not obvious. Hidden hazards can include outdated training, organizational issues, deficient operational processes and procedures.
Interviews	Interviews during gap analyses or audits, or even informal interviews during inspections represent an excellent opportunity to identify hazards with line workers and supervisors – those airport personnel with the most in-depth knowledge of the airport systems.
Review of prior accident and incident reports	Usually, these reports will lead to an accident or incident investigation. The purpose of an investigation is to discover causal and contributing factors to the event so they can be prevented or mitigated. The airport staff can augment and complement investigations by performing a SRA and identifying risk mitigation actions and staff responsibilities to reduce the chances of a similar incident or accident.

CHAPTER 11

SRM Applied to Small Airports

Making SRM work to the advantage of small airports takes leadership, dedication, and ingenuity. Small airport operators may have to combat the perception that applying SRM to their operations is too difficult, too expensive, and unsustainable. The size of the airport staff and budget will fuel negative SRM views. The reality is that smaller airports may have some distinct advantages when it comes to SRM. This chapter discusses SRM application techniques, considerations, and paths to successful management of risk for the small airport.

11.1 Conducting Effective SRM with Limited Resources

In many cases, one person at the airport may wear multiple hats and be responsible for many aspects of operation. It is important to remember that subject matter expertise, which is knowledge of a particular issue, may reside with a single individual. When implementing SRM at a small airport, and the need to conduct an SRA with multiple areas of expertise required is identified, one person may have numerous areas of expertise. Often, one person may have general knowledge of the entire airport system. It then becomes a matter of ensuring that the person is prepared and available to provide the needed information about the specific subject matter of the SRA.

The size of the airport staff at a small airport may allow a more streamlined process and quicken the response time when key decisions are needed. Larger airports may incur lengthy delays from having people involved who have a narrow span of control, getting bogged down with decision making, and relying on someone else to provide information; smaller airports may not face these challenges.

At smaller airports, one or two people may be able to discuss an issue, use the 5-step process, and come to a conclusion without formally convening an SRA panel. One or two people may be able to provide the information of ten people from a larger airport. A formal panel may not be needed at smaller airports. The important thing is that the process is followed as best possible and that all of the necessary information is provided to support informed decisions.

11.2 Overcoming Challenges

Having limited staff can allow for streamlining. Identifying ownership of the processes and the risk information is vitally important when facing small airport SRM challenges. Mitigations, after-action plans, monitoring, and tracking of results all need to be performed and documented well. The person responsible for the process can also own the data. However, documentation of the process and the location and sources of data must be well thought out and made available to other appropriate staff to ensure continuity of the SRM in case the knowledgeable individual be unavailable. If the responsible person is not available when risk information is needed, proper documentation helps to ensure that key information is available. Ensuring that other appropriate staff know where and how to access the information is equally important.

Personnel can track the process and results with simple office software. This guidebook offers several examples of tools and processes that can be applied when implementing SRM. In general, most tools and processes can be accomplished using word processing and spreadsheet software. A complete SRM software package can help airports, but, airports should be able to develop, implement, and administer SRM using their existing administrative tools (for example, Microsoft Office). This will speed acceptance by the staff and stakeholders and reduce the amount of necessary administrative changes.

11.3 Making It Simple

If one of the triggers for an SRA raises a safety concern (see Chapter 16), one person may choose to conduct an SRA and contact the appropriate people who have the necessary subject matter expertise. This panel can be large or small, but it needs to represent the stakeholders involved with the issue. At a small airport, two or three people can work through the 5-Step SRM process and complete an SRA in a relatively short time. The process can be simple, if it is understood by the people who have the needed knowledge.

One trigger for applying SRM processes may be undesirable trends in safety-related data. The sources of safety data (such as accident reports, hazardous condition reporting, or property damage reports) can still be generated from their current sources. Data need to be formatted for easy review in accordance with a schedule that is appropriate for that particular airport's management. In other words, having an electronic spreadsheet with accident/incident data input and having it reviewed by the airport manager monthly prior to a board meeting or county commissioners meeting is perfectly acceptable, if it fits the structure of that particular airport.

Tracking mitigations or hazardous conditions and their associated risks also does not need to be cumbersome. Again, personnel can use simple office software tools and results can be input and reviewed by appropriate personnel within the airport's management structure. The most important aspect about capturing data and/or tracking mitigations is reviewing and analyzing the results. Data and information is worthless if nothing is done with it.

11.4 Using Simple Tools for Risks and Controls

Simple software applications can provide the necessary tools to track risks and their controls or mitigations. Appendices C and D provide examples in the form of tables and spreadsheets.

Because of the limited frequency of accidents and incidents at smaller airports, data mining software is normally not necessary but may be helpful if an airport can procure it and put it in place. Electronic databases are effective and inexpensive tools for data mining. These tools produce charts and graphs to depict trends. Again, the airport must ensure that the process is followed and the data are captured and analyzed for a successful SRM program—this does not depend on how sophisticated the tools are.

PART IV

SRM in Daily Operations

The previous parts of the guidebook focus on SRM principles and processes and how the 5-step process works. The chapters in this part link existing airport activities to SRM concepts and steps, explain how effective SRM uses mitigation strategies and risk controls the airport already has in place, and address ways airport personnel can apply SRM thinking when faced with unanticipated hazards in daily activities.

CHAPTER 12

SRM in Daily Operations

Chapter 7 discussed how SRM can be phased to mirror the phases of an airport event or project. In the planning and preparation phases, looking into the future and formulating strategies to manage risk are key aspects of these SRM phases. However, airports do not experience losses during the planning and preparation phases; airports experience losses while executing the tasks required to keep the airport working. Closing the SRM loop and ensuring it works as a continuous process requires application of SRM principles during daily operations; those on the ramp, in the baggage well, or performing maintenance must understand that SRM principles apply at all times. SRM is integral to operational excellence.

12.1 SRM as a Component of Operational Effectiveness

All airport personnel should receive SRM training—not just those most likely to be participants in SRA panels. Staff performing the challenging daily tasks that present risks to the airport must understand that their actions in an operational setting play the most important role in managing risk. Their understanding of the hazards and why certain mitigations were put in place helps ensure the success of airport operations and the preservation of valuable assets. These two benefits lead to greater operational effectiveness and efficiency.

Because the success of the airport SMS hinges on the effectiveness of SRM and because effective SRM demands participation at some level of all airport personnel, training programs for all airport employees should include applicable SRM concepts.

SRM training programs, an element of the SMS Safety Promotion component, should highlight the links between SRM in the planning phase and SRM in the execution. Formal training for those regularly in the execution phase and performing airport business should produce an understanding of the operational effects of improperly managed risk, which include the following:

- **Injuries**: In addition to causing workplace stress, lost time by employees puts greater burdens on replacements and loss of expertise on the job.
- **Damage**: Equipment taken off the line requires repair time, incurs the financial costs of replacement parts, and may delay operations.

- **Delays:** Errors can cause delays that interrupt schedules and cost money for air carriers and general aviation operators alike.

Introducing SRM in the execution phase of airport operations minimizes and often eliminates these undesirable effects, thus improving airport efficiencies and operational effectiveness.

12.2 SRM in Operational Settings

The application of SRM in the execution phase is meant to help personnel who

- Work in a dynamic environment
- Monitor or inspect daily or routine operations
- Supervise planned execution and routine tasks where errors can occur
- Need to make decisions rapidly, often based on partial information

In these roles, employees and supervisors need to remember the importance of recognizing anticipated hazards and having planned mitigations ready to control risk. Personnel also need to maintain a mindset that new and unanticipated hazards may surface at any time.

12.2.1 Daily Inspections Provide Information to Support SRM

Inspections are part of each airport day. They are a requirement for airports certified under 14 CFR Part 139 and a best practice for doing business. Inspections are also a vital part of SRM in the execution phase. Having "trained eyes" watching the airport and observing the activities that go on daily is an important source of safety information and a key hazard identification activity.

SRM is not a standalone airport process. Daily airport activities, such as daily inspections required under 14 CFR Part 139, are part of the SRM process.

Airports can enhance SRM efforts by ensuring that

- Airport operations supervisors are well versed in SRM concepts
- Airport inspections include hazard identification in addition to Part 139 compliance
- Inspection documentation is integrated into the airport safety information system or hazard identification system
- Safety information is passed to the SMS Coordinator for trend recognition and to support the safety assurance process

12.2.2 Preparing for Complex Changes

Planning and preparing for complex airport changes are enhanced by the application of SRM, typically through the conduct of an SRA. SRM performed in the planning phases anticipates hazards, analyzes and assesses risks, and plans for mitigation strategies to control risk to acceptable levels. In the execution phase, mitigations are put into place and applied to the tasks identified during planning.

Performing SRM in the preparation phase is the bridge between SRM in the planning phase and the execution phase. Supervisors involved in complex changes should

- Be well versed about the anticipated hazards identified in the planning phase
- Understand the mitigations put into place to manage the anticipated risks
- Brief all participants involved with the change on the anticipated risks and the planned mitigations
- Ensure that participants understand their responsibilities in watching for the emergence of new hazards and addressing errors before they result in adverse outcomes

Many risk mitigation actions reflect FAA recommendations contained in ACs. Staff need to ensure such recommendations are in place and effective during the execution of the change (e.g., airside construction).

12.2.3 Performing Routine Operational Tasks

Airports run on a routine. In particular, airports with scheduled air carrier service run on a defined routine well known by all employees. Effective SRM in the execution phase requires the vigilance of supervisors and line workers alike to watch for variance, guard against error, and be aware of changing conditions.

Routine breeds complacency.

One way to keep the SRM mindset active in the execution phase is to ask a simple question when going into an event or preparing to perform a task that is done multiple times per week, per month, each year:

What is Different Today?

Answering this question reminds those about to perform routine tasks that they should take care and heighten their senses. Answering this question raises awareness of changing conditions and focuses those who continuously perform the same tasks on the potential for error.

"What is different today?" can lead to follow-up questions such as

- Will the weather cause problems with this task?
- Do I have the right tools with me?
- Did I get a good sleep last night and am I as alert as I need to be?
- Am I performing this task in an unfamiliar location?

Questions such as these can start the mental execution of the SRM process and will enhance both situational awareness and operational performance.

12.2.4 Responsibilities of Supervisors

Supervisors are an extra set of eyes and the objective observers of operations on the airport. Often, supervisors have the most experience. Supervisors assigning or monitoring routine operations must ask those performing tasks about changes they are facing and about things that are different from other times they have performed similar actions. Supervisors can ask “What is different today?” during shift changes, event briefings, and during their “walk-arounds” when observing work happening on the airport.

CHAPTER 13

Time-Critical SRM—ABCD Model

Both supervisors and frontline workers need an easy-to-recall way to both trigger and execute a quick run-through of the SRM process. The 5-step process described in Chapter 9 can be effective in a short-response situation if those facing risk decisions are well versed in the process. Usually, this is not the case for frontline workers not exposed to the SRM process daily.

The Department of the Navy uses an easy-to-remember trigger for the SRM process in the execution phase—this may be useful for those working at airports. The ABCD Model provides frontline workers involved in high-risk tasks with an easy-to-recall trigger that engages the risk management thought process. The ABCD Model, a variation on the 5-step process, is for fast action.

"ABCD" stands for

Assess the situation
Balance resources
Communicate to others
Do and debrief the event

This model provides those in the execution phase with a consistent approach and easy-to-remember tool for dealing with changing conditions and hazards previously unforeseen.

As an event begins or conditions change, the focus of the individuals involved tends to shift to understanding the changes and how to deal with them. As participants become more focused, their ability to take in additional information or give adequate attention to normal procedures diminishes. This paves the way for errors. The use of a tool such as the ABCD Model can help individuals take a step back, maintain situational awareness, and better manage risk during dynamic conditions.

A detailed explanation of the ABCD Model is presented below [as adapted from the Navy's Instruction on Operational Risk Management (OPNAV Instruction 3500.39C)].

- **Assess the Situation**: In a real-time situation, individuals must consider the event in which they are engaged and choose appropriate resources and controls to meet the hazards they identify. In a time-critical situation, assessing the situation requires an accurate perception of what is happening in a relatively short time and then quickly projecting its effect—in other words, maintaining good situational awareness. Unlike in the planning or preparation phases where there is time to assess hazards, an individual's ability to comprehend the situation and apply appropriate, available resources quickly and effectively can mean the difference between success and failure.
- **Balance Resources**: After assessing the situation, personnel must consider all the resources available for the task or activity. Are backup personnel available if additional people are

needed? Is there a way to call supervisors or emergency response assets? Are spare tools nearby if something breaks? Thorough planning before an event will increase the availability of appropriate resources to mitigate hazards effectively. Understanding the task or mission, proper training, using PPE, and knowing personal limitations are essential aspects of balancing resources; they are also aspects that can be pre-planned.

- **Communicate to Others**: Good communication is essential to the success of SRM in the execution phase. The "C" in ABCD is a reminder to explicitly communicate during the event, and it is tied to all steps of the 5-step process. Maintaining good situational awareness of changing conditions and increased task loading is critical to communication. This is because perception and communication skills deteriorate as people lose situational awareness. As stress increases or events become more time constrained, communication tends to become limited or non-existent. Individuals who understand this relationship are better able to adjust and mitigate additional risk when they recognize a loss of awareness.

  Although communicating intentions works best when multiple individuals are involved in the event, situations may occur where individuals must weigh decisions on their own, where "self-communication" is crucial. When working alone, individuals should ask themselves:

  - Who needs to know about the situation?
  - Who can help or assist?
  - Who can provide backup?
  - Can this be done differently?

  These are just a few examples of questions individuals can ask to ensure positive and effective communication takes place.

- **Do and Debrief**: The "D" of the Model starts the risk mitigation actions—Do the task or execute the evolution. To ensure success in the task or event, the individual must select and use the appropriate resources while adjusting actions as required to manage the new risks. The second aspect of the "D" is ensuring that the feedback loop or "Debrief" aspect of the model is performed. It is beneficial for individuals or teams to follow through and complete the ABCD mnemonic loop by identifying what worked and what did not work and then ensuring documented lessons are disseminated. Debriefs will improve performance and mitigate risks in future activities. During debriefs, questions should be asked of those completing the event or task, such as

  - Was our assessment accurate?
  - Were we lucky?
  - How well did we use the resources?
  - Was the communication effective?
  - What can we do to improve response to similar events in the future?

  Asking these types of questions, and then documenting the new hazards and real-time mitigation actions taken and discussed in an event debrief, helps ensure future activities are improved and risks are reduced.

To illustrate the ABCD Model in action, the actions of a supervisor of a snow removal team during a snow event are used. The storm is worse than forecast. Team leaders and team members using the model will

- *Assess the progress of the snow event*: the amount of snow or ice falling; the temperatures; the winds; the length of time the event is forecast to take place; the conditions anticipated following the event.
- *Balance resources during the event*: the staff, equipment, and chemicals available prior to the storm; the available backups like contractors to augment the airport staff; FAA ATCT to assist with pilot communications; working radios or mobile phones; alternate runway options.
- *Communicate to others about the changing conditions and considered actions*: contact airport management and ATCT about the changing and unanticipated conditions; pass on recommendations and actions being taken on the scene; airport management will communicate with snow crews, contractors, airlines (if operating at the field), and other stakeholders as appropriate.
- *Do or act on the recommendations using available resources*: Take actions based on the best information available. Lastly, the airport will conduct a de-brief to discuss the changes needed to handle the unanticipated intensity of the storm; consider recommendations for changes to the airport snow removal plan.

CHAPTER 14

Implementing Mitigation Actions

The last step in the SRM process is to mitigate and monitor the actions taken for the identified hazards. This step includes tasks and actions that should be implemented to reduce the risk. In most situations, these actions will be assigned when the level of risk is found to be unacceptable; however, actions may be established to address medium and low risk as well. Medium risk should be mitigated whenever possible and feasible, and low risks can be further mitigated if simple, low-cost actions are possible (e.g., improve situational awareness). Medium risk should be mitigated further if it is believed that the outcome is a single point of failure, defined as a part of a system that, if it fails, will stop the entire system from working.

To understand how mitigation actions can reduce the level of risk, it is necessary to understand basic risk concepts, particularly severity of outcome and likelihood. This chapter presents different categories of risk mitigation actions, how mitigation actions can affect different components of risk, and how actions should be managed and monitored to complete the SRM process.

14.1 Working with Likelihoods and Outcomes for Risk Mitigation

As described previously, risk has two components: severity of outcomes and likelihood of occurrence. The severity of the outcome is the effect on the system from the hazard. The effect is normally associated with the worst credible outcome.

Outcome

The potential outcome or effect if the hazard is not addressed is the first component of risk. The key question to answer is "what can go wrong?" when certain conditions are assumed. For example, the user can ask what can go wrong during an aircraft landing if the runway surface is contaminated with ice and runway friction is reduced. The answer could be "a runway excursion."

In reality, there is a range of outcomes—from a minor veer-off with no damage to the aircraft to a catastrophic overrun with hull loss and multiple fatalities. So, which outcome should be used when doing a risk assessment?

There is no rigid rule for this; a few **credible** outcomes should be used so that the focus of mitigation actions is defined. There is an important difference between the worst outcome and the worst credible outcome. The worst outcome is always major asset loss, major damage to the environment, or death. When considering airports, catastrophic failure of the system is always possible.

To illustrate how varying outcomes for a single hazard are considered when assessing risk, contamination of runway landing area is used as an example.

Working with the **worst** rather than the **worst credible** outcome can have major effects on resources required to mitigate risks, and risk classification will lose its effectiveness because every risk will fall in one column of the risk matrix. In many situations, it will be significantly more expensive to implement actions for over-rated risks.

For the example, the worst credible outcome for a runway excursion is likely to be an accident with multiple fatalities. The outcome is credible because accidents with this level of severity have happened, and a collision between two aircraft or an aircraft at high speed and a vehicle during a landing can lead to a catastrophic accident.

Another example is the risk of wingtip collision during taxiway operations when the separation is lost. Chances are that an aircraft may deviate excessively from the taxiway centerline resulting in collision of aircraft wingtips. There may be a tendency to classify the worst credible outcome for this type of risk as catastrophic because of the possibility of fuel spillage and fire that could kill everyone on board and destroy the aircraft. However, historical records indicate that no events of this type involving fatalities have occurred in the United States during the past 30 years. A more credible outcome is major damage to aircraft involved. This does not mean that the catastrophic event will never happen, but it is unrealistic to expect that it will happen at any individual airport in the next 100 years.

Therefore, when estimating the severity of a risk, it is important to recall if the event has occurred in recent years at the airport or in the U.S. aviation industry. The NTSB accident databases are excellent sources of information on whether or not an event has occurred at other airports.

The two components of risk: severity of outcome and likelihood, are related because likelihood is always associated with the specific level of consequences assumed for the risk.

Risk classification involves the assumption of credible outcomes. In most situations, the person or group assessing the risk will have a risk matrix to make the classification and a single classification for severity should be selected. Table 14-1 provides the FAA severity classification impacts specific to airports.

When reviewing the examples presented, the credible outcome for a runway excursion can be classified as *Catastrophic (1)*; and the severity associated with wingtip collision during a taxiway operation is *Major (3)*, because major damage to aircraft is a plausible scenario.

Likelihood

The second component of risk is likelihood; it is the chance that the assumed outcome will take place. Likelihood is normally presented in terms of the number of occurrences per number of operations or number of occurrences per period. For example, the likelihood of a birdstrike

Table 14-1. FAA Order 5200.11 (Change 1) – hazard severity classification.

Catastrophic (1)	• Complete loss of aircraft and/or facilities or fatal injury in passenger(s)/ worker(s), or • Complete unplanned airport closure and destruction of critical facilities, or • Airport facilities and equipment destroyed.
Hazardous (2)	• Severe damage to aircraft and/or serious injury to passenger(s)/ worker(s), or • Complete unplanned airport closure, or • Major unplanned operations limitations (i.e. runway closure), or • Major airport damage to equipment and facilities.
Major (3)	• Major damage to aircraft and/or minor injury to passenger(s)/ worker(s), or • Major unplanned disruption to airport operations, or • Serious incident, or • Deduction on the airport's ability to deal with adverse conditions.
Minor (4)	• Minimal damage to aircraft, or • Minor injury to passengers, or • Minimal unplanned airport operations limitations (i.e. taxiway closure), or • Minor incident involving the use of airport emergency procedures.
Minimal (5)	• No damage to aircraft but minimal injury or discomfort of little consequence to passenger(s) or workers

to commercial aircraft is one per 7,300 movements. If we use this rate for a large airport with 1,000 commercial aircraft movements per day, one birdstrike per week is expected for the airport; however, if this rate is applied to a smaller airport with only ten commercial flights per day, a birdstrike is expected to occur approximately every 2 years.

Appendix F presents a table with benchmark risks based on historical rates for the U.S. aviation industry. The information may be helpful when assessing the likelihood component of a specific risk. Table 14-2, used by the FAA to classify risk likelihood in five different levels, is a simplified version of the FAA Likelihood classifications presenting those specific to airports.

An important question arises from these examples: Should the rate or the occurrences per number of movements be used or should the expected period for one occurrence be the reference? The answer is simple. . . it depends! For the small airport with low traffic volumes, the expected period is usually best, and for the large airport, the incident rate may be more appropriate. The rule is simple: the likelihood should be classified according to both the accident/incident rate and expected period, and then the lowest likelihood classification should be used. Likelihood criteria are normally presented in both accident/incident rate and expected period for occurrence, as shown in Table 14-2. Other forms of determining likelihood are the use of passenger enplanement numbers for airports with commercial service. This is particularly helpful when dealing with terminal issues. (See Appendix D, SRM Templates for the tables for likelihood.)

Table 14-2. FAA Order 5200.11 (Change 1) – likelihood classifications for airports.

Frequent (A)	Expected to occur more than once per week or every 2500 departures, whichever occurs sooner
Probable (B)	Expected to occur about once every month or 250,000 departures, whichever occurs sooner
Remote (C)	Expected to occur about once every year or 2.5 million departures, whichever occurs sooner
Extremely Remote (D)	Expected to occur once every 10-100 years or 25 million departures, whichever occurs sooner
Extremely Improbable (E)	Expected to occur less than every 100 years

Here is an example using the “birdstrike scenario” for different size airports. When using the table to classify the risk of birdstrikes for the large airport, the accident rate of 1/7,300 movements can be used, and the likelihood is “Frequent (A).” In the period form, the same likelihood level is obtained, considering the frequency of one birdstrike per week.

The results for the small airport are different. When using the rate, the same classification for the large airport is obtained: “Frequent (A).” Nevertheless, if one event every 2 years is used, the likelihood classification is “Remote (C).” In this case, the lowest likelihood classification is “Remote (C),” and this should be the likelihood classification for birdstrikes when analyzing risk at the small airport.

At small airports, for most situations, the risk likelihood classification is based on the expected time to occur between accidents or incidents resulting from a specific hazard.

The understanding of risk components and risk classification will help the understanding of how mitigation actions may affect the severity, the likelihood of the event, or both.

Risk classification is illustrated using faded runway markings as an example.

For example, based on PIREPS, an airport has identified that runway hold position markings are faded and difficult to see from the aircraft cockpit during rain or low-visibility conditions. A possible outcome associated with this hazard is a runway incursion. A risk assessment performed by the airport staff classified the credible outcomes as catastrophic and the likelihood as remote. Two mitigation actions were planned: the first action was to repaint the markings and the second to install stop bars at the runway intersections most used by aircraft.

The credible outcomes with mitigation actions remain catastrophic; however, the likelihood was considerably reduced and is now classified as extremely improbable. Figure 14-1 illustrates the risk change. In this case, the credible outcome was not changed by the mitigation actions, and only the likelihood of a runway incursion was reduced to take the risk from unacceptable (red) to medium (yellow). The risk assessed falls in the yellow or medium half of the lower right box of the 5×5 matrix because other mitigations are in play for risk of a runway incursion; in other words, the repainting of the runway markings is not a single point of failure in the system.

At another airport, an airside vehicle struck a ramp worker, resulting in a severely injured employee. The accident investigation identified the causes of the accident as poor driver training and speeding. A risk assessment by the SMS manager assessed the risk of new accidents and assumed that the worst credible outcome could be classified as “Hazardous (2),” according to the airport’s risk matrix, which is similar to that presented in FAA Order 5200.11. Reviewing the history of similar accidents and incidents at the airport in the past 10 years, it was found that

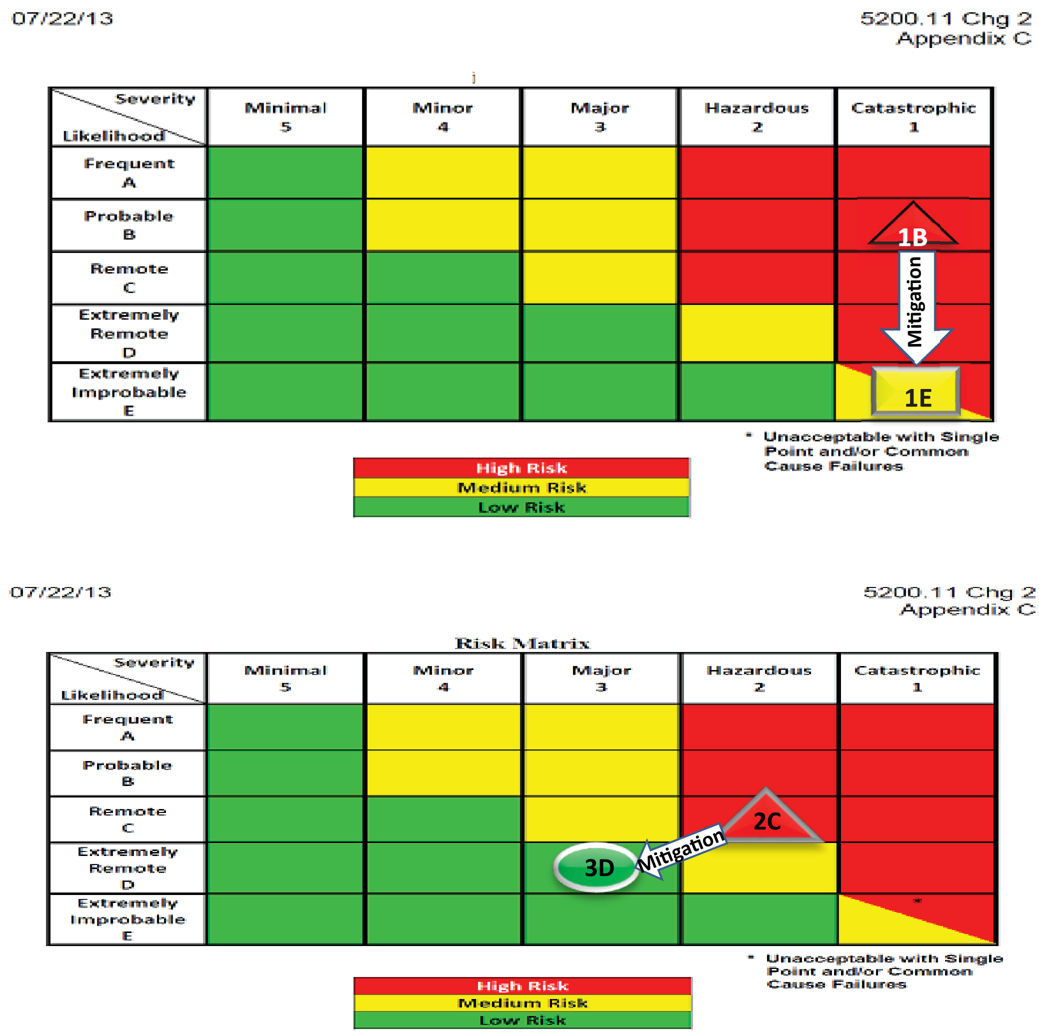


Figure 14-1. Assessment with new mitigation actions.

two similar events had occurred and the likelihood was classified as “Remote (C).” Therefore the existing risk was classified as 2C using the matrix, or high risk.

Based on the accident investigation, the airport decided to make changes to its airside driving program and introduce an airside driver responsibility and speed enforcement program. The actions are expected to reduce both the likelihood and severities if the vehicle speed is reduced to minimum levels. The assessment with the new mitigation actions classified the credible outcomes as “Major (3)” and the likelihood to “Extremely Remote (D),” taking the risk to the green zone, as illustrated in Figure 14-1.

14.2 General Considerations

14.2.1 Mitigation Strategies

When selecting a strategy, personnel should review and assess proposed safety risk mitigation options from the following perspectives:

- **Effectiveness**: the extent to which the options reduce or eliminate the safety risks. Effectiveness can be determined in terms of reliability to reduce the risk significantly.

- **Cost/benefit**: the extent to which the perceived benefits of the mitigation outweigh the costs. Cost estimation of mitigation actions is normally a separate process but is essential to support decision making.
- **Practicality**: the extent to which mitigation can be implemented and the appropriateness of available technology, financial, administrative, and operational resources. This is barring any legislation or regulation, political issues, and so forth.

Many risk mitigations can be an improvement or an extension of existing airport practices and controls. FAA ACs provide the minimum level of mitigations and controls in many cases. However, airports must take into account ALL existing mitigations and controls when determining the most appropriate ones to put into place. Identification of existing mitigations and controls is part of defining the system in Step 1 of the 5-Step SRM process. These existing mitigations and controls should be carried over into the decision-making process for mitigation strategies.

Because operational budgets can be affected by hazard mitigation programs if no funding has been planned, personnel should consider establishing a line item for risk mitigation in the estimation of project funding and when planning operational budgets.

When conducting risk assessments, it is common to identify risk mitigation alternatives based on airport capabilities. Risk mitigation is one option available to treat risk. Other strategies that may be used are summarized below.

14.2.2 Risk Acceptance

Although acceptance does not reduce the risk, it is still a strategy. This strategy is sometimes used when the risk is classified as medium and additional control actions are not feasible from a cost, physical, or environmental perspective. An example is the risk of runway incursions presented in the previous section. Although mitigation actions were used to reduce the risk, the risk was still classified as medium because limited resources meant it was not possible to further reduce the severity of credible outcomes of a runway excursion.

14.2.3 Risk Avoidance

Risk avoidance is used when further mitigation actions are not feasible. For example, an airport is certificated for operation of Group III aircraft; however, the separation between one of the taxiways and a hangar complies only with Group II aircraft. Under this scenario, the taxiway is restricted to operations of Groups I and II aircraft. The risk associated with the small separation for Group III aircraft is, in this case, avoided.

14.2.4 Risk Transference

Using this strategy, the airport passes the risk to another party more capable of managing the risk. A typical example of risk transfer is having an insurance contract to avoid bankruptcy when the financial situation becomes dire. Here is an example of operational risk transfer—an airport measured runway friction after noticing excessive rubber accumulation on the runway surface and found that it is lower than acceptable levels. The airport then decided to issue a NOTAM announcing that poor braking conditions should be expected when the pavement was wet. The information was acquired by the pilots and they chose whether to use or avoid the runway when the pavement was wet. Issuances of NOTAMs by airports are examples of a risk transfer strategy.

The *FAA Safety Risk Management Guidance: The 5-Step Process* (dated September 14, 2012) states "One of the fundamental principles of system safety is the Safety Order of Precedence in eliminating, controlling, or mitigating a hazard. Safety professionals use the techniques listed in the Safety Order of Precedence, in priority order, for reducing risk." The priority order is

1. Design the hazard out
2. Provide physical guards or barriers
3. Provide warning devices
4. Train people
5. Communicate the hazard

14.3 Making Decisions About Risk Mitigations

A frequently overlooked but critical aspect of risk mitigation is the decision-making process to implement risk mitigation actions, particularly at larger airports where key decisionmakers may not be able to participate in SRA panels.

When an SRA is conducted, the panel will recommend several actions to address the risks identified and sometimes assign the parties responsible for implementing those actions. However, non-participation of key decisionmakers in the SRA panels, or the lack of cost estimates to implement the actions, may postpone the decisions for some of the actions, particularly those involving significant expenditures. At smaller airports, key decisionmakers typically participate in SRA panels and decisions can be made in a timely manner.

In any case, following the documentation of risk mitigation action during an SRA, it is necessary to make final decisions about implementing the recommended actions, assigning responsibilities, establishing a schedule, and monitoring to ensure the implementation is completed. If some actions are not approved, the SRA documentation should be updated and, if necessary, the residual risk classification should be changed to reflect that one or more actions will not be implemented or will be modified. Ideally, the approval process for risk control actions should be described in the airport's SMS manual.

Figure 14-2 illustrates the flow of safety management information and decision making for a large-hub airport. The SMS manager can take some simple and immediate decisions on frequently reported hazards. If the implementation of risk mitigation actions involves more significant resources, decision making is taken to the upper levels of management. However, if actions involve multiple stakeholders and significant resources, decisions about which mitigation actions will be implemented are made with the support of cost information during stakeholder meetings.

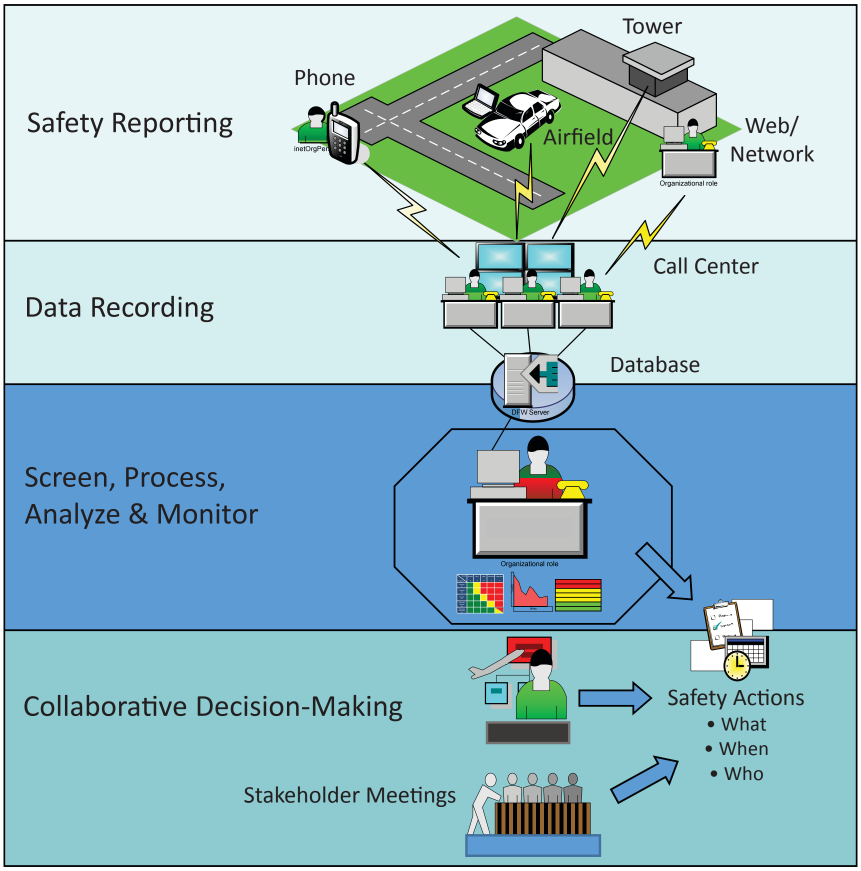


Figure 14-2. Decision making of risk control actions at large-hub airport (example).

At smaller airports, with a reduced management structure and fewer employees, airport directors and deputies are normally participants in safety assessments or SRA panels, and decisions about control actions can be made immediately.

14.4 Ensuring Risk Mitigations Are in Place

During a risk assessment, each risk is normally evaluated more than once because planned mitigation actions may change the assessed level of risk. The first assessment considers the current or planned conditions with existing mitigation actions; follow-on assessments consider additional recommended actions to further reduce the risk.

All commercial and general aviation airports have some type of FAA regulatory compliance requirements. Such requirements are considered required or existing risk mitigations. Existing airport mitigation examples include the following:

- Airport policies or procedures
- Airport infrastructure requirements
- Redundant systems

- Training programs
- FARs, FAA ACs, Letters of Agreement (LOAs), FAA Orders
- Pilot reports (PIREPS)
- FAA Runway Safety Action Team (RSAT)
- Airspace and Aeronautical Information Management (AIM)
- Commonly Used Safe Operational Practices for Taxi Safety (CAST)
- Automatic Terminal Information System (ATIS)
- Pre-construction meetings
- Standard Operating Procedures (SOPs)
- Mutual aid agreements
- Modification of Standards (MOS)
- Airport Certification Manual (ACM)
- TSA 1542 Airport Security
- Local ordinances
- Airport Codes of Rules and Regulations

When considering the present condition during risk analysis, the references listed are assumed to be existing risk mitigation measures. Although this is true for many situations, that some procedures are documented in ACs does not mean that those procedures are in place or will be in place when the hazardous situation is present.

For instance, one of the common hazards of construction projects on the airfield is FOD. Construction debris may be generated during demolition, excavation, and paving operations and ingested or blasted by aircraft engines causing damage and/or injuries. FAA AC 150/5370-2, *Operational Safety on Airports during Construction*, describes FOD management as one of the elements of a Construction Safety and Phasing Plan (CSPP). The airport must ensure that the CSPP is developed for the specific construction project, that a plan for FOD management is included, that the plan is in place during construction, and that the plan is working effectively to control FOD generated by construction activities.

14.5 Monitoring Mitigation Actions and Risk

Under an SRM, numerous hazards are identified, and their risks assessed and documented, sometimes on a daily basis for larger airports. One or more mitigation actions may be assigned to each risk, and personnel must ensure that the actions are in place and are effective to achieve acceptable risk levels.

At larger airports, an IT solution, such as a web-based hazard reporting system, preferably integrated with existing airport information systems, may be very helpful to keep track of hazards and risk mitigation actions. Some available systems include an electronic dashboard that gives the SMS manager a brief picture of prioritized risks and the status of risk mitigation actions that may require attention.

At smaller airports, a simple electronic spreadsheet can be very helpful to track risks and associated control actions, with responsibilities assigned and an implementation schedule developed.

Monitoring mitigation actions and risks involves three basic tasks:

- Ensuring that mitigation actions are in place and having the desired effective outcome
- Reassessing the risk based on observations or trends of performance indicators
- Checking for unintended outcomes or creation of new hazards

The first task involves ensuring that the responsible party has put the mitigation actions in place, that implementation schedules are being followed, and that changes can be measured. With the example of implementing a FOD Management Plan for airfield construction, during the construction period, airport operations and engineering staff may want to check the areas near the construction site frequently for the presence of FOD, even though Part 139 airports should already include this task in daily inspections processes. If FOD is present, the FOD control plan may not be effective and should be evaluated for improvements. If the amount of FOD is higher than expected based on observations during daily inspections, the planned mitigations are not having the desired effect. A new risk assessment should be made and mitigation action changes identified.

The success of risk mitigation actions can be determined by using established performance indicators as a baseline. For example, an airport may decide to monitor the number of wildlife strikes that adversely affect operations. An adverse outcome of this hazard may be aircraft damage or a flight delay, a go around, or an aborted takeoff. By taking data from the *FAA Wildlife Database* and counting the number of strikes during each month, it is possible to see the trend over a period of a few years to check if the wildlife management program is working as expected or if additional actions should be considered to further reduce the presence of certain species in the airport area and its vicinity.

14.6 Mitigation Actions

A proven way to manage risk mitigation actions is to develop a hazard and risk log or table. Numerous off-the-shelf software programs are available and can be used to document hazards, associated risks, and actions for mitigation. However, smaller airports can use basic office software, such as an Excel spreadsheet, for the same purpose. There are also software packages for managing assets and work orders that can be customized for SMS and can incorporate the capability to log hazards, their associated risks, and the mitigation actions put in place.

CHAPTER 15

Daily SRM for Small Airports

As discussed throughout the guidebook, small airports have less staff and resources to facilitate the easy addition of new approaches and tasks to routine operations. For small airports, SMS in general, and SRM in particular can be seen as a burden, rather than a benefit. Much of this perception comes from the fact that larger airports have dedicated staff to coordinate SMS activities and are taking steps to implement specific software solutions for hazard reporting and documentation, as well as providing SMS training to staff.

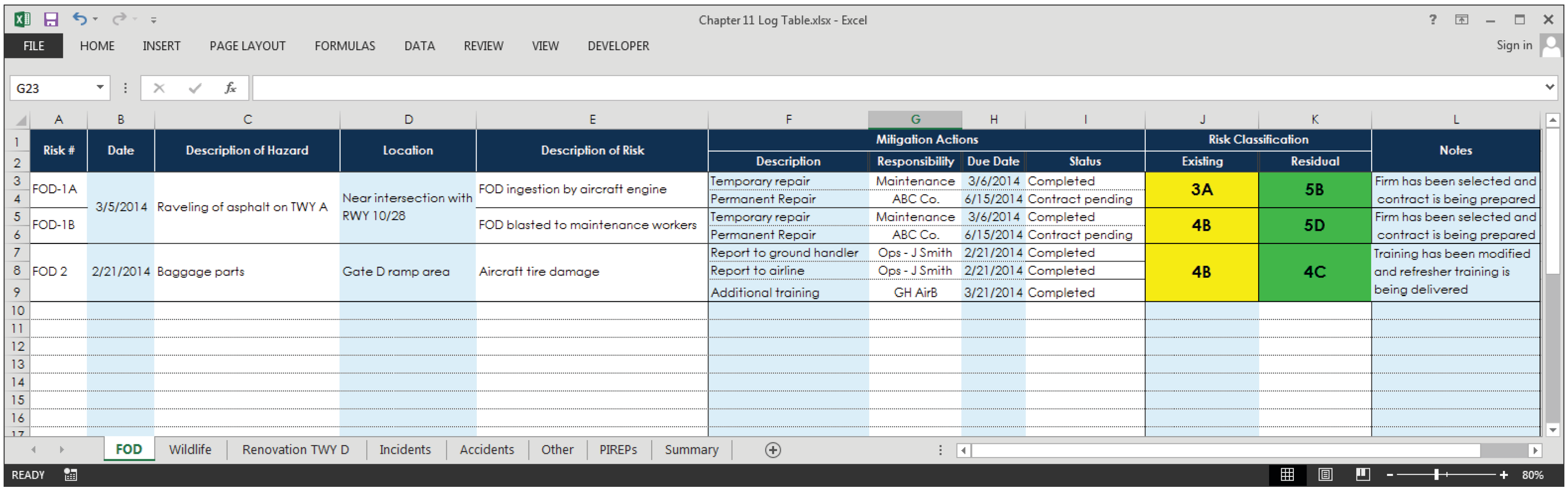
Smaller airports have some unique advantages for using SMS and SRM precisely because of having fewer staff members. In most cases, staff members work in the same area and communicate face to face many times during the day. Small airports do not require special software to report hazards and unsafe conditions because a simple phone call, electronic message, or daily discussions are effective to initiate and make decisions to implement actions to mitigate risks. Simple electronic spreadsheets or database software is sufficient and effective to document and track hazards, classify risks, and define control actions—the only added requirement is the discipline to take these administrative actions.

The ABCD Model presented in Chapter 13, or the more thorough SRM 5-step process, should be used daily. Before SMS, airport managers likely did not have clear, systematic approaches to address safety issues, document them, and support risk decisions. SRM provides the processes for this when used properly and regularly. The ABCD Model enables employees at small airports to address risk faced in everyday activities, even when performing tasks alone. When more complex safety issues arise, convening a small group, perhaps two or three employees and stakeholders if necessary, to conduct an SRA is appropriate. The keys to success are knowledge and practice.

An example of SRA for a small airport was provided in Chapter 8. The focus was the towing of aircraft to the hangar following the reporting of a few incidents associated with this type of operation. The SRA example involved only the airport manager, the supervisor of operations, and a towing operator. The example showed how the SRM process is beneficial in determining simple risk control actions that can be implemented with a low level of effort and few resources (e.g., developing a simple SOP for towing aircraft and developing posters to remind the operator on the SOP).

Figure 15-1, Example of Hazard and Risk Log Table, provides an example of a hazard and risk table that can be used by small airports and some large ones alike. Tables 15-1 and 15-2 provide example lists of ACs that airports use as guidance for risk controls and mitigations.

The Hazard and Risk Log Table in Figure 15-1 is relatively easy to develop and use and can be a great tool for smaller airports to track SRM actions.



Risk #	Date	Description of Hazard	Location	Description of Risk	Mitigation Actions: Description	Responsibility	Due Date	Status	Risk Classification: Existing	Residual	Notes
FOD-1A	3/5/2014	Raveling of asphalt on TWY A	Near intersection with RWY 10/28	FOD ingestion by aircraft engine	Temporary repair	Maintenance	3/6/2014	Completed	3A	5B	Firm has been selected and contract is being prepared
					Permanent Repair	ABC Co.	6/15/2014	Contract pending			
FOD-1B				FOD blasted to maintenance workers	Temporary repair	Maintenance	3/6/2014	Completed	4B	5D	Firm has been selected and contract is being prepared
					Permanent Repair	ABC Co.	6/15/2014	Contract pending			
FOD 2	2/21/2014	Baggage parts	Gate D ramp area	Aircraft tire damage	Report to ground handler	Ops - J Smith	2/21/2014	Completed	4B	4C	Training has been modified and refresher training is being delivered
					Report to airline	Ops - J Smith	2/21/2014	Completed			
					Additional training	GH AirB	3/21/2014	Completed			

Figure 15-1. Example of hazard and risk log.

Table 15-1. **Risk management references available to airports.**

Document Title	Number	Description
Air Traffic Control	Order JO 7110.65	Provides Air Traffic Control Procedures and Requirements
Irregular Operations Plan –Tarmac Delay Plan	Order 5200.10	Provides Guidelines and Requirements for Developing and Compliance with a Tarmac Delay Plan (IROPS)
Foreign Object Debris Management	AC 150/5210-24	Provides Guidance on Foreign Object Damage (FOD) and Guidelines for Developing an Airport FOD Plan/Program
Airport Safety Self-Inspection	AC 150/5200-18	Provides Guidance on Self – Inspection Processes and Programs
Notices to Airmen (NOTAMS)	AC 150/5200-28	Provides Guidance and Requirements for Issuing NOTAMS
Airport Winter Safety and Operations	AC 150/5200-30	Provides Guidance and Guidelines on Winter Safety and Operations and Developing a Snow Plan
Heliport Design	AC 150/5210-20	Provides Guidance for Developing a Heliport
Ground Vehicle Operations on Airports	AC 150/5300-13	Provides Guidance for Training, Control and Safety of Ground Vehicles
Airport Design	AC 150/5300-13	Provides Airport Design Standards and Guidance
Surface Movement Guidance Control System (SMGCS)	AC 120-57	Provides Guidance for Developing and Implementing a SMGCS Plan /Program
Signs, Markings and Lighting, Standards for Airport Sign Systems	AC 150/5340-1 and 18	Provides Guidance for Signs, Markings, and Lighting and Standards for Airport Sign Systems
Hazardous Wildlife Attractants On or near Airports	AC 150/5200-32	Provides Guidance for Wildlife Attractant Development and Mitigation
Qualifications for Wildlife Biologist	AC 150/5200-36	Provides Guidance and Experience for Selecting Wildlife Consultants and Experience and Credentials/Certifications
Debris Hazards	AC 150/5380-5	Provides Guidance for Developing a Debris Program and Controls
Design and Installation Details for Airport Visual Aids	AC 150/5340-30	Provides Guidance and Data for Design and Installation of Airport Visual Aids
Safety During Construction	AC 150/5370-2	Provides Guidance for Developing a Construction Safety Phasing Plan (CSPP) and Safety Processes

Table 15-1. (Continued).

Document Title	Number	Description
Guidebook for Airport Irregular Operations (IROPS)	ACRP Report 65	Provides Guidance on Developing an Irregular Operations Plan
Construction Safety Phasing Plan (CSPP)	(See AC 150/5370-2 above)	Provides Guidance on Developing a Construction Safety and Phasing Plan (CSPP)
Pilot Reports (PIREPS)	SEE Order JO 7110.65 and Order JO 7110.10	PIREPS provide real-time pilot reports of restricted visibility, icing conditions, turbulence, cloud base, layers, tops and other information of Flight Conditions for Pilots and Air Traffic Controllers and FAA Flight Services (FSS)
Aeronautical Information Manual (AIM)	AIM	Provides wide range of regulatory and non-regulatory references with capability of cross-referencing CFRs and Advisory Circulars
Obstruction Lighting and Marking	AC 150/7460-1	Provides Guidance for Lighting and Marking Obstructions on Airports and Filing
Objects Affecting Navigable Airspace	Part 77	Provides Requirements and Standards for proposed construction and to determine obstructions
Operator Driver Training	Parts 121, 135	Provides Guidance and Requirements for Airline Vehicle Operators
Airport Certification Manual (ACM)	AC 150/5210-22	Provides Methods for Meeting Certification Requirements for the ACM
Runway Safety Program	Order JO 7050.1	Provides Information and Guidance on FAA's National Runway Safety Program to reduce runway incursions
Airport Traffic Control Tower Siting Order	Order JO 6480.4 Air Traffic Control Siting Order	Provides Guidance and Requirements for Proposed New, Relocated or Existing Tower Site, Height and Visibility Requirements
FAA Engineering Brief # 75	Engineering Brief # 75	Provides Guidance for Incorporating Runway Incursion Prevention into Taxiway and Apron Design
Safety Management Systems for Airports	ACRP Report 1; Volume 2 Guidebook	Provides comprehensive reference that will help users determine what constitutes an airport SMS. Offers guidance in planning, implementation, and operation of an airport SMS. This guidebook supplements ACRP Report 1: Volume 1 which provides an overview of SMS.
Letters of Agreement (LOAs)	LOAs	Provide wide distribution of information to users on specific operating processes for e.g. LOA between Air Traffic Control and Airport Operations when responding to an emergency
Standard Operating Procedures (SOPs)	SOPs	Provide wide distribution of information to users on frequently used operating protocols. I.e. consistent and frequently used procedures primarily used internally to an airport department for e.g. airport FBO towing aircraft into / out of a hangar

Table 15-2. Key FAA advisory circulars and CertAlerts applied to airport safety.

Advisory Circular	Number
Standards for Airport Markings	AC 150/5340-1
Reporting Wildlife Aircraft Strikes	AC 150/5200-32
Performance Specifications for Airport Vehicle Runway Incursion Warning System	AC 150/5210-25
Aircraft Fuel Storage, Handling, Training and Dispensing on Airports	AC 150/5230-4
Airport Design	AC 150/5300-13
Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns	AC 150/5220-22
Qualifications for Wildlife Biologists Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved In Controlling Wildlife Hazards on Airports	AC 150/5200-36
Operational Safety On Airports During Construction	AC 150/5370-2
Airport Avian Radar Systems	AC 150/5220-25
Airport Foreign Object Debris (FOD) Management	AC 150/5210-24
Standards for Airport Sign Systems	AC 150/5340-18
Painting, Marking, and Lighting of Vehicles Used on an Airport	AC 150/5210-5
Airport Emergency Plan	AC 150/5200-31
Airport Winter Safety and Operations	AC 150/5200-30
Systems for Interactive Training for Airport Personnel	AC 150/5210-18
Notices to Airmen (NOTAMS) for Airport Operators	AC 150/5200-28
Hazardous Wildlife Attractants On or Near Airports	AC 150/5200-33
Airport Certification Manual	AC 150/5210-22
Construction or Establishment of Landfills Near Public Airports	AC 150/5200-34
Airport Self-Inspection	AC 150/5200-18
Ground Vehicle Operations on Airports	AC 150/5210-20
CERT ALERTs Part 139	CERT ALERTs Part 139

PART V

Safety Risk Assessment (SRA)

This part presents a detailed discussion about the SRM application likely to be the most visible to airport management, staff, and stakeholders. The SRA is the practical application of the 5-step process in a formal, in-depth manner. This part introduces the concept of SRA triggers—precursors that lead to an airport's formal use of the SRM process and triggers that may not require the formal use of a panel. The chapters describe the SRA process, keys to its effective and efficient conduct, and recommendations and lessons learned for effective facilitation of the SRA.

CHAPTER 16

Introduction to SRA

SRM processes are used to address many different types of safety issues, from simple hazards, like FOD originated from uncovered trash cans, to very complex airport construction and improvement projects that affect airfield operations. These examples illustrate conditions that require changes to how the airport does business. Change generates risk. An SRA is a way to thoroughly address the risks.

The SRA is a safety assessment performed by a panel of stakeholders and subject matter experts (SMEs) to analyze a safety issue, run the SRM process to establish risk mitigation actions, and document the process. The SRA is a formal application of the SRM process to study an airport condition, either planned or discovered. The SRA will likely be the most visible application of SRM to airport personnel and tenants. The SRA is triggered by conditions or events at the airport; follows the SRM 5-step process in a formal, proactive manner; is facilitated by a person well versed in the SRM process; and provides airport management with actionable knowledge to enhance effective, risk-informed decisions.

In general, an SRA should be conducted if a change to the airport system is planned or deemed necessary. A planned system change might come in the form of an airport construction project, such as the renovation of a concourse. A system change that is deemed necessary could be discovered from the analysis of safety reports that highlight an undesirable trend, such as increased levels of FOD. Some safety issues may be unique to specific airport conditions, but may affect multiple airport stakeholders. Although certain corrective actions may seem apparent and easy to correct, the airport personnel who identify the condition may not fully understand all of the effects of the condition or the range of effects the corrections may have. Similarly, when a change to the configuration of the airport is planned, the integrated nature of airport operations and the number of stakeholders affected demand a thorough examination of the change. For scenarios such as these, an SRA gives airport decisionmakers the information necessary to make fully risk-informed decisions regarding the allocation of resources.

> At small airports, the panel of stakeholders and SMEs might only need to be two to three people. It is the subject matter that is most important. The facilitator may be a member of the airport staff who understands the SRA process thoroughly. The effective execution of the process is what is most important.

16.1 Benefits of an SRA

Among the most important benefits of convening a panel and performing an SRA are as follows:

- The SRA takes the airport through a full and systematic process to identify hazards and reduce risk levels.
- The SRA coordinates the actions of multiple airport functions (e.g., operations, maintenance, engineering, and ARFF) and stakeholders and provides a greater understanding of how each function may interact to improve overall safety.
- The SRA documents hazards, risks, mitigation actions, and responsibilities for those actions.
- The SRA provides a framework and schedule to manage mitigation actions and accomplish safety goals.
- The SRA increases awareness of risks affecting the various airport functions and stakeholders.
- The SRA supports airport safety policy, helps the airport achieve its safety goals and acceptable levels of safety, and promotes regulatory compliance.

16.2 Responsibility to Conduct an SRA

In certain situations, the FAA may require an SRA. With the introduction of SMS in the aviation industry, every line of business within the FAA may initiate an SRA. The FAA ARP may request an airport conduct an SRA and, depending on the scope of the assessment, may ask parties outside the airport to participate.

ARP uses a process called Safety Assessment Screening (SAS) to "document the evidence to support whether the proposed action is acceptable from a safety risk perspective." The SAS and an SRA follow nearly identical processes. The SAS is internal to the FAA, and airports will only provide information requested. The FAA ARP project manager will complete the SAS-1 form (SAS report) as appropriate based on the findings from the SAS. The procedures for the SAS apply to projects, Modification of Standards, and development/modification of AC standards. Therefore, airport projects submitted to the FAA for approvals will undergo an SAS and, according to FAA Internal Order 5200.11, may require SRM actions and determination as to the requirement for an airport SRA. If so, the FAA may recommend that the airport sponsor convene an SRA panel for the safety assessment and the airport will pay for the associated costs.

The costs of the SRA normally will include preparing the SRA briefing documents for distribution to the SRA panel members, arranging for a facilitator, scheduling a suitable meeting place for the panel, sponsoring SME participation, and other costs related to organizing and hosting the meeting, and documenting the results.

In addition to FAA-required safety assessments for projects and Modification of Standards, the airport may organize its own SRAs as part of its internal SMS processes. Any safety issue or concern is a candidate for an SRA. Typically, only those issues associated with higher risk and need for a multidisciplinary team to conduct an analysis are selected for a formal SRA. Refer to Appendix A (SRM and the FAA) for more information on FAA-required SRAs.

An SRA may involve one or more airport functions and departments. An SRA supporting an airfield construction project will involve several functions of the airport (e.g., operations, engineering, and ARFF), as well as airport stakeholders (e.g., airlines, ground handlers, and fixed-base operators [FBOs]). In some cases, an SRA may also involve staff of only one airport department. For example, the head of an airfield maintenance department has received complaints from the FAA ATCT personnel that maintenance staff is not using proper ingress/egress procedures to access the airfield movement areas. The Director of Maintenance determines an SRA may help determine risks and identify actions for the maintenance department to take to improve the use of correct procedures. In this case, only staff from the maintenance department may be involved in the SRA because the issue was specific to the department.

16.3 When Is an SRA Needed?

There are many factors to consider when deciding to conduct or not conduct an SRA. Airports need to determine their own set of requirements for initiating an SRA.

16.3.1 Basic Principles

An SRA should be conducted any time the airport determines that a full safety analysis of an airport condition or event is warranted. Three rules of thumb can help in the determination:

- A change in the airport system is pending.
- The allocation of significant airport resources is required.
- An undesirable trend in airport safety metrics is revealed.

In each of these instances, airport management will face decisions regarding operations and assets that will alter the way the airport does business. With change comes potential risk. The SRA is the most complete method to ensure risk is managed as effectively as possible.

The rules of thumb are not all inclusive. Any issue that affects aviation safety can be the subject of an SRA. The following questions can be asked when considering the need for a panel:

- Will the FAA require an SRA for a planned change/project?
- Do we have an important safety issue that we have not been able to resolve?
- Do we have undesirable trends in our safety performance indicators and we cannot explain why?
- Was an incident reported at another airport with causes similar to conditions at our airport?
- Are incidents or reported hazards on the rise?
- Does a type of incident occur frequently at the airport?
- Is a safety issue affecting the airport's reputation?
- Is there an important safety issue on the landside of the airport?
- Have we received frequent complaints from our stakeholders about a certain safety issue at the airport?
- Is an important decision pending that has safety implications?

If the answer is "yes" to one of these questions, there is a good chance that an SRA will benefit the airport.

Another determining factor regarding when to conduct the SRA is time. Is there sufficient time to prepare, conduct, and document the SRA? If a panel of SMEs is needed, an effective and complete SRA requires time. The amount of time necessary may be a function of the complexity of the issue at hand, the size of the airport and number of stakeholders, or the availability of data needed to properly analyze and assess the risks. For some airports participating in the SMS Pilot Studies, an SRA scheduled over 2 days, with one 4-hour block held each day was effective. This length of time allows the panel members to continue their daily duties and to gather more information for the SRA if required. Other airports learned that one 8-hour day worked well, or even two 8-hour days were best if the subject matter was complex and the discussions among the panel members warranted the added time.

In general, the SRA should primarily be considered as a proactive planning evolution. It is best used in advance of a planned system change or as a result of safety trend analysis.

The airport will generally use its internal resources to support the SRA. On occasion, it may be necessary, and beneficial, to call upon external resources from stakeholders and consultants. Although the availability of resources may pose a near-term obstacle when deciding to execute an SRA, it is important to remember that SRM is a key component of an effective SMS and that absorbing near-term costs may achieve greater long-term safety and capacity benefits.

16.3.2 SRA Triggers

An SRA Trigger is a condition, a system change, or piece of information that prompts management to convene a panel to conduct the 5-Step SRM process or an event that automatically requires convening a panel. In most cases, SRA triggers are associated with safety issues that require a multidisciplinary team to perform the SRM process thoroughly.

> Many of the same triggers that lead to the convening of a panel can initiate application of the 5-Step SRM process in the field to manage daily operational risks.

The FAA uses an internal procedure to identify the need to organize an SRA Panel and complete a safety assessment systematically. The Safety Assessment Screening (SAS) process is described in FAA Order 5200.11 and ARP SMS Desk Reference guide. Some of the triggers defined by the FAA (e.g., development and update of ARP standards) will only require internal FAA actions. Other FAA triggers may require actions by airport operators to participate in and organize a safety assessment and convene an airport SRA panel. The list below presents the most common FAA triggers for airport SRAs:

- Airport Planning
- Airport Construction Safety and Phasing Plan (CSPP) Development
- 49 CFR Part 150 Noise Compatibility Planning Projects
- Modification of FAA Airport Design Standards
- Airspace Determinations for Non-Construction Changes

Additional Non-Construction Changes include

- Runway or taxiway designation changes
- Pavement marking and signage changes
- Runway categories changes
- Planned approach/departure procedure changes
- Airport modifications or updates that substantially change an action already approved by the FAA

Some triggers can be considered universal; all airports can use these as SRA initiation points or as catalysts for evaluating the need for an SRA. Additionally, each airport should determine its own SRA triggers that fit the needs of the airport, its available resources, and the philosophy of airport management. Table 16-1 lists common SRA triggers.

Table 16-1. Common airport SRA triggers.

SRA Trigger	Description	Example
Construction	Airfield improvement	Runway 15 extension
	Airfield rehabilitation	Resurfacing Taxiway C
	Airfield maintenance (beyond day to day work)	Rubber removal; chip seal on Runway 10
	Construction of tower	Construction of new ATC tower
	Terminal expansion	Additional gates and gate areas
	Landside roadway reconfiguration	Additional lanes into the terminal area
	Parking area modifications or rehab	Parking garage rehab or updating facilities
	Changes in access roads onto airport property	Adding or subtracting lanes and access points
Standard Operating Procedures Changes	New SOP	SOP for towing aircraft; SOP for mowing grass in safety areas
	Modification to existing SOP	Changes to SOP on snow removal due to new equipment
Airport Organization	Significant changes to airport organizational structure or key personnel	Rearranging the Department of Operations; creating an SMS Division
Safety Reports (Hazardous Condition Reports)	Safety issues reported by pilots or airport employees (including tenants)	Reports of pavement failure, blind spots, or hazardous conditions on the ramp
	Safety issues resulting from daily inspections	FOD generated by poor pavement conditions at the intersection of taxiways
	Accidents and incidents	Surface or ramp accident; birdstrikes
Special Event	Major sport events	Super Bowl; Olympic Games; Major College Football Game
New Equipment or Software	New aircraft brought in by a carrier	Starting operation of A380 or B787 aircraft
	New passenger boarding bridge	Installation of new bridges that have different capabilities
	New ramp equipment that requires special consideration	Introduction of towbar-less tractor
	Changes to information management systems	Changes to reporting procedures during self-inspections
Proposed New Infrastructure/Facilities and Regulatory Standards	FAA research and development work (e.g. the FAA Tech Center)	Perimeter taxiway; new NextGen equipment
Safety Assurance	Trends identified from safety performance indicators (e.g. birdstrikes, FOD, etc.)	Increase of birdstrikes with damage to aircraft
	Safety audits	Unsatisfactory SMS internal or external audit results

At the time of the development of this guidebook, the FAA ARP, through the Notice of Proposed Rule Making regarding SMS, anticipates limiting the application of SMS to the Air Operations Area (AOA), inclusive of the movement areas. Airports can and are encouraged to include triggers for those conditions that fall outside the AOA as well. This promotes an airport-wide approach to safety management with consistent processes, regardless of location and regulation.

16.4 Categories of SRA Triggers

This section explains and provides examples of the most common triggers used by airports to define the need to conduct an SRA.

16.4.1 Hazard Reports

Hazard reports at airports are used to describe safety issues (e.g., presence of wildlife, damaged NAVAID, and FOD) identified during routine procedures. The diverse sources may include

- Daily inspections by airport staff
- PIREPs
- Observations from airfield workers (e.g., Maintenance, ARFF, and FBO)
- Observations from ATCT personnel

At larger airports, hazards are generally reported using systems designed to capture and save the information, such as airport intranet systems or telephone communications systems.

At small airports, communication between airport personnel is normally very effective, and frequently safety issues are communicated and discussed verbally. A method to document such discussions will enhance SRM at small airports.

Table 16-2 presents examples of frequently reported airport hazards. In most situations, the parties listed in the table are those reporting the issues; in special circumstances, other stakeholders may report the issue. Some of these issues are SRA candidates, particularly if reported frequently at the airport, frequently at a specific location, or in the movement area of the airfield.

For these hazard categories, only the most serious or frequently reported issues generally lead to a formal SRA. In fact, convening a panel would only slow the decision-making and reaction processes necessary for normal daily operations. Airports are encouraged to consider panels in those cases of frequently recurring issues; an example might be FOD reported every day, in the same location, at about the same time of day. Examples like this are clear indications of systemic problems that a panel might be better equipped to solve completely. The SRA process would identify root causes, determine risk levels, and mitigate the situations more thoroughly rather than just treating the symptom—routinely picking up the FOD every day.

Table 16-2. Typical safety issues reported.

Hazard	Who Reports
FOD (debris)	• Airport operations personnel performing daily inspections • PIREPs • Airport maintenance personnel during routine work • ARFF personnel • Airlines' ground personnel
Low runway friction	• PIREPs • Airport maintenance staff performing runway friction measurements • Airport Operations personnel • Daily safety inspections
Vehicles and equipment speeding in ramp areas	• Ground handlers • Airline ground personnel • Airport public safety personnel
Presence of wildlife	• Airport operations personnel performing daily inspections • PIREPs • ATCT • Airport maintenance personnel during routine work • ARFF personnel
Inoperable NAVAID	• Airport operations personnel performing daily inspections • PIREPs • ATCT
Damaged signs and lights	• Airport operations personnel performing daily inspections • PIREPs • ATCT
Faded or removed pavement markings	• Airport operations personnel performing daily inspections • PIREPs

16.4.2 Accident and Incident Reports

Accident and incident reports constitute an important category of triggers. In most cases, these reports lead to an accident or incident investigation. The purpose of an investigation is to determine causal and contributing factors to the event so such factors can be prevented or mitigated. Airport staff can augment and complement investigations by performing an SRA and identifying risk mitigation actions and staff responsibilities to reduce the chances of a similar incident or accident.

The most common types of accidents and incidents in this category are

- Surface incidents/accidents
- Wingtip collisions and incidents
- Runway incursions and excursions
- FOD (damage)
- Wildlife strikes

According to the FAA Order 7050.1A, a surface event is an ". . . occurrence at an airport involving a pedestrian, vehicle, or aircraft on the movement area that involves an incorrect presence, unauthorized movement or occurrence that affects or could affect the safety of flight of an aircraft." The same reference defines a surface incident as an "unauthorized or unapproved movement within the designated movement area (excluding runway incursions) or an occurrence in that same area associated with the operation of an aircraft that affects or could affect the safety of flight." Most frequently, surface events and wingtip collisions happen in the ramp areas. Having many workers and much equipment in a confined area, often under substantial time pressure, creates an environment in which injuries and aircraft damage may occur.

Runway incursion and excursion accidents and serious incidents are investigated by the NTSB and the FAA. Determination of causal and contributing factors will help the airport evaluate the need for mitigation actions, such as new equipment installations to prevent runway incursions, modifications of airfield layout to avoid confusion and hotspots, or improvements to runway friction, safety areas, and emergency response. An SRA using the investigation reports as a resource will assist in the evaluation.

FOD and damage caused by wildlife strikes frequently occur at all types of airports. Although these events rarely lead to fatal accidents, direct and indirect associated costs are high. Airport SRM will benefit by tracking these events to evaluate trends in frequency, location, and severity. The SRA may identify further actions in addition to those outlined in the investigation report to mitigate risk at specific areas or for certain species involved in wildlife strikes.

16.4.3 Trend Analysis

With the implementation of SMS comes the introduction of safety performance indicators. These could be new measures of safety developed to support the SMS and its SRA component. Data for these indicators are collected and trends are followed to determine the need for new actions if an undesirable trend is identified. Examples of indicators in this category are the frequency of wildlife strikes at the airport, the number of FOD incidents in movement areas, or the number of specific incidents on the ramp (e.g., frequency of vehicle/equipment speeding reports).

To illustrate trending, recorded wildlife strikes are used as an example. An airport created a KPI to measure trends of birdstrikes. Data was collected from the FAA Wildlife Database during the past 10 years and the trends were graphed (see Figure 16-1).

A wildlife strike with adverse effect (AE) is one that causes some type of effect on a flight (e.g., damage, delay, or go around). As shown in Figure 16-1, a general increasing trend to the number of AE strikes is seen, despite some periods when the number of strikes decreased relative to the previous year (e.g., 2009 as compared to 2008). The trend is undesirable and the airport intends to further evaluate the species that may be causing the trend using an SRA.

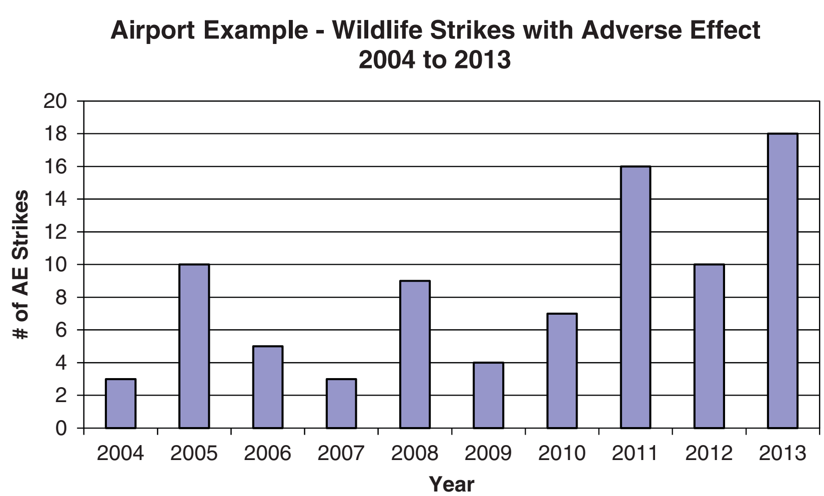


Figure 16-1. Trends in wildlife strikes.

Sometimes the simple analysis and trending of data may help identify the focus of actions to mitigate risks. However, to understand which actions will be more effective will require a discussion with SMEs or personnel from specific airport functions. In this case, an SRA may be the best option to understand the problem, the associated risks, and the means to reduce the likelihood of occurring.

16.4.4 Major System Changes

Major system changes at the airport are sources of risks. Some typical examples of such changes include

- Airfield improvements: runway rehabilitation and extension, construction of new taxiway, renovation of terminals
- Operation of a new large aircraft: B747-800, A380
- Changes to airport management: reorganization of Dept. of Operations, new Director at a small airport
- Introduction of new snow control equipment
- Special events: Super Bowl, college football game, air show
- Introduction of new systems: new NAVAID, new IT system for work orders
- Development of new operational or administration procedures
- Financial priority adjustments
- Rapid airport growth: aircraft operations increases, passenger increases

16.4.5 New SOPs

In most cases, the introduction of a new SOP will not represent a major system change. However, SOPs that focus on procedures used in the airfield can substantially affect safety. Conducting an SRA may enhance the safety effect of the changes and enable stakeholders to examine fully how the change affects their operations.

The effective approach is to develop a draft SOP that highlights the proposed changes and distribute this draft to the parties involved for review. A follow-up SRA will help identify safety issues associated with the new procedures as well as necessary modifications to the SOP to reduce the likelihood of incidents and accidents.

> An aircraft towing incident illustrates the use of an SRA to examine SOPs.

For example, a small airport had a few incidents with aircraft under tow to the hangars. In a few cases, the wingtip of the aircraft struck the doors or the internal structures of the hangar. An SRA with the airport director and staff responsible for towing aircraft helped to revise the existing SOP and reduce the likelihood of the incident occurring. During the brainstorming session, the group identified each step of the towing process (e.g., place work order, assign tow crew, select tow equipment, hook up, tow, maneuver aircraft in/out hangar, and park and secure aircraft). Risks were assessed for each step of the proposed procedure, and the procedure was reviewed again to address the higher risks.

In this example, each towing incident caused major problems and legal actions for the small airport. The airport management was seeking alternatives to reduce the negative perception of stakeholders and ensure the view that hiring airport services for towing aircraft was safe. The results of an SRA would support both of these goals.

16.4.6 Concerns Presented in Meetings

Safety concerns are commonly raised during internal and external airport meetings with stakeholders. These meetings offer excellent opportunities for important discussions about safety issues. Time is a critical constraint in multi-stakeholder meetings. How safety issues are presented can determine the value of the safety decisions that come out of such meetings. Airport safety leaders can submit specific issues for inclusion in the agenda with recommendations for immediate action or convening of an SRA. The presentation of the results from completed SRAs can also be included in the agenda of an upcoming meeting and can direct the group toward decisions about the actions proposed.

As an example, one tenant airline pointed out to the airport Safety Manager that traffic speeding on the commercial ramp was a concern voiced by several airline employees. The Safety Manager contacted the airport manager's office and asked that the issue be added to the agenda of the next Airport Advisory Board meeting. In the meeting, the group recognized this as a significant safety issue that should be addressed and the airport manager directed the convening of an SRA. Following the completion of the SRA, the Safety Manager again requested that a presentation on the results be added to the agenda of the next Advisory Board meeting. When the recommendations for action were presented, including the estimated costs of each recommendation, the board decided to act on two of the four SRA recommendations and monitor the progress of those actions.

16.4.7 Formal Reporting Process for Hazardous Conditions

Formal airport reporting systems take many forms. Many reporting systems are regulatory requirements to meet compliance standards. For example, Part 139 commercial airports are required to conduct a "daily safety" inspection of the aircraft movement area. Some airports use an internal voluntary reporting system or a voluntary reporting system for employees and passengers, either by online reporting, a voicemail hotline, or written forms submitted to the airport.

Airport hazard reports can come in the form of pavement management friction reports, wildlife strike reports, and vehicle accidents reports. Because safety is a job requirement for all employees of the companies working on the airside, airport hazard reports can also come through tenant companies. These companies should have internal formal reporting systems for airport hazards by their employees, with a responsible company representative reporting to the airport. Any and all concerns reported through a formal reporting process must be evaluated and, if required, an SRA should be conducted.

16.5 Support Material

Support material for SRAs is presented in the guidebook appendices as follows:

- Appendix A: SRM and the FAA describes interactions and interfaces between FAA internal SRM processes and those required by Part 139 airports
- Appendix B: SRM Handbook provides practical information that can be customized and used as a quick reference guide during an SRA

- Appendix C: SRM Process Tools presents practical processes and associated tools for use during the SRM process
- Appendix D: SRM Templates presents additional templates, risk matrixes, SRA report structures and examples
- Appendix E: Preliminary Hazard Lists provides lists of common hazards for various categories of airport safety issues
- Appendix F: Typical Accident and Incident Rates presents historical accident and incident rates for airport safety issues that can be used as baselines during the SRA process
- Appendix G: Typical KPIs and Associated Data provides examples of typical Key Performance Indicators that may be used/created by the airport for monitoring trends after SRA control actions have been implemented
- Appendix H: Basic Probability and Statistics for SRM presents basic approaches to calculating probability and statistics which are intended to support the risk assessment portion of SRM

CHAPTER 17

Conducting an SRA

The SRA process can be divided into three different parts: preparation, conduct, and documentation. Each part includes two or more subtasks, as illustrated in Figure 17-1. The process can be used for a range of safety issues with varying degrees of complexity. Some of the subtasks described in this chapter can be eliminated if the SRA Panel is experienced with SRM processes.

17.1 Before—SRA Preparation and Planning

17.1.1 Review Documents

One way to ensure the SRA is conducted as efficiently as possible is to ensure that appropriate documentation is collected in advance while developing the SRA Plan. If the SRA is planned to cover a construction project, then all documentation that explains and describes the proposed project needs to be reviewed and understood by the appropriate airport staff. Most likely this will be the SMS manager and the primary project owner or sponsor. The documents should include all available information about the project's effect and proposed schedule. Documents covering the SRM process and SRA procedures are very helpful to ensure the SRA is planned and executed properly, particularly if the panel members are new to the SRM process. The same is true for non-construction-related SRAs as well. As an example, documents describing elevators and escalators in a terminal building would be appropriate to review for an SRA that will cover passenger conveyance issues in a terminal.

17.1.2 Develop SRA Plan

SRA pre-planning, as with most group exercises, is critical to ensuring the effort is efficient and effective. As presented later in the templates section of this guidebook, use of SRA checklists is recommended and examples are provided. By having already reviewed the documents, the SMS manager and SRA owner or sponsor should be able to determine basic logistics of the SRA and assign responsibilities. This is helpful to make the SRA as participant friendly as possible, which will help to support process buy-in.

17.1.3 Identify Panel Members

The number of panel members may vary—from a couple of people for smaller airports to over 40 as observed in SRAs conducted during the FAA SMS Implementation Pilot Study—depending on the complexity and reach of the SRA topic. Key personnel with expertise in the areas affected by the subject or trigger of the SRA will be required attendees, along with select decisionmakers from the airport staff.

Figure 17-1. SRA parts.

SRAs are relatively new and represent a change to business practices for airports. Those that participate will need prior notification and guidance.

In many cases, it may be beneficial to limit the size of the panel, particularly when the group is formed with the most experienced personnel involved with the specific SRA theme. Smaller groups of no more than ten people are easier to manage. The SRA needs to include the ultimate owner of the subsystem being assessed, the project manager (if the assessment will cover a construction project), the SMS manager, and important stakeholders of the potential impacts of the assessment.

Examples of required panel members include

- Airport operations
- SMS manager/coordinator
- Risk management
- FAA (as appropriate from ARP, ATC, Tech Ops)
- Airlines
- SMEs
- Facilitator (while not a voting panel member, a facilitator ensures the process is followed)

Panels may also include staff from:

- Airfield maintenance
- Planning
- Development and engineering
- Public safety (Police and Fire)
- Environmental management
- Ground handlers
- FBOs
- Fueling services
- Transportation

17.1.4 Identify Facilitator

Identifying an experienced facilitator is important to a successful SRA. The person should be selected immediately after a decision is made to conduct the SRA. Ideally, the facilitator is also a SME with the safety issue that triggered the SRA and has no conflict of interest with the parties involved. For these reasons, an airport sponsor may choose to use an outside consultant or use airport staff from another airport if such an arrangement is possible.

According to FAA Order 5200.11 (08/2010), facilitators should complete the SRA Panel Facilitation course before leading ARP SRA panels. This is only the case for those panels required by FAA ARP. However, it is recommended that facilitators engaged by the airport have a similar qualification, thus, providing a certain level of consistency to the industry. It is also important to understand the need for and identify necessary support staff—individuals who can take notes, organize documents, and run presentations, freeing the SMEs to focus on the SRA.

Refer to Chapter 18 for more information on how to facilitate an SRA.

The facilitator should not be responsible for taking the overall notes that will make up the information contained in the SRA report. The facilitator should only be responsible to take bullet-form notes to record information requested from or provided by panel members. The facilitator bullet-form notes should remain visible to the panel. This provides a level of reassurance to the panel members that their input was heard and noted. Ideally, a designated note taker will assist the facilitator and help with documentation required for the final report.

17.1.5 Contact Stakeholders

In most situations, when the need for an SRA is determined, a group of stakeholders are invited to participate in the brainstorming sessions. It is important to contact key stakeholders and SMEs as early as possible to ensure their availability and avoid conflict of schedules. The presence of certain key panel members may be critical to achieve effective results and a successful SRA. Organizing the list of panel members with their respective contacts will save time during the coordination and scheduling of the SRA session.

When contacting stakeholders, make sure they are aware of the SRA topic and have a timeframe to check their availability. When confirmed, they should receive documentation to understand the issue or system to be assessed and prepare for the discussions. Appendix B has a template to help identify the preliminary information to be passed to panel participants.

17.1.6 Prepare Materials

17.1.6.1 Review Documents

Panel members and particularly the SRA facilitator should review the documents and data associated with the safety issue. Examples of valuable SRA documentation include the Airport Certification Manual (ACM), operating procedures, safety performance trends, project plans, Construction Safety and Phasing Plan (CSPP), and the Airport Master Plan.

17.1.6.2 Develop Preliminary Hazard List (PHL)

A Preliminary Hazard List can save valuable time during the panel's brainstorming sessions. Appendix E presents some hazard lists associated with common airport safety issues. Although these lists address many of the hazards, they are not comprehensive and many of the listed hazards may not be relevant to the specific problem. The airport should develop its own PHL before the SRA starts. The lists help the group involved with the SRA select some hazards for the specific situation.

17.1.6.3 Organize a Template for SRA Flow

A template that follows the SRM 5-step process will help the conduct and flow of the SRA. A common SRA template is a simple table, often generated using an electronic spreadsheet, which lists the SRM steps and several sub-steps that will guide the SRA. Annotating an estimated time allotted to each step can assist in SRA schedule adherence.

The type of template used will depend on the type of SRA. Information used to help select the type of SRA is provided in the ensuing chapter. The template will help the facilitator and the panel navigate through the brainstorming session.

Appendix D has typical templates used for different types of SRAs along with information on how to use each template.

17.1.6.4 Prepare SRA Briefing

A valuable tool used to kick-off the SRA is an introductory briefing to present the problem and introduce SRM concepts to those less familiar with the process. The duration of the briefing depends on the complexity of the issue and the knowledge of the panel. The briefing could last 30 minutes for a focused and narrowly scoped SRA topic or 2 hours or more for a complex project with a large panel. The briefing content should include the following:

- SRA objective
- SRM basics with examples
- Description of the SRA process with example
- Description of the system that will be assessed during the SRA
- Preliminary plans and initial data associated with the SRA

17.1.7 Schedule the SRA

Scheduling an SRA involving a large panel can be challenging. It is rare that all key participants and SMEs will be available during the same days; therefore, flexibility must be built into the schedule. For smaller panels, with six or fewer participants, it may be easier to accommodate the requirements of the participants and a couple of days can be reserved for the SRA. For larger airports when a facilitator is brought in from outside the airport, a hard start and end time and dates are likely, thus requiring more detailed advanced planning. A basic SRA schedule example is provided in Table 17-1. This type of schedule was used by some of the airports participating in the SMS Pilot Studies, on various SRA topics, and by different sizes of airports (non-hub, medium-hub, and large-hub airports). *Note: in the example Table 17-1, only 8 hours are planned for the actual conduct of the SRA itself. The amount of time needed should be driven by the topic and the complexity of the airport.*

It is difficult to estimate the duration of an SRA. Risk assessments associated with airfield construction may require 8 or 12 hours over 2 or 3 days. It is necessary to limit the time of each session because brainstorming sessions may be very demanding. After a few hours, the exercise becomes less effective. Examples from the FAA SMS Pilot Studies include two half-day sessions

Table 17-1. Basic SRA schedule (example).

Day 1 (2 hours) 1/6/14	Day 2 (4 hours) 1/7/14	Day 3 (4 hours) 1/8/14
12:00 PM to 2:00 PM	8:00 AM to 12:00 PM	8:00 AM to 12:00 PM
Briefing with airport staff • Confirm logistics and processes and procedures	Steps 1-3 of the SRM process 1. Describe the System 2. Identify the Hazards 3. Analyze the Risks	Steps 4-5 of the SRM process & SRA Documentation 4. Assess the Risks 5. Mitigate 6. Document the process and mitigations

(allowing staff to have time for their daily responsibilities and provide more information for the SRA process if necessary), a single session lasting a full day, and a single half-day session. There is not enough information in the airport industry yet to recommend a time standard. Airport operators need to determine what works best at their airports and how best to ensure the process is followed and productive.

A simple table where each column represents the date and rows represent the period of the day (i.e., morning or afternoon) is suitable. The cells should contain

- The time period (e.g., from 8:00 AM-12:00 PM)
- The location (e.g., Meeting Room A, Ops Bldg.)
- The parties involved if the sessions involve smaller groups (e.g., Ops and Engineering only)

It may be hard to schedule SRAs with large parties. An alternative is to break the panel into smaller groups of up to ten people. This approach allows for the accommodation of individual schedules and organizes more manageable groups to make the process simpler and focused, thus helping the facilitator and the groups to keep the SRA efficient. The disadvantage of an SRA with multiple groups is that some synergy and interaction between different parties with varied views may be lost. To mitigate this disadvantage, the final SRA meeting can be scheduled to have at least one member of each group present to overcome the loss of interaction. This strategy also avoids discussions focused to only one or two subgroups, while the other SRA panelists remain silent and may lose motivation.

17.2 Conducting an SRA

Figure 17-2 presents the recommended steps to conduct an effective SRA and the flow of the SRA process.

17.2.1 Step 1: Opening Remarks, Introductions, Handouts, & Agenda

The SRA opens with remarks by airport leaders or SRA sponsors describing the subject of the SRA and introducing the organizations involved. Each participant is asked to introduce himself/herself, including name, affiliation, and position. Next, the meeting agenda is presented, describing the steps and any schedule issues. Any handouts (e.g., risk matrix and categories of hazards) should be provided to participants. Every participant should be aware of the purpose of the meeting, expected outcomes, and the items to be covered during the SRA. The agenda will help participants get ready for the discussions. Having start times for each agenda item will help maintain the pace of the discussions and keep conversations focused. In addition, this will ensure that the number of agenda items to be covered remains realistic for the time allotted.

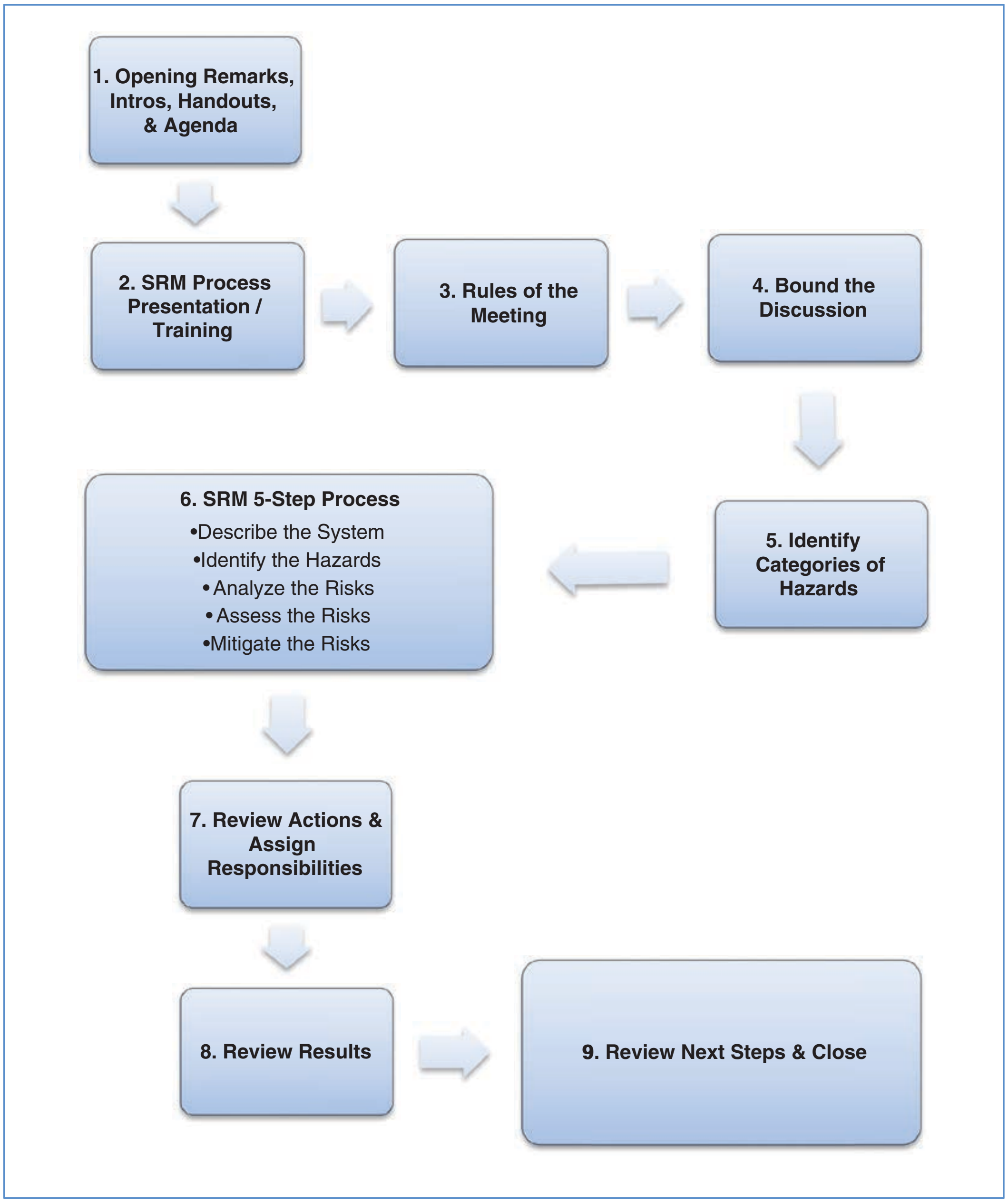


Figure 17-2. SRA facilitation process.

17.2.2 Step 2: SRM Presentation/Training

The introductory briefing is next. An SRM briefing/training is presented to familiarize the participants (particularly those who have not participated in SRA exercises) with the 5-step process and the tasks at hand, understand the SRM process, and introduce or review the airport-specific risk matrix. The presentation ensures all participants are on the same page, whether or not preliminary information was provided prior to the meeting.

17.2.3 Step 3: Rules of the Meeting

The participants should be briefed on what role they will play, what is expected from them, and how they should act to help achieve a successful outcome. Before the meeting begins, address things to avoid during the meetings (e.g., responding to text messages, answering phones, and sidebar conversations). Only one person should speak at a time during the SRA.

17.2.4 Step 4: Bound the Discussion

Discussing the specific portion of the system involved in the assessment will help participants further understand the scope of the analysis. For example, a construction job on the airfield assessment may be bounded as the construction area (e.g., Taxiway M, from Taxiway C to Taxiway F), equipment, haul routes, workers, airport staff and other stakeholders, construction materials and debris, and the environment comprised by the movement and non-movement areas impacted. When proceeding through the process and discussing each individual hazard, a new subsystem may be identified as associated with the specific hazard and should be part of the bounded SRM process for that hazard.

17.2.5 Step 5: Identify Categories of Hazards

Although a list of **specific** hazards should not be provided to participants, a list of categories may help with hazard identification. Hazard categories for a construction job could include hauling, excavation, and paving.

17.2.6 Step 6: SRM 5-Step Process

One approach is to discuss each category of hazards and perform the SRM 5-step process for each hazard identified within the specific category. The subsystem for the category is described, and the first hazard is identified. Risk is determined and assessed for the hazard under existing conditions and controls for that hazard are identified. The risk should be classified and additional mitigation actions may be deemed necessary to address medium and high risk. The risk should be reassessed to determine the expected residual risk following implementation of new mitigation actions. The process is repeated for each hazard within the specific category. The whole 5-step process is repeated for each category of hazards.

17.2.7 Step 7: Review Actions and Assign Responsibilities

One or more risk mitigation actions may result from an SRA. These actions will help further mitigate the risk level in addition to existing controls. A person or group at the airport should be responsible for implementing these risk mitigations; often, so as to avoid potential organizational conflicts, the implementation is assigned to one or more stakeholders without engaging a specific person. In most situations, the results of an SRA will be presented during a regular airport meeting for decisions related to recommended actions and assignment of parties responsible.

Although this step could be performed during the SRA facilitation meeting, it may be more effective to perform after the 5-step process is complete. Grouping mitigation actions before assigning responsibilities for implementation creates more efficient assignment of responsibilities. The objective is to identify the party responsible, rather than the person. Each party will later follow specific management processes to appoint the person responsible for each action.

17.2.8 Step 8: Review Results

Participants usually have different views of what happened during the SRA and what are the next steps. Five to ten minutes before the end of the meeting, participants should review the main risk mitigations resulting from discussions and convert those decisions into action. To improve the quality of the SRA, the group should be asked "What went well?" and "What can we improve on next time?"

17.2.9 Step 9: Review Next Steps & Close Meeting

The final step in conducting the SRA is to describe the next steps and the schedule (including preparation of the SRA report, submittal of the report to the participants for approval, and collection of information on mitigation actions approved by the parties at their specific decision levels). Following this, the SRA is closed.

17.3 After—SRA Documentation

17.3.1 Consolidate Information

The SRA process will generate several documents. Regardless of how the information is collected, either via a computer using MS Excel or a Word document or by using large note paper, a lot of information will be captured and must be gathered so that it can be easily made into a report.

17.3.2 Prepare Report

It is necessary to document both the SRA process and the results. The report ensures that the essential elements of the SRA were discussed. These elements include

- Who was involved with the assessment,
- The hazards and risk levels identified, and
- Particularly the risk mitigation actions that should be implemented.

The report will contain important details and may be used to guide discussions in other meetings, particularly for decision making on risk mitigation actions that should be implemented and the persons responsible for those actions.

Small airports may only need a one-page template in order to document the SRA and the results effectively. Appendix D includes a template for small airports.

SRA reports, in general, should contain the following sections:

- Cover and Table of Contents
- Quality Assurance and Version Tracking
- List of Participants
- Executive Summary
- Background and Scope
- Description of the System

- Hazards, Risks, and Risk Values
- Mitigation Actions and Responsibilities
- Conclusions and Recommendations
- Attachments

The cover should provide the name of the airport, the type of report, the theme of the safety assessment, the report number, the report version, and the date.

17.3.2.1 Quality Assurance and Version Tracking

Some SRA reports will be reviewed by several participants and decisionmakers. Track the modifications to ensure that relevant comments and suggestions are properly addressed. Appendix D's example SRA reports include

- **M**ission: The purpose of the system being described, such as the safe movement of aircraft on the ground, and during takeoff and landing operations, when describing the airfield.
- **M**achine: A physical description of the site or area involved with existing structures (e.g., buildings and facilities, airfield areas, access routes, parking or staging areas, gates, utilities, equipment, and systems).
- Hu**M**an: A description of the functions involved, including airline operations, airport functions, and other stakeholders.
- Environ**M**ent (**M**edia): The environment composed of the types of operations and weather conditions to which these operations are subject. This may also include key behavioral influences such as psychological, physical, and physiological stressors (e.g., night shifts or long working hours).
- **M**anagement: A list of safety-significant activities, processes, procedures, rules, and regulations that govern the conduct of the mission described for the system.

17.3.2.2 Hazards, Risks, and Risk Values

This section summarizes hazards, associated risks, and risk values. It is normally presented as a table with risk value cells with background color corresponding to the level of risk: green for low, yellow for medium, and red for high. For simpler SRAs, current risk, residual risk, and mitigation actions are presented in the same table. Table 17-2 illustrates the concept.

The risk values assigned in Table 17-2 are examples only. The values should be determined by the definitions for severity and likelihood that were developed specifically for the airport and then assessed using the airport's risk matrix. Examples of severity and likelihood definitions and risk matrixes are included in Appendix C. Some facilitators prefer to sort the risks from highest to lowest in this type of table. Examples are presented in the example SRA reports in Appendix D.

Table 17-2. Hazards, risks, and risk values.

Haz #	Hazard	Outcome	Risk Value		
			Severity	Likelihood	Risk Value
1	Haz 1	1-1	Sev. 1-1	Lik. 1-1	RV. 1-1
		1-2	Sev. 1-2	Lik. 1-2	RV. 1-2
2	Haz 2	2-1	Sev. 2-1	Lik. 2-1	RV. 2-1
3	Haz 3	3-1	Sev. 3-1	Lik. 3-1	RV. 3-1

Table 17-3. Summary of mitigation actions.

Haz #	Hazard	Identified Hazard
	Outcome	*Potential result associated with the Identified hazard*
	Risk Value	*This section provides the severity, likelihood and value of the Identified risk. The field may be colored to reflect the color scheme set up in the risk matrix used for this exercise. Yellow in this case represents a Medium level of risk.*
	Risk Mitigation Actions	*This section identifies both:* • *The policies, programs and other measures that the airport or the FAA already has in place that contribute to the management of the risk identified; and* • *The actions that are to be put in place as a result of the specific hazard.*
	Updated Risk Value	*This section provides the severity, likelihood and value of the Identified Risk revised in light of the mitigating actions. The field is colored to reflect the color scheme set up in the matrix used for this exercise. Green in this case represents a low level of risk, I.E. the airport was able to lower the risk value through mitigation(s).*
	Recommended further Risk Mitigation Actions	*This section provides, when applicable, further actions that could be implemented by the airport to further mitigate the risk and reduce its value.*

17.3.2.3 Mitigation Actions and Responsibilities

This section can be a single table or multiple tables with each presenting a single hazard. Table 17-3 presents a description of each field. More examples are in the example SRA reports in Appendix D.

17.3.2.4 Conclusions and Recommendations

This section summarizes the main hazards, risk categories, and mitigation actions in bullet form. Tables may be necessary for better organization as shown below.

Risk 2-1 (Medium Level of Risk): Performance of routine operations in the presence of new structures erected to support construction work causing lack of situational awareness and potential accidents in ramp area affected by construction.

Risk mitigation actions:

- Markings and signage
- Temporary routes
- Temporary protective structures
- Stakeholder construction meetings
- Employee Awareness campaigns
- Airport staff, airlines and third-party operators training programs
- Daily safety briefings and employee awareness
- Issuing of NOTAMs

A table summarizing the parties responsible for implementing each risk mitigation action is also desirable in this section.

17.3.2.5 Attachments

This section should include the risk matrix used to determine risk values, along with any materials supporting the SRA (e.g., plans, procedures, and data).

17.3.3 Submit Report

Following the completion of the documentation, the airport should have a documented process that describes how the report is to be submitted and accepted by the appropriate management personnel. These personnel may include the SMS manager, the Accountable Executive, the project sponsor, or other personnel authorized to accept and ensure the risk mitigation plan is implemented and tracked to determine if it is successful. Further, the SRA report must be archived so that the process used and the results are available as future SRA reference material and as evidence that the airport followed its own SMS processes for audit and regulation purposes.

CHAPTER 18

Facilitating an SRA

18.1 Preparing to Facilitate an SRA

An experienced facilitator can help ensure the success of an SRA. Ideally, a facilitator who is also a SME in the safety issue that triggered the SRA and who has no conflict of interest with the parties involved should be selected. The facilitator must be familiar with airport operations to the extent the subject matter deals with those aspects. If the facilitator is not familiar with the particular topic of the SRA, time needs to be spent preparing so that the facilitator will have a basic knowledge of the system to be described during the process.

> A good facilitator can make the difference between an SRA that enhances airport performance and an SRA that "checks a requirements box."

The facilitator should spend time with the airport staff in advance of the SRA. The time should be spent accomplishing preparatory tasks and getting answers to important questions such as

- Learning about and understanding the reason for the SRA. What was the triggering event and how does it fit into the existing system?
- What is the airport staff's understanding of the issues associated with the SRA? What are the underlying conditions, personalities, or hidden agendas that may surface during the SRA?
- Confirm the SRM processes, procedures, and templates to be used. Have these been agreed to with any outside agencies who are participating? (e.g., FAA and airlines)
- Confirm the logistics associated with the SRA
  - Dates
  - Times
  - Location (exact)
  - Refreshments
  - Projectors
  - White boards and or white paper to capture notes in real time
  - Responsibilities for documents, drawings, plans, and data
  - Responsibilities for other logistics as needed
- If the triggering event is a construction project, the airport staff should provide a detailed description of the project, including any preferences the staff may have with regard to project phasing and priorities to tenant and airport impacts.

18.1.1 Invitations to Participate

Following the initial briefing with the airport staff, decisions need to be made concerning the invitations to participate in the SRA. The first decision is on the responsibilities to prepare and send the invitations. Usually, airport staff will send the invitations; however, the facilitator, especially if he or she is an outside consultant, may be assigned to prepare the invitation. In this case, some questions will need to be answered before the development of the invitation:

- Will the invitation be sent via email or hard copy?
- If via email, who is responsible to ensure that all the invitees' email addresses are correct?
- How elaborate does the invitation need to be? Will it require photos and/or will appropriate logos be necessary?
- What are the dates for distribution? Will there be a reminder sent closer to the actual date of the SRA?

Identifying the right people to invite will set the stage for the success of the SRA. Invitations should be offered to those having a stake in the issue and to those with expertise in the topic area. The invitation should explain the purpose of the SRA and outline the topics and issues to be discussed. Make it clear in the invitation what the needed expertise is and how the airport expects to benefit from the SRA. Prepare a list of items and information each individual invitee is expected to bring. This list should be included in the SRA invitation so that other members of the panel can see and understand who is responsible for what.

After coordination discussions are complete, the invitation can be prepared. The invitation should include, at a minimum, the following information:

- Title (Example: Invitation to a Safety Risk Assessment).
- Dates.
- Times.
- Location (exact, including room numbers or names if necessary).
- A description of the triggering event for the SRA. If it is a construction project, the project designer might need to provide this information. The description should be short and concise.
- The exact reason why the invitees are receiving the invitation. (Example: You are receiving this invitation because of your SME and we are requesting your participation in this SRA to assist us with making important safety risk management decisions.)
- The list of invitees and all the information they are expected to bring.
- Logistics, such as refreshments.
- Any other pertinent issues.
- An RSVP link or phone number. An exact number of participants is needed for proper planning.

18.1.2 SRA Templates

The templates for use during the SRA should be identified well in advance. The appendices of this guidebook offer examples. Appendix D is specific to templates. In general, the three most important templates for use during the conduct of the SRA are

- Definitions for severity and likelihood
- Risk matrix
- Hazard table (which tracks the SRA process)

Sometimes, airport staff may be able to fill in certain templates as the SRA is being conducted. However, this approach slows the process because members of the SRA panel begin to assist with writing the details in the tables and report, rather than responding to questions and providing information that supports decisions.

18.1.3 Risk Matrix

The guidebook's appendices contain several sample risk matrixes for use by an airport. Appendix D is specifically provided to give airport operators options to select risk matrixes that best fit their needs. The facilitator needs to be familiar with the risk matrix to be used and understand why that particular matrix was chosen by the airport staff. The airport should determine which matrix is to be used and it should be included in the SMS manual. Appendix D contains a 5 × 5 matrix used by various airports of varying size and complexity and recommended in current FAA SMS guidance.

> When presenting or reviewing the risk matrix, the facilitator should illustrate the two ways to reduce risk—decrease the severity of the outcome or reduce the likelihood of the undesirable outcome.

18.1.4 SRA Briefing to Participants

One of the most important sessions during the SRA is the initial briefing to the panel participants. The initial briefing sets the tone for the level of professionalism expected and enables the airport and the facilitator to be seen as leaders who will ensure the success of the process. In most cases, the briefing should be presented by a member of the airport staff, particularly, a senior member of the staff who most likely is seen as the SRA sponsor or SMS manager. It may be beneficial for the facilitator to make the presentation, particularly if bias among the panel members may exist.

For illustration, the assumption is made that the briefing consists of a PowerPoint presentation outlining the issue to be assessed. In general, the presentation should include the following:

- Introduction slide
- Roles and responsibilities
- Logistics
  - Dates and times
  - Refreshments and breaks
  - Overall agenda. (Note: If the SRA will last over 2 days, indicate which parts of the 5-step process will be covered on which days)
- Brief description or depiction of the 5-Step SRM process
- Definitions for Hazard, Risk, and Mitigation (if necessary, based on the panel members' knowledge)
- Risk Matrix to be used
- Definitions of Severity and Likelihood to be used
- Detailed description of the issue to be covered (i.e., the triggering action, event, or proposed change to the system). If it is a construction project
  - Site plans
  - Phasing
  - Haul routes
  - Planned mitigations to be implemented during the project
- Close out slide to allow any questions prior to starting the process

To be effective, the presentation should be complete and concise. To some panel members it may be their first exposure to SRM, and creating a positive first impression of the SRA process is important. Alternately, panel members experienced with SRAs may have had a bad experience, such as a protracted timeline, arguments among panel members, or poor data, which may arouse negative feelings about the process. The briefing is an opportunity to demonstrate how this SRA will be improved. Keep the mood professional and focused on the tasks at hand.

18.1.5 Handouts to Participants

The SRA will be more efficient if the SRA panel members have pertinent information at their fingertips during the SRA. Refer to Appendix B for the minimum recommended information that should be made available. Appendix B, a brief handbook that can be tailored to fit the needs of an individual airport, can be printed and bound into a small handout for reference.

18.1.6 SRA Checklist

Appendix B also includes an SRA checklist that can be tailored to any airport. During the SRA, it is beneficial to have the checklist available to confirm roles, responsibilities, and actions. Someone on the administrative staff of the airport should be tasked with using the checklist to confirm that things are occurring as anticipated.

18.2 Facilitating the SRA

An effective facilitator is essential for conducting a successful SRA. The facilitator ensures that the panel members make the most of their time and that the correct information is gathered to support timely and pertinent decisions. The facilitator must wear multiple hats to make this happen. Being the SRA's leader is one; being the SRA's number one listener is another; and being the SRA's manager is yet another. The panel members need to feel heard and sense that their opinions matter. However, the facilitator must also ensure that the process is followed and the information and decisions made are appropriate and timely. This is a tough assignment for even the most experienced person.

Having some focused facilitation training is very beneficial. The FAA ARP provides guidance on facilitator training in FAA Order 5200.11 and the FAA SMS Desk Reference Guide, Appendix F. The Order identifies courses consistent with the training and experience needed to assist with FAA ARP-required and -led SRAs. The FAA uses this guidance for ARP-led panels.

Although 5200.11 is an internal document to ARP, it does and will affect Part 139 airport operators because of the requirements placed on airport operators to provide facilities and facilitation services.

Regardless of the requirement, facilitation is more art than science, and participants in the SRA will benefit from an accomplished facilitator; this is true whether the facilitator is a third-party consultant, part of the airport's staff, or provided by the FAA.

18.2.1 Keeping to a Timeline

To ensure the process is followed and the SRA is accomplished in the time allotted, the facilitator also needs to serve as timekeeper. There are several ways to accomplish this; but, in general, reminding the panel members of what they have accomplished and what will be covered next is very effective. It reminds the panel members that more work is needed and that providing information and making decisions is why they were asked to participate. Specific techniques include

- Establishing the timeline in advance, making it part of the overall briefing and putting it in the invitation if the SRA is planned over multiple days

- Referring to the timeline prior to taking breaks and coming out of breaks so that panel members see progress and can adjust accordingly
- Starting on time after breaks and refreshment periods
- Having a plan for how long each step in the process will take for discussion and decisions
- Asking panel members what can be done to ensure the process and the timeline proceeds efficiently
- Calling time-out and reminding the panel members that their time is valuable and you, as the facilitator, want to ensure it is not wasted. This may be necessary for those panels members who insist on straying off topic and discussing matters that do not directly pertain to the SRA
- Striving to prevent participants from skipping ahead. Following the process is critical to ensure the best and most accurate results come from the SRA. Some SMEs who are participating on the panel may want to skip ahead in the process and jump to conclusions. The facilitator must recognize this and not allow it to happen

The best technique to ensure the timeline is followed is to keep the panel members focused on the process. Gather the necessary information from them and ask for decisions. By leading the process, the facilitator can help ensure that the SRA follows the agreed timeline.

> Keeping the discussion moving during the earliest stages of the SRA can help keep to the timeline. Typically, panel members will become overly focused on individual issues early on and then rush toward the end realizing they are running out of time.

18.2.2 Focusing the Participants

The SMEs sitting on the SRA panel often come from different organizations, but they are all related by aviation. Representatives from the airport staff, the FAA, the airlines, airport tenants, and ground service providers might all sit on the panel as SMEs. Often, the panel members already know one another and work with each other frequently—thus, panel members want to "visit" and discuss topics unrelated to the SRA subject. As mentioned in the introductory sections, SMS and SRM are in various stages of development in the United States. The diverse background of panel members may also mean they have different views of SRM and how the SRA process should be followed. These pre-conceived thoughts may slow or hinder the process. The facilitator must be aware of this possibility *before* the SRA begins.

To focus the panel members and keep them concentrating on the tasks at hand, the following techniques can be used:

- Describe the process, the risk matrix to be used, and the definitions for the severity and likelihood up front; get agreement from the panel on what is to be used
- Layout the overall timeline and advise the panel that the facilitator's job is to ensure participants stay focused on the process and adhere to the timeline
- Establish the ground rules. Reserve the right as the facilitator to refocus the panel members to ensure the SRA is accomplished
- Remind the panel members that the process will be followed. To make progress, they need to work the process as prescribed
- Call on them individually and remind them that they were asked to participate for their expertise and knowledge

- Allow some discussion, but be mindful of the schedule and call the panel members back if need be. Some discussion is important because it gives the panel members an opportunity to debate and perhaps discover issues that otherwise would not be mentioned
- Take breaks. When a break is finished, make it clear when the panel reconvenes as to where they left off and what is coming next

As mentioned earlier, facilitation is more art than science. Each SRA panel will have a different dynamic and the members will have different relationships with one another and perhaps bias about the topic being assessed. To the extent possible, the facilitator should be aware of these conditions in advance and understand how these conditions may affect the SRA process.

18.2.3 Techniques for Hazard Identification

In general, the facilitator keeps the panel members focused and actively participating in the process. The facilitator may find it beneficial to summarize the techniques used to make the process more effective. If the panel members offer suggestions that are not classified as hazards, but rather the outcome of a hazard, the facilitator may choose to not correct the panel member specifically. Rather, a successful technique is to allow the process to continue and when no other hazardous conditions are offered, go back through the list and discuss each one to ensure consensus among the panel; a correction can be made then. In such a case, the process continues and the panel member who offered the non-hazardous condition will not feel their input was rejected, thus keeping them engaged in the process.

18.2.4 What to Do When a Preliminary List of Hazards Is Not Available

Some things can be done in the absence of a PHL:

- Allow time for hazard identification in the process. The SRA panel members will develop the list of hazards from scratch. Therefore, enough time should be allocated in the schedule.
- Plan to use the techniques described in Chapter 9, Step 2, to develop the list. The panel members should be asked to go back through the list to confirm the items are, in fact, hazardous conditions, and then add or subtract as appropriate.
- Use the general lists of hazards provided in Appendix E of this guidebook as a starting point for the discussions. The examples provided in Appendix E may not be exact matches for each individual airport, but the examples can put the hazardous conditions in context and spark discussion among the panel members.

The facilitator must ensure that hazard identification is as inclusive as possible. Encouraging the panel members to consider all appropriate conditions and under all appropriate circumstances is necessary. This critical step in the SRA process should not be cut short; extra time should be allowed and the panel should be encouraged to continue exploring all possible conditions.

18.2.5 Playing "Devil's Advocate"

Often panel members may begin to agree with one another as a matter of gradually developing process routine, rather than as a result of honest deliberation. This may stifle thoughtfulness and leave out important information. The facilitator must identify this behavior and address it. One way to do so is to play "devil's advocate." This means the facilitator challenges the consensus and asks "What-If" or "what about." The facilitator must understand the system and the issue being assessed well enough to be able to ask such questions and have the panel members recognize what is being asked.

SRA panel members will sometimes want to assess risk based on the worst outcome of the hazardous condition and not necessarily on the worst *credible* outcome. People tend to believe that all hazardous conditions could lead to a catastrophic event. Although the worst can happen, it may not represent what is reasonable or credible. The facilitator needs to challenge this by specifically asking for data to support the panel's assertion. Questions the facilitator should ask include, "Is that truly what you expect to happen?" or "When was the last time that occurred?" These are simple ways to challenge the panel without stifling discussion and interaction.

18.3 Recording/Documenting the Proceedings

The facilitator is responsible for capturing what is said by the panel members, not verbatim, but by topic or in a bullet formatted list. The panel members expect to be heard, and the most effective way to demonstrate that the facilitator did hear them is to capture the topic or issues they provide. Such capture can be accomplished in several ways:

- Use large whiteboards or poster paper and capture thoughts with a marker. This is a long standing technique used by facilitators of various industries and provides immediate feedback to the panel members that they were heard. This technique is taught in detail in the Certified Master Facilitator's Course referenced in Section 17.1.4. With this technique, it is important to keep track of the pages used with a simple numbering system. Also putting headers at the top of each page will help in tracking progress.
- Use an electronic table and project it on a screen for all the panel members to see as it is being filled in. This technique may require additional staff to type in the information while the facilitator manages the process. This technique may save on documentation on the backend of the SRA by providing the beginnings of the final report. One drawback to this technique is that panel members may become more interested in editing the projected table rather than staying on task and working the SRA process.
- Allow each member of the panel to have a template at their place that they can fill in as the process moves along. This is a way to provide panel members with quick visual references and feel more involved. This should *not* replace the facilitator's documentation. The facilitator needs to ensure consistency and provide the official results of the SRA.

The facilitator must understand that personally capturing focused comments does not replace the need for a dedicated note taker to capture the detail of the discussion and the decisions made.

> It is very difficult for the facilitator to both take notes and effectively facilitate during the SRA. SRAs may benefit from having a recorder or note taker to free the facilitator to focus on keeping the process moving and productive.

At the conclusion of the SRA, all notes should be gathered and pulled into a draft report as expeditiously as possible. This ensures the capture of the information while it is still "fresh" in everyone's minds. Refer to Appendix D for sample final report templates.

CHAPTER 19

SRA for Small Airports

19.1 SRA Planning

At small airports, an SRA will likely involve few people, regardless of the complexity of the issue. Typically, panel members will come from the airport staff. The planning process can be less formal and a meeting can be scheduled using regular electronic messages or verbal communication. Scheduling should be easier due to the number of people participating.

19.2 Conducting the SRA

The main challenge faced by a small airport is in finding a facilitator with experience and training to lead the SRA brainstorming. At airports with limited resources and for airports that do not fall under FAA SRM requirements, having someone on staff who understands the SRA process and can lead a group of people through the process is very valuable. Having at least one employee with formal facilitator training can ensure small airport SRAs are effective and efficient while relying on internal resources.

For SRA panels with less than five people, the facilitator may only need to ensure the process is followed and document a discussion as it occurs. The size of the SRA panel will determine how involved the facilitator will need to be. Some airport panels may only involve two people and they may simply carry on a discussion about the safety issue being assessed. One person might act as facilitator by taking notes in a logical and thorough manner. The need for a facilitator should be driven by the number of people needed to conduct the SRA and the complexity of the issue being assessed.

Small airport operators should determine the need, roles, and responsibilities of a facilitator, based on the size of the SRA panel and the complexity of the issue being assessed. Internal staff may be acceptable and should be considered first in order to save costs.

19.3 Documenting the SRA

Unless it is an FAA-led panel, there is no need for a formal report to document the SRA. Appendix D presents an SRA report example from a small hub airport. The report may be as simple as an SRA template that presents the hazards, risks, and risk mitigation actions, with any relevant notes or comments presented during the SRA meeting attached to the completed template.

APPENDIX A

SRM and the FAA

The FAA may require some 14 CFR Part 139 certificated airports to develop and maintain an SMS that encompasses aircraft movement areas of the airfield. The SMS should include the four components: safety policy, safety risk management, safety assurance, and safety promotion.

In addition to the "internal SMS" processes required by the FAA, there are some important interfaces between Part 139 airports and the FAA lines of business, particularly Airports—ARP and Air Traffic Organization—ATO, which are summarized in this guidebook. Figure A-1 illustrates the interactions among ARP, ATO, and the airport. Some areas are common to two of the three elements; in some situations, all three SMS will interact. This section describes how these elements may work together regarding SMS.

The information presented here may be changed and updated by the FAA, so the airport operator as the certificate holder should always obtain updated information and advisory material from the FAA website (www.faa.gov).

A-1 Framework of SMS Amendment to Part 139 Proposed Rule

The basic proposed requirements for SRM described in the Notice of Proposed Rulemaking for Part 139 SMS are as follows:

- Establish a system for identifying safety hazards;
- Establish a systematic process to analyze hazards and associated risks using the five SRM steps;
- Ensure that mitigations are implemented where appropriate to maintain an acceptable level of safety;
- Monitor safety objectives for regular assessment of safety level achieved;
- Aim to make continuous improvement to the airport's overall level of safety; and
- Establish and maintain a process for formally documenting identified hazards, their associated analyses, and management's acceptance of the associated risks.

A more detailed look at the minimum elements required in the regulation is presented to help certificate holders understand the potential effect of the SMS amendment.

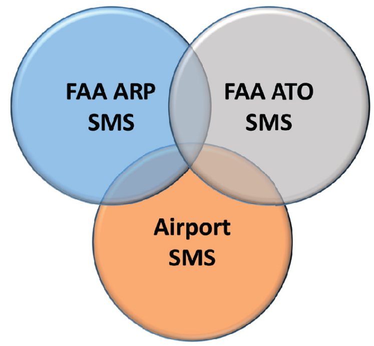


Figure A-1. SMS interactions between FAA and Part 139 airports.

System to Identify Hazards

A system to identify hazards is a key element of the airport SMS. The airport may decide to use or create a hotline for hazard reporting or to use its IT systems and create a tool for online reporting of hazards. A few airports may use drop-boxes and hazard reporting forms in paper form. At larger airports, this alternative has limitations because there may be a delay in collecting and processing the information. At smaller airports, verbal communication is common. As an example, a small airport announced to its employees and stakeholders that hazards could be reported using the same hotline used by operations. The calls are normally documented in the operations log book and a checkmark was added to identify if the call reported an issue relevant to SMS. The information is then passed to the staff member responsible to coordinate the SMS, for actions when necessary.

Process to Analyze Risks

This process consists of the five steps for risk analysis described by the FAA and includes describing the system, identifying hazards, analyzing the risk, assessing the level of risk, and mitigating risks (see Figure A-2). The process presented in the FAA regulatory and advisory material on SMS is usually documented in the airport's SRM component of the SMS manual. The process is one of the most important elements of safety management. An example of a process to analyze risks is an SRA for an airfield construction project.

Figure A-2. The 5-step process.

Ensuring Mitigations Are Implemented

Following the process to analyze risks and identify actions to mitigate risks, it is necessary to ensure that mitigation actions are in place and effective. This is done by assigning parties responsible for implementing each action, defining deadlines for completion, checking the status, and determining if actions are in place when milestones occur. For smaller airports, the electronic spreadsheet presented in Chapter 15 (Figure 15-1) can be used for this function.

Monitoring of Safety Objectives

Safety performance indicators are defined by the airport to monitor specific risks of concern to the airport. Reducing the level of risk associated with these performance indicators is part of the objectives defined by the airport and, in some cases, these objectives are documented in the SMS manual. For example, a large airport established a safety objective of reducing by 40% the monthly number of birdstrikes causing adverse effect to flights over a period of 2 years. Historical information collected from the FAA Wildlife Strike Database served as the baseline for future improvements and actions were implemented to reduce the presence of species causing adverse effects. The trend was monitored over a 2-year period, with additional measures implemented to affect the presence of the most hazardous species and a reduction of 55% in the annual number of serious birdstrikes was achieved after 2 years.

Continuous Improvement to Safety

A more detailed look at the minimum proposed elements of SMS is presented that target continuous improvement of safety levels in airport operations. In the SRM component, continuous improvement is achieved with the continuous identification of hazards, trend analysis of safety performance indicators, and execution of the SRM cycle using the five steps to identify actions that should be improved or implemented to reduce risks. As an example, an airport administrator received reports of miscommunication incidents between the tower and airfield maintenance staff. Based on the analysis of these incidents, the risks were assessed and additional training was provided to maintenance staff to mitigate the risk. However, after the training was delivered, new incidents were reported and a new safety assessment was conducted. With the new assessment, the airport decided to replace the mobile radios used by maintenance staff.

> The SRM cycle does not end with the implementation of risk mitigation actions. Often, it is necessary to monitor both the effectiveness of those actions and the risk level achieved to ensure risks are and remain acceptable. Whenever it is identified that risk was not controlled to acceptable levels, the SRM 5-step process should be restarted.

Documenting Hazards, Risks, and Actions

The airport should keep track of reported hazards, associated risks, and actions to take risks to acceptable levels. At larger airports, an IT solution may be beneficial to monitor and document the processes and actions. At smaller airports, a simple electronic spreadsheet may be sufficient. In addition, safety issues analyzed by a panel can be documented with reports describing the SRA study, conclusions, and actions.

A-2 SRM Interface with the FAA

The SRM processes carried out by the airport as part of its internal SMS aim to continuously and proactively improve the operations' safety. The proposed SMS amendment in the Part 139 Rule would add another element of compliance for those airports affected by the revised Rule.

Table A-1. FAA internal SMS triggers for airport operator involvement.

FAA SRM Trigger	Airport Involvement	Type of Involvement
Development and Update of ARP Standards	No	Consultants and representatives of trade organizations may be invited to participate as panel members of safety assessments.
Airport Planning	Yes	Exceptions include as-built airport layout plans and long-term planning beyond 15 years.
Airport Construction Safety and Phasing Plans (CSPP)	Yes	The airport is responsible for acquiring independent facilitation services for the safety assessment when a panel is required.
49 CFR Part 150 Noise Compatibility Planning Projects	Yes	Safety assessment required for proposed plans that can affect safety critical elements of the NAS. The airport is responsible for acquiring independent facilitation services for the safety assessment when a panel is required.
Modification of FAA Airport Design Standards	Yes	The airport is responsible for acquiring independent facilitation services for the safety assessment when a panel is required.
Airspace Determinations for Non-Construction Changes	Yes	The airport is responsible for acquiring independent facilitation services for the safety assessment when a panel is required.
Operational Changes Impacting ATO's SMS	Yes	FAA expects the certificate holder to participate in the FAA risk analysis instead of performing an independent risk assessment under its SMS.

Some safety assurance processes used by the FAA, like Part 139 certification inspections, have been in place for decades.

With the implementation of the FAA ARP's internal SMS, some triggering actions for safety assessments have been established and may require interactions with the airport operator, as presented in Table A-1. Not all safety assessments will require a panel, and the FAA will inform the airport about the need to convene a panel.

Note: sometimes, the FAA ARP can provide facilitation services, but this is handled on an individual basis.

A-3 Understanding the SRM Process Used by the FAA Airports' Division (ARP)

Understanding the process used by FAA ARP to conduct safety assessments may help airports support the FAA efforts and strengthen the interface between the FAA's SMS and the airport's SMS. The process is summarized in this section and details can be found in the FAA Office of Airports Safety Management System (SMS)—Desk Reference "National Policy"—Order 8040.4A (04/30/12) available on the FAA website. The FAA process in Figure A-3 is one where the FAA leads and the airport sponsor may be asked to procure facilitation services, provide additional data, and participate on the panel.

The following are the steps in the process:

1. A project plan, change, or other approval is proposed by the airport or the FAA and a Safety Assessment Screening (SAS) is required.
2. Documents and relevant information are reviewed by the FAA office overseeing or administering the project.
3. The appropriate SAS form (Form 5200-8, 5200-9 or 5200-10) is initiated.
4. The airport sponsor and/or facilitator prepares a Proposal Summary and, when necessary, submits this summary to other FAA offices and stakeholders to verify the effect on aviation/airport safety and operations.

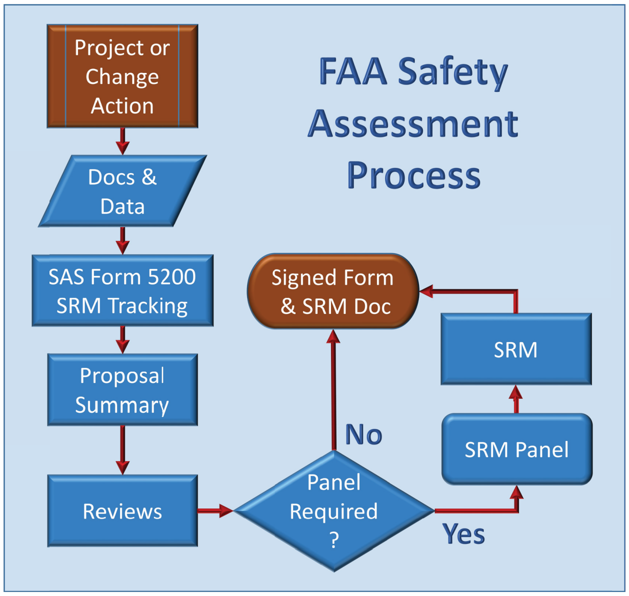


Figure A-3. FAA safety assessment process.

5. Based on the reviews, it is determined if an SRM Panel is required. If a panel is not required, the project manager completes and signs the SAS form and the process stops.
6. If an SRM panel is necessary, the airport will be notified for coordination, to acquire a facilitator and arrange the panel, and prepare the schedule. Additional safety data and analyses are assembled by the FAA and the airport to support the SRM panel meeting.
7. The panel meeting is conducted using standard SRM processes and tools, and the discussions, conclusions, and actions are reported.
8. The SAS Form is prepared, completed, and finalized prior to being signed by meeting participants, the airport sponsor, and the FAA; the process is then complete.

FAA's SRMTS is an internal IT system to document and manage hazards and risks. With this system, the FAA can keep track of hazards identified in its internal processes as well as those involving airport changes and improvements and monitor risks and the implementation of actions associated with these risks. With this tool, the FAA can screen the SMS elements by risk level, risk category, risk priority, airport, and specific categories of mitigation action.

A-4 SRM Panel Documentation

Whenever the FAA notifies the airport of the need to convene an SRM panel for a safety assessment, the airport will be responsible for coordinating the schedule with the panel participants and arranging a facilitator for the analysis. The final documentation is prepared by the FAA and the airport according to Table A-2.

Table A-2. Documentation responsibilities.

Document	Responsibility	Note
SAS Form completed and signed by panel members, FAA official and airport sponsor	FAA	Airport sponsors sign the SAS form only if a panel is held and at the conclusion of the panel deliberations
Project proposal summary	Airport Sponsor	Based on proposal documents
Hazard identification and analysis tool worksheet and hazard mitigation plan completed by the panel	Airport Sponsor	In most situations the facilitator will be acquired/arranged by the airport
Narrative of discussions and dissenting opinions	Airport Sponsor	In most situations the facilitator will be acquired/arranged by the airport
Pictures, plans and other supporting documents and data	FAA and Airport	Including proposal documents

APPENDIX B

SRM Handbook

The following material is designed to be customized, removed, and copied in order to provide a 5- to 6-page handbook that is scalable for all airports. The information in these examples is for illustration only. Each airport should use information pertinent to that airport. Having a handbook for reference during an SRA, especially with a large panel of SMEs, has proven very helpful. Individual roles and responsibilities of those conducting and participating in the SRM process are also defined on Page 4 of this handbook. **Note: this handbook is intended to assist airports conducting a SRA by and for their own needs. It is not intended to replace the FAA ARP process as defined in FAA Internal Order 5200.11 and explained further in the FAA ARP SMS desk reference guide.**

The Five-Step Safety Risk Assessment Process

1. *Describe the System*

The system is described to limit the scope of the risk assessment. The system is often described using the 5M Model, which includes:

- **Mission:** the specific airport activity (e.g. taxiway B reconstruction)
- **huMan:** the personnel involved with the activity (e.g. construction workers, airport engineering and operations staff, etc.)
- **Machine:** the equipment involved (e.g. trucks, pavers, compactors, etc.)
- **Media or environMent:** the environment including physical areas and ambient conditions (e.g. taxiway B between taxiways J and N, haul routes, night work)
- **Management:** organization, procedures, regulations, advisory material (e.g. FAA ACs, Construction Safety Phasing Plan)

2. *Identify Hazards*

There may be multiple hazards associated with the system that is being evaluated. For example, a construction project may involve hazards such as FOD and the movement of haul trucks in airfield areas.

3. *Analyze Risk*

Each hazard may have one or more outcomes (e.g. FOD may cause damage to aircraft if ingested by the engine, or it may cause injuries to construction workers due to jet blast). NOTE: It is important to identify existing controls. The controls should be considered before assessing the level of risk prior to other mitigation actions that are not in place. SOP, ACs, safety plans, and regular inspections are examples of existing controls (e.g., FOD control plan for a construction project).

4. *Assess Level of Risk*

The level of risk <u>with the existing controls</u> is estimated and recorded. Use the risk matrix on Page 2 of this handbook. The user or the group will estimate the worst credible outcome and then the likelihood of occurring. The background color to indicate if the risk is low (green), medium (yellow) or high (red). The colors will provide quick identification of higher risks. Within each box (25) there is a letter which represents the overall level of risk, i.e. green, yellow, or red and a corresponding number which represents the level of risk based on the level of consequence, "1" being the lowest and "25" being the highest. The combination makes up the RAC which can be used to prioritize mitigations within a particular color group.

5. *Mitigation Actions*

The high and medium risks should be controlled with mitigation actions. Each risk may have one or more mitigation/control actions to reduce the risk to an acceptable level. An airport that is experiencing high frequency of FOD may reduce the risk of accidents by taking additional measures such as increasing frequency of maintenance and removal of debris with sweeper trucks, and increasing the frequency of inspections.

PAGE 1

Customizable Checklist for SRM

ITEM	DOCUMENTATION OR TASK	OWNER	STATUS
A - Meeting and Logistics			
1. SRA Topic			
1a. Description of Proposed SRA			
2. Onsite Contact			
3. Facilitation Date(s)			
4. Location			
5. Start Time (Airport Team)			
6. Start /End Time SME Panelists			
7. Documentation			
8. Visual Aids			
9. Agenda			
10. Other Logistics			
B - Stakeholder Names and Contacts			
1. Facilitator			
2. Meeting Coordinator			
3. Consultants			
4. (airport) Ops/Safety			
5. (airport) Admin. (properties)			
6. (airport) Admin. (risk mgmt.)			
7. (airport) ARFF/PD			
8. (airport) Maintenance			
9. (airport) Engineering and Planning			
10. Major Airline			
11. Major Airline & or Cargo			
12. FBO			
13. Catering Company			
14. Others tenants (Part 135 operators, flight schools, etc.)			
15. Other federal agencies: Border Protection, Customs, Federal Security Administration, FAA FSDO			
16. FAA ATCT			
17. FAA Certification			
18. FAA Tech Ops			

(continued on next page)

C - Supporting Documentation/Information			
Document Title (examples)	**Specific Document**	**Responsible Party**	**Status**
1. Gate Assignments			
2. e.g. Airline Operations #			
3. e.g. Gate Layout (aircraft restrictions)			
4. e.g. Airline Scheduled Aircraft			
5. e.g. Snow Removal Plan			
6. Others			

D - Final Documentation			
Section/Content		**Author/Owner**	**Status**
1. SRA Draft Report			
2. SRA Review Team			
3. SRA Final Report			
4. SRA Signoff			
5. SRA Submittal			
6. Hazard Tracking			
7. Hazard Status			
8. Final Budget			

PAGE 2

Sample Risk Matrix (5 X 5)

Likelihood \ Severity	No Safety Risk	Minor	Major	Hazardous	Catastrophic
Frequently	L5	M13	H20	H22	H25
Probable	L4	M12	M15	H21	H24
Remote	L3	L8	M14	M17	H23
Extremely Remote	L2	L7	L10	M16	M19
Extremely Improbable	L1	L6	L9	L11	M18

Low	Medium	High
No Action Required	Monitor, Determine if Risk can be Mitigated to a Low Risk	Must be Mitigated to a Medium Risk

Definitions for Severity and Likelihood (Examples)

Severity:				
	People	**Assets**	**Environmental**	**Reputation**
Catastrophic	Fatality+	Loss of an aircraft/or over $1,000,000 dollars in damage/or loss of critical system(s) for an extended period of time	A spill or release that is not contained and results in long-term damage to the environment and fines to the airport.	An event or a series of events resulting in the community NOT using XXX for an extended period of time.
Hazardous	Severe Injury, requiring hospitalization	Damage to an aircraft taking it out of service for an extended period of time/or damage in excess of $500,000/or disruption of critical services for extended period of time	A reportable spill or release that requires mitigation.	An event or a series of events resulting in the community lessening the use of XXX causing negative (annual) financial or operational impacts.
Major	Minor Injury requiring medical treatment	Damage to an aircraft that is reparable/or damage to equipment or facility that is reparable within a short period of time.	A reportable spill or release that is contained.	An event or a series of events resulting in the community lessening the use of XXX for a short period of time.
Minor	Minor injury not requiring medical treatment	Minor damage to an aircraft, equipment, or facility not requiring it to be taken out of service	A spill or release that does not require a report.	An event or a series of events resulting in the community questioning the reliability of XXX.
No Safety Risk	No injury	No Damage	No Impact	No Impact

Likelihood:	
Frequently	*Occurs once every* month or XXXX commercial operations or XXXXXX passenger enplanements
Probable	*Occurs once every* year or XXXXX commercial operations or XXXXXXX passenger enplanements
Remote	*Occurs once every* 5 years or XXXXXXX commercial operations or XXXXXXXXX passenger enplanements
Extremely Remote	*Occurs once every* 10 years or XXXXXXX commercial operations or XXXXXXXXX passenger enplanements
Extremely Improbable	*Occurs once every* 20 years or over XXXXXXXX commercial operations or XXXXXXXXXX passenger enplanements

PAGE 3

Roles and Responsibilities Table (typical examples)			
Role	**Organization**	**Position Held**	**Responsibilities**
SRA Sponsor	Airport	Accountable Executive, Safety Manager, Department Head	Approve and or require the SRA to be conducted Ensure it is conducted in accord with the airport's protocols Participate as needed Review and approve results
SRA Facilitator	Airport or consultant (FAA-led SRA may be provided by the FAA)	Consultant, Safety Manager, other designee in the organization	Lead the panel in accord with the documented airport's process Ensure the five-step SRM process is followed correctly Ensure the panel members participate as needed Ensure the documentation is thorough and accurate (this may be completed by the scribe; however the facilitator needs to ensure it's accomplished and correct)
SMEs AKA: Panel members	• Airport (operations, maintenance, engineering, police, fire department, properties, other as appropriate) • Airlines (chief pilot, ground crews, properties, station management) • FAA (tech ops, ARP certification, environmental management, project management, ATCT personnel) • Other stakeholder(s)	As appropriate for the subject matter necessary to ensure the SRA has the needed information to appropriately cover the topic	Participate as requested Provide any requested information Bring any requested materials, drawings, maps, or other Review results (if requested) Ensure your information is accurately presented
Note taker or scribe	Airport's responsibility to ensure someone is assigned the duty. Must work hand in hand with the facilitator	Airport personnel and or consultant	Take all appropriate notes and documentation in order to develop and provide the final SRA report which represents the SRA, decisions made, and actions taken.
PAGE 4			

APPENDIX C

SRM Process Tools

C-1 Introduction

This appendix presents templates to support risk assessments. The templates guide the user through the necessary steps to conduct an SRA and identify the most important factors and parameters in the process.

C-2 How to Use the Templates

The templates may be used to guide the risk assessment. In most cases, a template is presented as a table or worksheet and each column represents a parameter of the risk assessment. For each type of analysis, a specific worksheet is presented, each field is briefly explained, and examples are provided. In most cases, the columns should be filled in sequence, starting from column one.

C-3 Categories

Many techniques may be used to identify hazards and conduct risk assessments. The templates present techniques for use by airport staff performing analyses of many common airport issues. Techniques include

- Basic Risk Assessment
- Safety Risk Assessment (SRA)
- Comparative Safety Assessment (CSA)
- Bowtie
- What-if Analysis

C-4 Basic Risk Assessment

This technique includes the FAA-recommended SRM steps. Most of the techniques presented use this process; however, the process and the parameters evaluated may change. A basic risk assessment has the following steps:

1. Describe the system
2. Identify the hazards in the system
3. Analyze risk associated with the hazard
4. Assess the level of risk
5. Mitigate the risks

An SMS Administrator could use this technique daily to make risk assessments of simple safety issues reported or identified during self-inspections. A formal report may not be required. Having software to record the parameters presented in the template may be very helpful to track implementation of actions and perform trend analysis. Table C-1 illustrates this process.

The following are the parameters in the template:

Column 1—Describe the System

Describing the system limits the scope of the risk assessment. The system is often described using the 5M Model, as follows:

- Mission: the specific airport activity (e.g., taxiway B reconstruction)
- Man: the personnel involved with the activity (e.g., construction workers and airport engineering and operations staff)
- Machine: the equipment involved (e.g., trucks, pavers, and compactors)
- Media: the environment, including physical areas and ambient conditions (e.g., taxiway B between taxiways J and N and haul routes)
- Management: organization, procedures, regulations, and advisory material (e.g., FAA ACs)

Column 2—Identify Hazards

Multiple hazards may be associated with the system being evaluated. For example, a construction project may involve hazards such as FOD and movement of haul trucks in airfield areas. Letters may be used to identify each hazard.

Column 3—Analyze the Outcome

Each hazard listed in Column 2 may be associated with one or more outcomes (e.g., FOD may cause damage to aircraft if ingested by the engine or it may cause injuries to construction workers due to jet blast). Using the hazard letter and a number will help maintain the organization of the template (e.g., Risk B2 is the second risk associated with hazard B).

Column 3a—Identify Existing Controls

This column should be used to identify existing controls. It is important to consider these controls before assessing the level of risk prior to other mitigation actions that are not in place.

Table C-1. Basic risk assessment template.

(1) Describe the System	(2) Identify Hazards	(3) Analyze Outcome	(3a) Identify Existing Control	(4) Assess Level of Risk	(5) Mitigation Actions	(5a) Reassess Level of Risk with Mitigation Actions in Place
5M: Mission, Man, Machine, Media, Management	Hazard A	Risk A1	CA11, CA12, …	A1-prior	MA11, MA12,	A1-after
		Risk A2	CA21, CA22, …	A2-prior	MA21, …	A2- after
		Risk A3	CA31, CA32, …	A3-prior	MA31, MA32,	A3- after
	Hazard B	Risk B1	CB11, CB12, …	B1-prior	MB11, MB12,	B1- after
		Risk B2	CB21, CB22, …	B2-prior	MB21, …	B2- after
	Hazard C	Risk C1	CC11, CC12, …	C1-prior	MC11, …	C1- after
		Risk C2	CC21, CC22, …	C2-prior	MC21, MC22, …	C2- after
		Risk C3	CA31, CC32, …	C3-prior	MC31, MC32, …	C3- after

SOP, ACs, safety plans, and regular inspections are examples of existing controls (e.g., FOD control plan for a construction project).

Column 4—Assess Level of Risk

In this column, the level of risk with the existing controls is estimated and recorded. In most cases, a risk matrix will be used to estimate the risk. First, the user or the group will estimate the worst credible consequence and then the likelihood of this occurring. In most cases, a code consisting of a number (corresponding to the severity) and a letter (corresponding to the likelihood) will be assigned to identify the level of risk. It is always helpful to use a background color to identify if the risk is low (green), medium (yellow) or high (red). The colors will provide quick identification of higher risks. For example, if using the risk matrix used by the FAA, a risk level 2C represents a risk of hazardous consequences (2) and remote likelihood (C). A 2C risk level is assumed to be a medium risk (yellow). If colors are not used, the risk may be characterized as 2C-medium.

Column 5—Mitigation Actions

The high and medium risks should be controlled with mitigation actions. Each risk may have one or more mitigation/control actions to reduce the risk to an acceptable level. An airport experiencing high frequency of FOD on the runway may reduce the risk of accidents by taking additional measures (e.g., increasing frequency of maintenance and removal of debris with sweeper trucks, planning runway rehabilitation, and increasing the frequency of inspections).

Column 5a—Reassess Level of Risk with Mitigation Actions in Place

This column is similar to Column 5; however, the new control actions are considered in order to estimate the new level of risk when all mitigation actions are in place.

C-5 Safety Risk Assessment

Table C-2 is a template for use in an SRA. The columns in this table were described in the previous section. In addition to the basic risk assessment table, it is important to define the parties responsible for each mitigation action developed during the analysis. Table C-3 provides an example for an airfield construction project. The columns represent the following parameters:

Column 1—Haz #

A number to identify the hazard

Column 2—Hazard Description

A short description of the hazard

Table C-2. Risk assessment table.

(1) Describe the System	(2) Identify Hazards	(3) Analyze Outcome	(3a) Identify Existing Control	(4) Assess Level of Risk	(5) Mitigation Actions	(5a) Reassess Level of Risk with Mitigation Actions in Place

Table C-3. SRA mitigation table.

Haz # (1)	Hazard Description (2)	Outcome (3)	Risk Mitigating Actions (4)	Planning & Design (5)	Contract-or (6)	Ops (7)	ATCT (8)	Other (9)
1	FOD from construction vehicles on taxiways	Damage to aircraft	Sweepers at construction site	✓	✓			
			Establish monitoring procedures by Ops		✓	✓		
			Establish notification procedures between contractor/operations/ATCT		✓	✓	✓	
			Use trained contractor escort to identify FOD and report to Ops		✓	✓		
			Use trained flagmen equipped with brooms and shovels	✓	✓	✓		
			Install rumble strips at hauling route before pavement	✓	✓			
2	Unanticipated damage to utilities due to construction activities	Loss of systems leading to accidents	Locate utilities prior to construction activities	✓	✓			
			Test unidentified utility cables	✓	✓			
			Identify non-redundant systems for extra precautions	✓	✓			
			Place system cables in conduits	✓	✓			
			Mark location of utilities	✓	✓			
4	Construction vehicles crossing active taxiways	Collisions between aircraft and construction vehicles	AOA driver trained escorts at both ends of the convoy		✓	✓		
			Use trained flagmen	✓	✓			
			Safety briefings	✓	✓	✓		
5	Jet blast	Injuries to construction workers and gate operators, and damage to equipment	Evaluate blast envelope of larger aircraft	✓				
			Secure equipment at gates			✓		Airlines
			Safety briefings		✓	✓		Airlines
			Coordination: ramp tower/airlines/ATC		✓	✓	✓	Airlines
			Implement protective equipment for construction workers	✓	✓			
			Adjust routing to avoid construction zones if possible			✓	✓	Airlines
			Temporary signage at prone construction sites	✓	✓	✓		

Column 3—Outcome

A short description of the outcome involved with the hazard. There may be one or more outcomes associated with each hazard.

Column 4—Risk Mitigation Actions

Description of risk mitigation actions. There may be one or more recommended risk mitigation actions that the airport could implement.

Columns 5–9

Columns 5–9 indicate any involvement of a specific stakeholder to implement the specific mitigation action. In the first line of the example table, the planning and design, as well as the contractor staff are responsible for ensuring sweepers will be available at the construction site.

C-6 Comparative Safety Assessment (CSA)

A CSA is a comparison of the relative risk among multiple alternatives for resolving a safety issue or airport planning consideration. It is common to use a CSA to conduct tower siting studies. A Preliminary Hazard List (PHL) is normally used to identify the hazards; hazard analysis worksheets are used to document the severity of consequence and likelihood of occurrence to assess the risks associated with each alternative being evaluated. For example, an airport may decide to build a new control tower with four viable sites identified. Each site is evaluated against each of the system safety hazards identified in the PHL. The hazards are compared using a risk matrix for relative hazard ranking. The CSA only considers hazards that may affect aviation safety and does not address other issues (e.g., cost or environmental issues). The basic worksheet for a CSA is presented in Table C-4 with examples included.

- *Column 1—Hazard:* Hazards are numbered according to the alternative being evaluated and a hazard # is assigned. Hazard 2-3 is the third hazard identified for alternative 2.
- *Column 2—Hazard Description:* Describe each hazard. There is only one description for each hazard identified (e.g., difficulty in clearly identifying planes approaching runway 15).
- *Column 3—Causes:* Describe one or more causes for each hazard identified (e.g., it may be difficult to identify approaching aircraft due to long distance to runway end, and/or under low-visibility conditions).
- *Column 4—System State:* Describe the conditions when causes described in Column 3 are predominant (e.g., identification of aircraft will be difficult under low light conditions or for smaller approaching aircraft).

Table C-4. Sample CSA worksheet (example).

Hazard (1)	Hazard Description (2)	Causes (3)	System State (4)	Existing Control or Requirement (5)	Possible Outcome (6)	Severity Rationale (7)	Likelihood Rationale (8)	Initial/Current Risk (9)	Recommended Safety Requirements (10)	Predicted Residual Risk (11)
1-1	Poor visibility on the aircraft ramp 1-1	Lack of highmasted lighting #1 Faded lead-in lines at gates #2	At night #1 Consistently exacerbated at night #2	Airlines use wing walkers and lighted wands #1 Airlines use wing walkers and lighted wands #2 Local NOTAM issued to airlines who operate at that airport; posted in all airline operations offices #3	Aircraft accident with another aircraft #1 Aircraft incident with ground equipment #2	**Hazardous,** because of multiple aircraft being damaged and driving up $$$ #1 **Major,** because of damage to only one aircraft #2	**Extremely remote,** because it happened once in the past 10 years #1 **Remote,** because it happened within the past five years #2	#1: M16 – Medium #2: M14 – Medium	#1: Install highmasted lights #2: Paint new lead-in lines and aircraft safety envelopes	#1: **Hazardous and Extremely Improbable** (changed likelihood to every 20 years) = L11 – Low #2: **Major and Extremely Remote** (changed likelihood to occurring every 10 years) = L1 – Low
1-2	Desc. 1-2	…	…	…	…	…	…	…	…	…
2-1	Desc. 2-1	…	…	…	…	…	…	…	…	…
2-2	Desc. 2-2	…	…	…	…	…	…	…	…	…
2-3	Desc. 2-3	…	…	…	…	…	…	…	…	…
3-1	Desc. 3-1	…	…	…	…	…	…	…	…	…
4-1	Desc. 4-1	…	…	…	…	…	…	…	…	…

- *Column 5—Existing Control or Requirement:* Use this column to identify any measures in place that will help mitigate the risks associated with the hazard (e.g., FAA Orders, binoculars).
- *Column 6—Possible Outcome:* The hazard may lead to an unsafe condition, which is described in this column. The hazard may not necessarily be described in terms of consequences. There may be one or more possible effects for each hazard (e.g., loss of separation and holding aircraft interference with NAS equipment).
- *Column 7—Severity Rationale:* This column is used to justify the estimate of the worst credible consequence. Often, a SME or group of experienced stakeholders may perform the estimate.
- *Column 8—Likelihood Rationale:* Similar to Column 7, this column is used to justify the rationale used to obtain the estimate. A SME may have the experience to make the estimate, or it may be estimated using available data for the airport.
- *Column 9—Initial/Current Risk:* In this column, the level of risk with the existing controls in place is characterized. Usually, a risk matrix will be used to estimate the risk. The user or the group will estimate the worst credible consequence and then the likelihood of it occurring. Often, a code composed of a number (corresponding to the consequence) and a letter (corresponding to the likelihood) will be assigned to identify the level of risk. It is always helpful to use a background color to identify if the risk is low (green), medium (yellow), or high (red). The colors will provide quick identification of higher risks. For example, if using the risk matrix used by the FAA, a risk level 2C represents a risk of hazardous consequences (2) and remote likelihood (C). A 2C risk level is assumed to be a medium risk (yellow). If colors are not used, the risk may be effectively characterized as 2C-medium to ensure understanding.
- *Column 10—Recommended Safety Requirements:* In this column, the list of control actions to address the hazard should be included. Examples of controls to mitigate the risks for a tower siting study might include pilot position reports and signage to avoid runway/taxiway incursions.
- *Column 11—Predicted Residual Risk:* The residual risk is the risk level estimated if the controls are implemented to reduce the current risk. The new control actions are considered in order to estimate the residual level of risk when all mitigation actions are in place.

In addition to the CSA worksheet, a summary table can be used to help compare the alternatives being evaluated. Each line represents one of the alternatives evaluated and numbering follows the order used in the CSA worksheet. Three columns present the number of hazards with high, medium, and low risk for each alternative. The last column contains key justification for selection or elimination of the alternative, as shown in Table C-5.

Table C-5. Example of CSA initial risk ranking results.

Alternative #	High	Medium	Low	Comments
1	0	0	1	Recommended alternative
2	0	2	1	Eliminated because one of the medium risks could not be further mitigated
3	2	0	1	Eliminated due to two high risks with high cost to mitigate
4	1	1	0	Eliminated because alternative will not comply with FAA standard

C-7 Bowtie

The bowtie method of risk assessment is often used when quantitative data is available and is an excellent tool for communication to management. The focus is a single undesirable event (e.g., a runway/taxiway incursion at a specific hotspot or an aircraft overrun). The name originated from the basic shape of the analysis diagram, illustrated in Figure C-1.

The left side of the event (accident) is characterized as the fault tree and the right side as the event tree. The knot of the bowtie is the undesirable event. The fault tree contains proactive controls that act as safety barriers to prevent, control, or mitigate the chance that a hazard leads to an accident. The event tree has proactive controls to mitigate the severity of consequences if an accident/incident takes place, despite the proactive controls. The diagram helps illustrate the relationships among hazards, controls, and consequences and supports a systematic approach for the risk assessment.

The following are the steps to conduct a bowtie risk assessment:

1. *Identify the Undesirable Event*
   The objective of the assessment is to reduce the risk of the undesirable event by reducing the likelihood and mitigating the consequences when the event occurs. This is the focus of the bowtie analysis (e.g., aircraft overrun accident).
2. *Assess the Hazards*
   Identify the threats that may lead to the undesirable event (e.g., low friction, long touchdown, or small RSA).
3. *Assess the Consequences*
   There may be different types or levels of consequences. An aircraft overrun may result in an incident only or it may end up with multiple fatalities and catastrophic consequences (e.g., damage to aircraft or hull loss with multiple fatalities).
4. *Identify Proactive Controls*
   Proactive controls are used to eliminate or reduce the probability that the event takes place (e.g., runway grooving, monitoring runway friction, or installing EMAS). Each hazard may have one or more controls, and each control may address one or more hazards.
5. *Identify Reactive Controls*
   This is the type of control used if the undesirable event takes place. Instead of reducing the likelihood, reactive controls may only mitigate the consequences of the event (e.g., establish

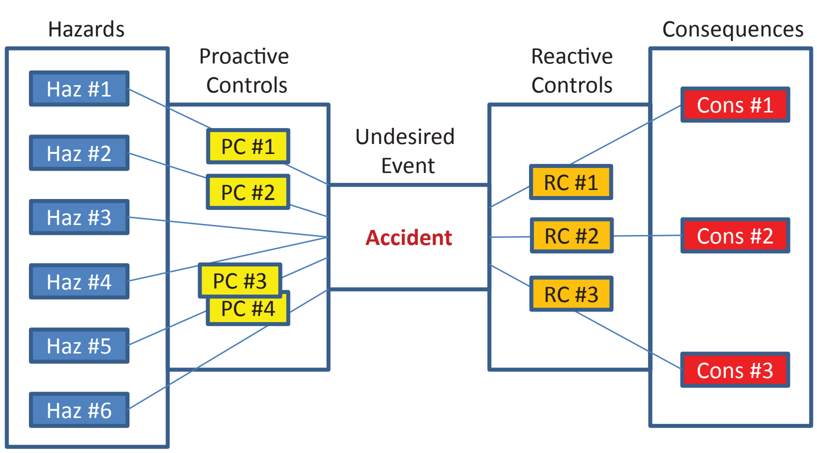


Figure C-1. Bowtie model.

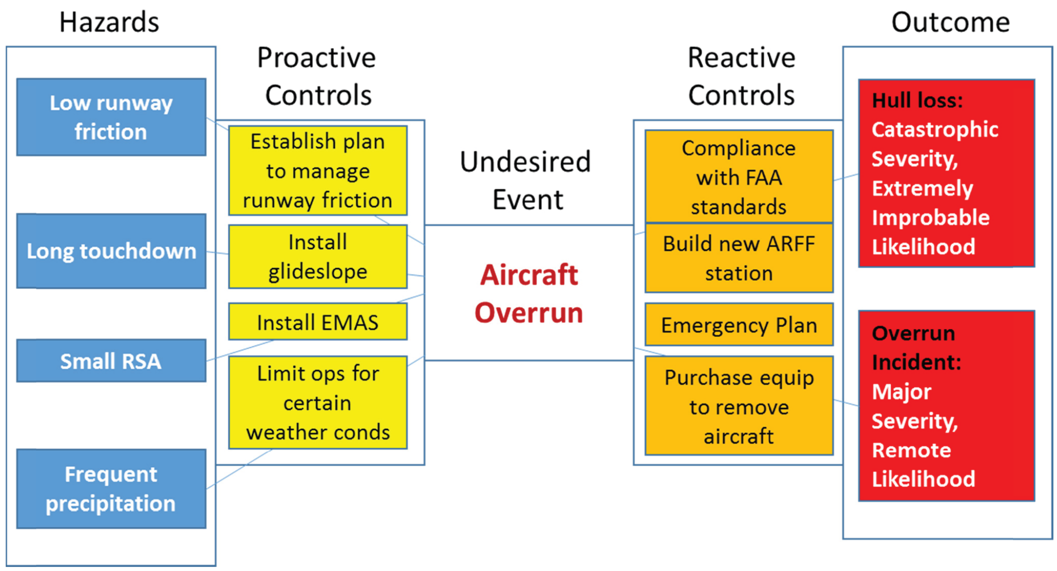


Figure C-2. Bowtie model with examples.

an emergency plan, reduce emergency response time, improve ARFF training, and establish a recovery plan for operations). Each reactive control may address one or more consequences and each consequence may be mitigated with one or more reactive controls.

Figure C-2 illustrates the application of the bowtie method for an airport safety issue. The undesirable event is an aircraft overrun.

C-8 What-If Analysis

What-If Hazard Analysis is a structured brainstorming method to identify what things can go wrong and assess the consequences and likelihood should the risk occur. The answers to these questions help classify the risks and determine a course of actions to control and mitigate the risks.

The template used for What-If analysis is shown in Table C-6. The example shows an analysis for aircraft refueling and the list should be considered only partial.

As with the SRM 5-step process, defining the system in which the hazardous condition exists is essential. In Table C-6, a quick way to define the system is consistent with the 5-M Model. The 5-M Model in this case would be captured as:

(1) Mission: Fueling Aircraft
(2) huMan: Aircraft crews and fueling personnel
(3) Machine: Fuel trucks and or system, the fuel itself, the aircraft
(4) Management: The fueling SOP
(5) Media: The aircraft ramp area/gate area

The What-If analysis then asks: what if certain components of the system failed? Table C-6 presents examples for just part of the system failing as listed above. Use this for all the 5-M Model components listed above for a complete picture of the What-If analysis.

Table C-6. Template for What-If hazard analysis.

System Failure	What-if? (1)	Answer (2)	Likelihood (3)	Severity (4)	Control Actions (5)
Fueling equip.	Mechanical failure adrift nozzle during fueling	Fuel may spray out between mating faces	Improbable	Minor	- Use of locking mechanism - Inspection and maintenance - Fueling adapter on aircraft designed to prevent back flow
Human error	Faulty gauge system or human error leads to overfill of aircraft tanks	Fuel spills from surge tank vent on the aircraft wing onto the ramp	Remote	Major (large quantity of fuel spill)	- Auto shutoff fueling valves - Overfill protection with fuel sensors in surge tank
Aircraft equipment failure	Aircraft brakes are not applied nor chocks are used and aircraft moves	Hose may get ruptured	Improbable	Major	- Operator should detect aircraft movement - Release dead-man's control to stop fuel transfer - Chock aircraft

APPENDIX D

SRM Templates

D-1 Introduction

The SRM templates support the SRM processes and procedures being developed by airports. Each section presents templates by category and briefly explains their origin. The templates were developed using MS Excel and Word templates to help airports in effective, efficient application of SRM. These templates are scalable and include examples used during the SMS Pilot Studies. There are explanations and an approach to developing individual airport-specific SRM templates along with these examples. The intent is not to require the use of any one template, but to provide airport operators with options and an approach so that local philosophy and requirements can be incorporated into the SRM process.

D-2 SRA Checklist

Identifying the need for, planning, preparing, executing, monitoring and tracking, and documenting a safety risk assessment (SRA) can be arduous. Depending on the complexity of the safety issue, system change, or system itself, the amount of effort that must go into the SRA is proportional. To make this process more manageable for airport stakeholders and operators, a simple checklist has been developed by several airports that have participated and some airports that did not participate in the SMS Pilot Studies. These checklists can help ensure the tasks, information, and panel member duties are accounted for, so that the SRA can be an effective, efficient process.

Following are two versions of such checklists. Table D-1 contains four sections with four columns; the last two columns are used to identify who manages or is in charge of the task and its status. Section A is used to summarize the general information about the SRA. Section B contains the SRA panel participants with their affiliation and contact information. Section C lists the documents relevant to the specific SRA. Finally, Section D is used to control the documents generated in the SRA.

Note: This checklist was used by multiple pilot study airports. It is flexible and not dependent on the size of the airport.

Table D-2 presents a checklist developed by the research team to support SRAs conducted for any size of airport and contains the minimum amount of information that may be necessary for SRA planning. It includes examples of the information.

Table D-1. SRA checklist from multiple pilot study airports.

ITEM	DOCUMENTATION OR TASK	OWNER	STATUS
A – Meeting and Logistics			
1. SRA Topic			
1a. Description of Proposed SRA			
2. Onsite Contact			
3. Facilitation Date(s)			
4. Location			
5. Start Time (Airport Team)			
6. Start /End Time SME Panelists			
7. Documentation			
8. Visual Aids			
9. Agenda			
10. Other Logistics			
B – Stakeholder Names and Contacts			
1. Facilitator			
2. Meeting Coordinator			
3. Consultants			
4. Airport Ops/Safety			
5. Airport Admin.			
6. Airport Admin.			
7. Airport ARFF/PD			
8. Major Local Airline			
9. Major Local Airline (Cargo)			
10. Any Other Airline Stakeholders			
11. FBO			
12. Catering Company			

(continued on next page)

Table D-1. (Continued).

ITEM	DOCUMENTATION OR TASK	OWNER	STATUS
13. Others?			
14. FAA ATCT			
15. FAA Certification			
C – Supporting Documentation/Information			
Document Title	**Specific Document**	**Responsible Party**	**Status**
1. Gate Assignments			
2. e.g. Airline Operations #			
3. e.g. Gate Layout (aircraft restrictions)			
4. e.g. Airline Scheduled Aircraft			
5. e.g. Snow Removal Plan			
6. Other			
D – Final Documentation			
Section/Content		**Author/Owner**	**Status**
1. SRA Draft Report			
2. SRA Review Team			
3. SRA Final Report			
4. SRA Signoff			
5. SRA Submittal			
6. Hazard Tracking			
7. Hazard Status			
8. Final Budget			

Table D-2. SRA checklist developed by the research team.

Topic:	New Taxiway Turnoff A-12 (example)		
Item:	**Item to be Provided**	**Person Responsible**	**Status**
Logistics ○ Date ○ Time(s) ○ Place ○ Other	○ *January 6, 2014* ○ *8:00 AM to 12:00 PM EDT* ○ *Wilber Wright Conference Room* ○ *Coffee provided*	*Mrs. Administration*	*Confirmed*
Facilitator	*John Doe, Airport WYZ*	*Mr. Administration*	*Confirmed*
Document Mgr.	*Mr. Administration*	*Mrs. Administration*	*Confirmed*
Data / Information	○ *Construction Drawings* ○ *ALP* ○ *Aerial*	*Mr. Engineering*	*TBD*
Panel Members			
1.	*Mr. FBO*	*Mr. Operations*	*Invited*
2.	*Mrs. US Airline*	*Mr. Operations*	*Invited*
3.	*Mr. FAA*	*Mr. Operations*	*Invited*
4.	*Mrs. GSP*	*Mr. Operations*	*Invited*
Additional Resources	○ *Incursion # from XYZ* ○ *Safety data from previous projects*	*Mr. Engineering* *Mr. Operations*	*Confirmed* *Confirmed*
Photos (as required)	*See above, Aerial*	*Mr. Operations*	*Confirmed*

D-3 Risk Matrix

One of the critical steps in SRM is classifying the risks. Classifying the risks provides the opportunity to prioritize resources necessary to mitigate the risks effectively. To address risks falling under multiple categories, airports need a consistent and locally generated reference to help prioritize resources for risk mitigation.

Risk is normally classified using a matrix—a simple table where the columns represent the levels of severity and the rows represent the levels of probability. The FAA, across multiple lines of business, has determined that a five-by-five risk matrix is appropriate to characterize safety risk in their varied regulatory roles in aviation (i.e., five categories of severity and five categories of probability). The tool serves FAA needs and is the risk matrix presented in the ACs for airports (see Figure D-1). The different colors help the user identify the risk level: high risk (red), medium risk (yellow), or low risk (green). Additional risk matrix examples are provided to allow users options when selecting the tool that best fits their operational and safety needs. Another version of the FAA risk matrix is presented in AC 150/5200-37 (Figure D-2). It is similar to the matrix adopted by all FAA lines of business; however, two red cells were adjusted for yellow cells. It is expected that this matrix will be replaced with that shown in Figure D-1.

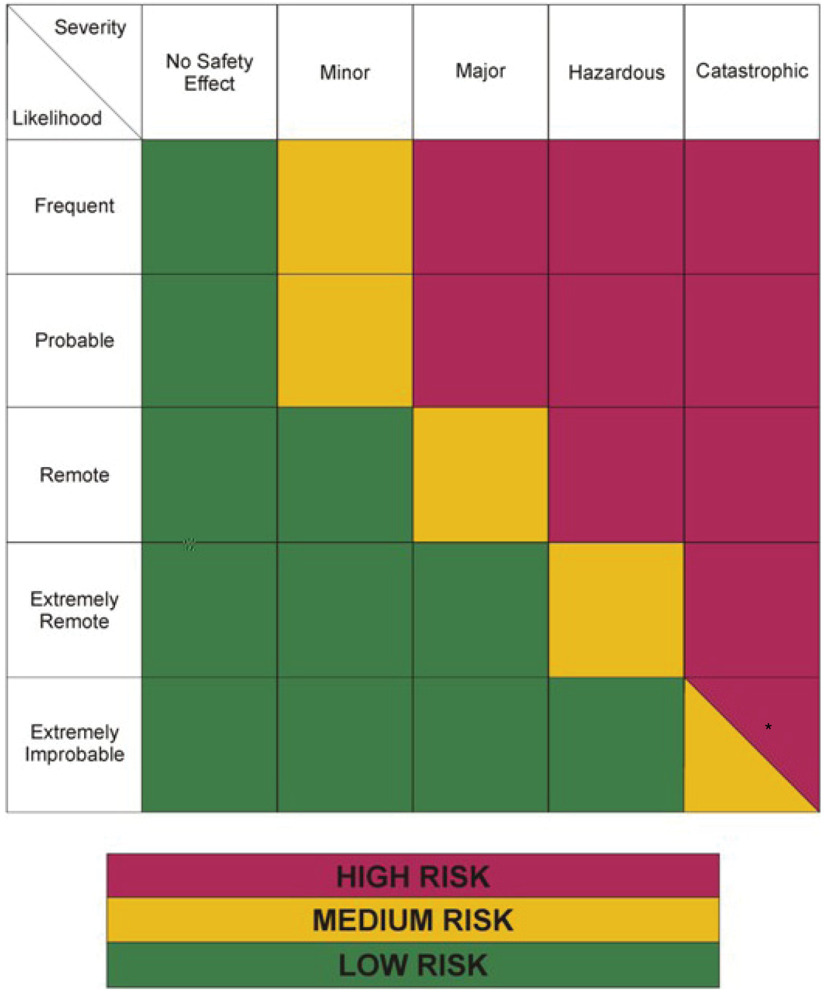
Figure D-3 illustrates a simple 4 × 4 risk matrix with only two risk classifications: acceptable and unacceptable risk. This type of matrix may be suitable for smaller airports where the numbers of identified risks are limited and do not require additional levels of classification for prioritizing risk management actions.

Severity / Likelihood	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A					
Probable B					
Remote C					
Extremely Remote D					
Extremely Improbable E					*

* Unacceptable with Single Point and/or Common Cause Failures

High Risk
Medium Risk
Low Risk

Figure D-1. FAA ARP risk matrix as of July 22, 2013 (update to document: Internal Order 5200.11 V2).



*Unacceptable with Single Point and/or Common Cause Failures

Figure D-2. Risk matrix from AC 150/5200-37.

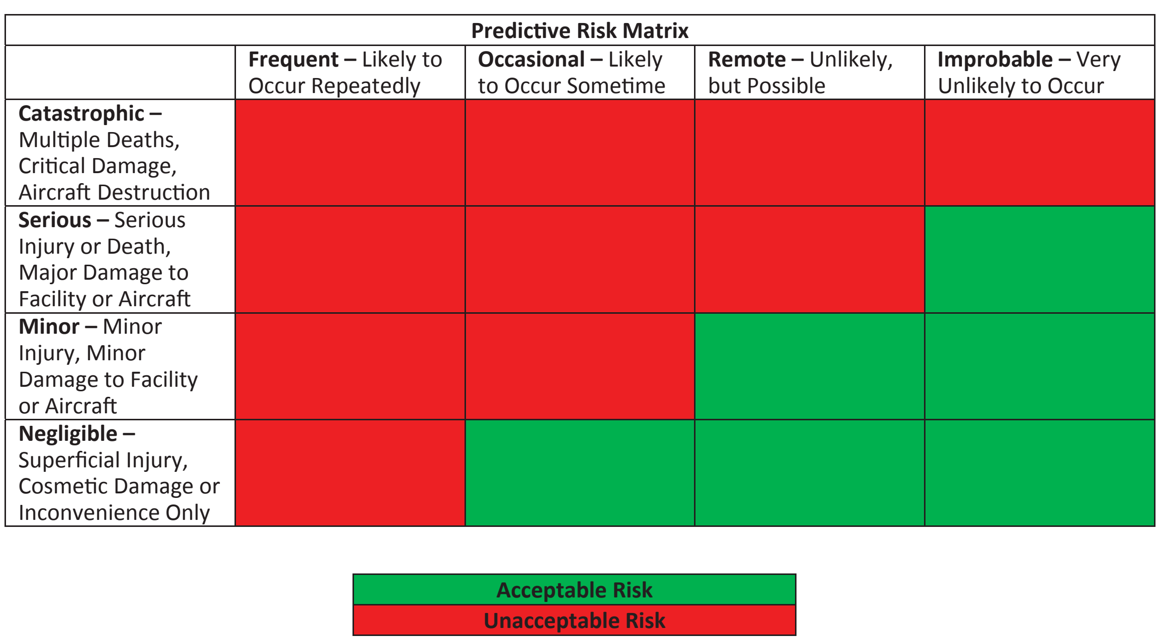


Figure D-3. Example of risk matrix presented in draft AC 150/5200-37A.

Severity / Likelihood	No Safety Risk	Minor	Major	Hazardous	Catastrophic
Frequently	L5	M13	H20	H22	H25
Probable	L4	M12	M15	H21	H24
Remote	L3	L8	M14	M17	H23
Extremely Remote	L2	L7	L10	M16	M19
Extremely Improbable	L1	L6	L9	L11	M18

Low	Medium	High
No Action Required	Monitor, Determine if Risk can be Mitigated to a Low Risk	Must be Mitigated to a Medium Risk

Figure D-4. Risk matrix used by multiple SMS pilot study airports.

Figure D-4 presents another type of risk matrix similar to that in use by the FAA and developed by consultants during the FAA Pilot Study. The cells are characterized by a letter representing the risk acceptability (low, medium, and high) and a number that helps classify the risk within the acceptability level: the higher the number, the higher the level of risk and the priority for mitigation actions. The combination of the letter and number represents the Risk Assessment Code (RAC).

In Figure D-4, each category of risk (e.g., Low, Medium, and High) is assigned a Risk Assessment Code (RAC) to enhance risk identification and prioritization. The risk level numbers increase within risk category from left to right, corresponding to increasing severity. Example: A risk assessed to be a M14 will carry a higher priority than a risk assessed to be a M12. Both are assessed to be Medium level of risk; however, the risk with the higher classification of severity will take priority for mitigation actions.

D-4 Severity and Probability Tables

Severity and probability tables reflect an individual airport's level of risk tolerance and are associated with the specific risk matrix adopted by the airport. The definitions for severity and probability give the risk assessment meaning and allow airports to quantify the risk associated with each risk of a particular hazard. Because risk is defined by the combination of severity and probability, those definitions must reflect the airport's risk acceptance. The following tables represent a broad variety of definitions for severity and probability. Some of the tables assign a "value" to the definitions. These values are used when risks are assessed using a risk assessment matrix and help to prioritize risks within a particular category (i.e., Low, Medium, or High).

Severity Definitions

Table D-3. Definitions for severity from the FAA ARP Internal Order 5200.11.

	Minimal-5	Minor-4	Major-3	Hazardous-2	Catastrophic-1
ATC Services	-Conditions resulting in a minimal reduction in ATC services, or -A loss of separation resulting in a Category D Runway Incursion (RI), or -An Operational Deviation (OD), or -A Proximity Event (PE)	-Conditions resulting in a slight reduction in ATC services, or -A loss of separation resulting in a Category C RI, or Operational Error (OE)	-Conditions resulting in a partial loss of ATC services, or -A loss of separation resulting in Category B RI or OE	-Conditions resulting in total loss of ATC services (ATC Zero), or -A loss of separation resulting in a Category A RI or OE	Conditions resulting in a collision between aircraft, obstacles or terrain
Flight Crew	-Flight crew receives TCAS Traffic Advisory informing of nearby traffic or, -Pilot Deviation (PD) where loss of airborne separation falls within the same parameters of a Category D OE or PE, or -Minimal risk on operation of aircraft	-Potential for PD due to TCAS Preventive Resolution Advisory (PRA) advising crew not to deviate from present vertical profile, or -PD where loss of airborne separation falls within the same parameters of a Category C OE, or -A reduction of functional capability of aircraft but does not impact overall safety (e.g. normal procedures per AFM)	-PD due to response to TCAS Corrective Resolution Advisory (CRA) issued advising crew to take vertical action to avoid developing conflict with traffic, or -PD where loss of airborne separation falls within the same parameters of a Category B OE, or -Reduction in safety margin or functional capability of the aircraft requiring crew to follow abnormal procedures per AFM	-Near mid-air collision (NMAC) results due to proximity of less than 500 feet from another aircraft or a report filed by pilot or flight crew member that a collision hazard existed between two or more aircraft; or -Reduction of safety margin and functional capability of the aircraft requiring crew to follow emergency procedures as per AFM.	-Conditions resulting in a mid-air collision (MAC) or impact with obstacle or terrain resulting in hull loss, multiple fatalities, or fatal injury
Flying Public	Minimal injury or discomfort to passenger(s)	-Physical discomfort to passenger(s) (e.g. extreme braking action; clear air turbulence causing unexpected movement of aircraft causing injuries to one or two passengers out of their seats) -Minor injury to greater than zero to less or equal to 10% of passengers	-Physical distress on passengers (e.g. abrupt evasive action; severe turbulence causing unexpected aircraft movements), or -Minor injury to greater than 10% of passengers	Serious injury to passenger(s)	Fatalities or fatal injury to passenger(s)
Airport	No damage to aircraft but minimal injury or discomfort of little risk to passenger(s) or workers	-Minimal damage to aircraft, or -Minor injury to passengers, or -Minimal unplanned airport operations limitations (i.e. taxiway closure), or -Minor incident involving the use of airport emergency procedures	-Major damage to aircraft and/or minor injury to passenger(s)/worker(s), or -Major unplanned disruption to airport operations, or -Serious incident, or -Deduction on the airport's ability to deal with adverse conditions	-Severe damage to aircraft and/or serious injury to passenger(s)/worker(s); or -Complete unplanned airport closure, or -Major unplanned operations limitations (i.e. runway closure), or -Major airport damage to equipment and facilities	-Complete loss of aircraft and/or facilities or fatal injury in passenger(s)/worker(s); or -Complete unplanned airport closure and destruction of critical facilities; or -Airport facilities and equipment destroyed

Table D-4. Definitions for severity (ACRP Report 1, Vol 2).

Criteria	Risk Severity Classification				
	No Safety Risk A	**Minor B**	**Major C**	**Hazardous D**	**Catastrophic E**
Risk on aircraft operations	No risk on safety	Slight reduction in safety margin or functional capabilities	Significant reduction in safety margin or functional capabilities	Large reduction in safety margin or functional capabilities	Hull loss
Risk on people	Inconvenience	Physical discomfort	Physical distress possibly including injuries	Serious or fatal injury to small number of people	Multiple fatalities
Risk on airport reputation	Slight to moderate impact	Loss of community reputation	Loss of state reputation	Loss of national reputation	Loss of international reputation
Financial loss	Slight damage is less than $10,000	Noticeable damage between $10,000 and $100,000	Large damage between $100,000 and $1,000,000	Major damage between $1,000,000 and $10,000,000	Severe damage exceeds $10,000,000

Table D-5. Definitions for severity from a medium-hub (SMS Pilot Study) airport.

	People	Assets	Environmental	Reputation
Catastrophic	Fatality+	Loss of an aircraft/or over $1,000,000 dollars in damage/or loss of critical system(s) for an extended period of time	A spill or release that is not contained and results in long-term damage to the environment and fines to the airport.	An event or a series of events resulting in the community NOT using XXX for an extended period of time.
Hazardous	Severe Injury, requiring hospitalization	Damage to an aircraft taking it out of service for an extended period of time/or damage in excess of $500,000/or disruption of critical services for extended period of time	A reportable spill or release that requires mitigation.	An event or a series of events resulting in the community lessening the use of XXX causing negative (annual) financial or operational impacts.
Major	Minor Injury requiring medical treatment	Damage to an aircraft that is reparable/or damage to equipment or facility that is reparable within a short period of time.	A reportable spill or release that is contained.	An event or a series of events resulting in the community lessening the use of XXX for a short period of time.
Minor	Minor injury not requiring medical treatment	Minor damage to an aircraft, equipment, or facility not requiring it to be taken out of service.	A spill or release that does not require a report.	An event or a series of events resulting in the community questioning the reliability of XXX.
No Safety Risk	No injury	No Damage	No Impact	No Impact

Table D-6. Severity definitions from a large-hub (SMS Pilot Study) airport.

	1 – People	2 – Continuity of Operations	3 – Environmental	4 – Reputation	5 – Assets
Minimal 5	No to slight injury	No impact	No impact	No impact	Less than $50k
Minor 4	Injury with medic response	Minor disruption to normal operations Recovery time = immediate	Non-Reportable – Containable minimal volume of hazardous material	Minimal media inquiries	$50K to <$1 Million
Major 3	Injury with transport to medical facility	Major disruption to normal operations Recovery time =24 to 48 hours	Reportable – Non-containable minimal volume of hazardous material	Local media coverage	$1 Million to $100 Million
Hazardous Severe 2	Multiple injuries or fatalities	Severe disruption to normal operations Recovery time = more than 48 hours	Reportable – Containable moderate volume of hazardous product/material	Local and national media coverage for more than 48 hours	$100 Million to $1 Billion
Catastrophic 1	Mass Casualty Incident	Widespread regional disruption Recovery time = indefinite	Reportable – Non-containable significant volume of hazardous product/material	Widespread international media coverage and reduction of air travel indefinitely	Over $1 Billion

Probability Definitions

Table D-7. Qualitative criteria for risk likelihood from the FAA ARP Internal Order 5200.11.

	NAS System & ATC Operational	NAS Systems		ATC Operational		Flight Procedures	Airports
		Individual Item/System	ATC Service/NAS Level System	Per Facility	NAS-Wide		Airport-Specific
Frequent A	Probability of occurrence per operation/operational hour $\geq 1x10^{-3}$	Expected to occur about once every 3 months for an item	Continuously experienced in the system	Expected to occur more than once per week	Expected to occur more than every 1-2 days	Probability of occurrence per operation/operational hour $\geq 1x10^{-5}$	Expected to occur more than once per week or every 2500 departures, whichever occurs sooner
Probable B	Probability of occurrence per operation/operational hour $\geq 1x10^{-5}$	Expected to occur about once per year for an item	Expected to occur frequently in the system	Expected to occur about once every month	Expected to occur about several times per month		Expected to occur about once every month or 250,000 departures, whichever occurs sooner
Remote C	Probability of occurrence per operation/operational hour $\leq 1x10^{-5}$ but $\geq 1x10^{-7}$	Expected to occur several times during an item's lifecycle	Expected to occur numerous times in a system's lifecycle	Expected to occur about once every year	Expected to occur about once every 3 years	Probability of occurrence per operation/operational hour $\leq 1x10^{-5}$, but $\geq 1x10^{-7}$	Expected to occur about once every year or 2.5 million departures, whichever occurs sooner
Extremely Remote D	Probability of occurrence per operation/operational hour $\leq 1x10^{-7}$ but $\geq 1x10^{-9}$	Unlikely to occur, but possible in an item's lifecycle	Expected to occur several times in a system's lifecycle	Expected to occur once every 10-100 years	Expected to occur about once every 3 years	Probability of occurrence per operation/operational hour $\leq 1x10^{-7}$ but $\geq 1x10^{-9}$	Expected to occur once every 10-100 years or 25 million departures, whichever occurs sooner
Extremely Improbable E	Probability of occurrence per operation/operational hour $< 1x10^{-9}$	So unlikely that it can be assumed that it will not occur in an item's lifecycle	Unlikely to occur, but it is possible in system lifecycle	Expected to occur less than every 100 years	Expected to occur less than every 30 years	Probability of occurrence per operation/operational hour $< 1x10^{-9}$	Expected to occur < every 100 years

Table D-8. Quantitative criteria for likelihood (ACRP Report 1, Vol 2).

Risk Likelihood Classification				
Extremely Improbable 1	**Extremely Remote 2**	**Remote 3**	**Probable 4**	**Frequent 5**
More than one event in 1,000,000,000 operations	Between 10,000,000 and 1,000,000,000 operations per event	Between 100,000 and 10,000,000 operations per event	Between 1,000 and 100,000 operations per event	Less than 1000 operations per event
Less than once in 100 years	Once every 10-100 years	Once every 1-10 years	Once every month	More than once every week

Table D-9. Quantitative criteria from a medium-hub (SMS Pilot Study) airport.

Likelihood:	
Frequently	*Occurs once every* month or 5,600 commercial operations or 336,000 enplanements
Probable	*Occurs once every* year or 68,000 commercial operations or 4,000,000 enplanements
Remote	*Occurs once every* 5 years or 340,000 commercial operations or 20,000,000 enplanements
Extremely Remote	*Occurs once every* 10 years or 680,000 commercial operations or 40,000,000 enplanements
Extremely Improbable	*Occurs once every* 20 years or over 1,360,000 commercial operations or 80,000,000 enplanements

Table D-10. Quantitative criteria from a non-hub (SMS Pilot Study) airport.

Likelihood:				
Frequently	*Occurs once every* month or 3,000 aircraft operations or 25,000 enplanements			
Probable	*Occurs once every* year or 34,000 aircraft operations or 300,000 enplanements			
Remote	*Occurs once every* 5 years or 170,000 aircraft operations or 1,500,000 enplanements			
Extremely Remote	*Occurs once every* 10 years or 340,000 aircraft operations or 3,000,000 enplanements			
Extremely Improbable	*Occurs once every* 20 years or over 700,000 aircraft operations or 6,000,000 enplanements			
Severity:				
	People	**Assets**	**Environmental**	**Reputation**
Catastrophic	Fatality+	Loss of an aircraft/or over $1,000,000 dollars in damage/or loss of critical system(s) for an extended period of time.	A spill or release that is not contained and results in long-term damage to the environment and fines to the airport.	An event or a series of events resulting in the community NOT using XXX for an extended period of time.
Hazardous	Severe Injury, requiring hospitalization	Damage to an aircraft taking it out of service for an extended period of time/or damage in excess of $500,000/or disruption of critical services for extended period of time.	A reportable spill or release that causes short-term damage to the environment and requires mitigation.	An event or a series of events resulting in the community lessening the use of XXX causing negative (annual) financial or operational impacts.
Major	Minor Injury requiring medical treatment	Damage to an aircraft that is reparable/or damage to equipment or facility that is reparable within a short period of time.	A reportable spill or release that is contained.	An event or a series of events resulting in the community lessening the use of XXX for a short period of time.
Minor	Minor injury not requiring medical treatment	Minor damage to an aircraft, equipment, or facility not requiring it to be taken out of service	A spill or release that does not require a report.	An event or a series of events resulting in the community questioning the reliability of XXX.
No Safety Risk	No injury	No Damage	No Impact	No Impact

Note: This airport combined severity and likelihood into one table for ease of reference.

Table D-11. Safety risk assessment process.

(1) Describe the System	(2) Identify Hazards	(3) Analyze Outcomes	(3a) Identify Existing Control	(4) Assess Level of Risk	(5) Mitigation Actions	(5a) Reassess Level of Risk with Mitigation Actions in Place
5M: Mission, Man, Machine, Media/environMent, Management	*Hazard A*	*Effect A1*	*CA11, CA12,*	*A1-prior*	*MA11, MA12, …*	*A1-after*
		Effect A2	*CA21, CA22,*	*A2-prior*	*MA21, …*	*A2- after*
		Effect A3	*CA31, CA32,*	*A3-prior*	*MA31, MA32,*	*A3- after*
	Hazard B	*Effect B1*	*CB11, CB12,*	*B1-prior*	*MB11, MB12,*	*B1- after*
		Effect B2	*CB21, CB22,*	*B2-prior*	*MB21, …*	*B2- after*
	Hazard C	*Effect C1*	*CC11, CC12,*	*C1-prior*	*MC11, …*	*C1- after*
		Effect C2	*CC21, CC22,*	*C2-prior*	*MC21, MC22,*	*C2- after*
		Effect C3	*CA31, CC32,*	*C3-prior*	*MC31, MC32,*	*C3- after*

D-5 Detailed 5-Step SRM Process

Table D-11 provides easy-to-follow, step-by-step guidance for process application during an SRA. Airport operators may choose to provide this template to SRA panel members for use during the SRA process. The SRA is typically led by a designated facilitator. The facilitator's role is to guide the SRA panel members through the process, document results, and provoke interaction, thought, expertise, and information exchange. Parameters in the template are as follows:

- *Column 1—Describe the System:* The system is described to limit the scope of the risk assessment. The system is often described using the 5M Model:
  – Mission: the specific airport activity (e.g., taxiway B reconstruction)
  – Man: the personnel involved with the activity (e.g., construction workers and airport engineering and operations staff)
  – Machine: the equipment involved (e.g., trucks, pavers, and compactors)
  – Media or environMent: the environment including physical areas and ambient conditions (e.g., taxiway B between taxiways J and N and haul routes)
  – Management: organization, procedures, regulations, advisory material (e.g., FAA ACs)
- *Column 2—Identify Hazards:* Multiple hazards may be associated with the evaluated system. For example, a construction project may involve hazards such as FOD and movement of haul trucks in airfield areas. Letters may be used to identify each hazard.
- *Column 3—Analyze Outcomes:* Each hazard listed in Column 2 may be associated with one or more outcome(s) (e.g., FOD may cause damage to aircraft if ingested by the engine, or it may cause injuries to construction workers due to jet blast). Using the hazard letter and a number will help maintain the organization of the template (e.g., Effect B2 is the second outcome associated with hazard B).

- *Column 3a—Identify Existing Controls:* This column is used to identify existing controls. It is important to consider these controls before assessing the level of risk and developing other mitigation actions. SOP, ACs, safety plans, and regular inspections are examples of existing controls (e.g., FOD control plan for a construction project).
- *Column 4—Assess Level of Risk:* In this column, the level of risk with the existing controls is estimated and recorded. In most cases, a risk matrix will be used to estimate the risk. Initially, the user will estimate the worst credible outcome or risk and then the likelihood of that outcome occurring. Usually, an alphanumeric code (a letter for likelihood and a number for severity) will be assigned to identify the level of risk. It is helpful to use a background color to identify if the risk is low (green), medium (yellow), or high (red). The colors allow for quick identification of higher risks. For example, if using the FAA risk matrix, a RAC 2C represents a risk of *hazardous* severity (2) and *remote* probability (C). A 2C risk level is assumed to be a High risk (Red). If colors are not used, the risk may be described as *2C-High* to ensure the correct characterization.
- *Column 5—Mitigation Actions:* Any risk classified as a high level of risk must be mitigated and cannot be accepted. Any medium risk level may be accepted, but should be controlled with mitigation actions to the degree possible, given the airport resources. Each risk may have one or more mitigation/control actions to reduce the risk to an acceptable level. An airport experiencing high frequency of FOD on the runway may reduce the risk of accidents by taking additional measures (e.g., increasing frequency of repairs and removal of the debris with sweeper trucks or planning runway rehabilitation and increasing the frequency of inspections).
- *Column 5a—Reassess Level of Risk with Mitigation Actions in Place:* This column is similar to Column 5; however, the new control actions are considered to estimate the new level of risk when all mitigation actions are in place. An example using this template is presented in the guidebook.

D-6 Hazard Tables

Sound documentation of processes and procedures is vital to both the success of the SRA and the proper implementation of follow-on actions. To track the SRA process effectively, a Hazard Table was used during several SRA at Pilot Study airports. The tables capture the results from the SRA. The SRA report documents why changes and/or decisions were made (i.e., why the remaining risk may have decreased in priority from the risk assessment). The hazard tables should capture the following information:

- Hazards
- Outcome (NOTE: during the pilot studies, several airports used the term Risk)
- Severity
- Likelihood
- Risk assessment (high, medium, or low) for each risk
- Mitigations
- Residual risk (high, medium, or low)

The hazardous condition within the context of the overall system is listed first. Then the outcome of that hazardous condition is listed (note: many airports that participated in the SMS Pilot Studies and those that have developed SMS on their own used the terms “risk” or “consequence” instead of outcome.) An outcome is a possible occurrence resulting from the hazardous condition. Risk is the combination of severity and likelihood.

Tables D-12 through D-14 present examples of Hazard tables.

Table D-12. (Example) Hazard table from large & medium-hub airports.

#	Hazard	Outcome	Risk Assessment			Mitigation(s)	Remaining Risk
			Severity	Likelihood	Result (Risk Level)		
1	Men and equipment working in Taxiway N safety area	1. Aircraft and vehicle accident 2. Aircraft and pedestrian accident	1. Hazardous 2. Hazardous	1. Remote 2. Extremely Remote	1. M17 2. M16	1. Marked and lighted equipment 2. Reflective vests on all personnel in area 3. FAA ATC ground radios in vehicles and actively monitored 4. Airport Ops personnel bi-hourly inspections and actively monitoring radio traffic.	1. M16 2. M16
2	XXXX	1. 2.	1. 2.	1. 2.	1. 2.	1. 2.	1. 2.

In Table D-12, the hazards are numbered. There can, and most likely will, be multiple effects associated with each hazardous condition. In this table each risk is tracked through the risk assessment process, mitigations are considered which may address multiple risks, and a risk reassessment is conducted and documented to determine the residual level of risk post mitigation. The RAC is highlighted to indicate the level of risk (in this case yellow, representing medium). In most cases, mitigations decrease the likelihood of the risk, not the severity. Severity can be reduced (e.g., wearing a helmet while riding a motorcycle).

In Table D-13, the smaller airport elected to provide the same level of information as provided in Table D-12 by using fewer cells and combining the information often presented in multiple

Table D-13. (Example) Hazard table from a non-hub airport.

Hazard	Outcome	Risk Assessment	Mitigation	Remaining Risk
1. Pedestrians on the airfield	Impact to pedestrians	Severity – Minor personal injury Likelihood – Probable Medium Risk	1. The FBO provides designated walking paths. 2. The FBO escorts all pedestrians to and from GA. 3. The FBO and the XXXX maintain visual contact with all pedestrians while they are on the airfield. 4. The FBO train all staff from other airports. 5. The FBO maintains a list of between 5 and 10 employees from other airports. Only those employees are allowed to work on major event days.	**MEDIUM**
2.				
3.				

Table D-14. Hazard table from a comparative risk assessment (FAA ATO).

Hazard (1)	Hazard Description (2)	Causes (3)	System State (4)	Existing Control or Requirement (5)	Possible Effect (6)	Severity Rationale (7)	Likelihood Rationale (8)	Initial/Current Risk (9)	Recommended Safety Requirements (10)	Predicted Residual Risk (11)
1-1	Desc. 1-1	Cause #1 Cause #2	SS-1 SS-2	EC #1 EC #2 EC #3	Eff. #1 Eff. #2	SRat. #1 SRat. #2	LRat. #1 LRat. #2 LRat. #3	4D - Low	RSR #1 RSR #2 RSR #3	4D – Low
1-2	Desc. 1-2	…	…	…	…	…	…	…	…	…
2-1	Desc. 2-1	…	…	…	…	…	…	…	…	…
2-2	Desc. 2-2	…	…	…	…	…	…	…	…	…
2-3	Desc. 2-3	…	…	…	…	…	…	…	…	…
3-1	Desc. 3-1	…	…	…	…	…	…	…	…	…
4-1	Desc. 4-1	…	…	…	…	…	…	…	…	…

cells. This airport also elected to use color coding to provide a visual cue for the reader (yellow representing a medium RAC).

In Table D-14, the CRA is used by the FAA ATO in tower siting studies and SRM panels for proposed changes to the NAS. Table D-14 provides a more granular level of information than Tables D-12 and D-13. This approach can mitigate causes and system state factors, thus changing the hazard condition rather than only mitigating the risks. An example of this: A hazardous condition exists on a commercial aircraft ramp at night because it is dark. By simply lighting the ramp with highmasted ramp lights, in accord with ACs, the hazardous condition has changed; the hazard probability of the possible effect of a vehicle—aircraft accident occurring has been lessened.

D-7 Mitigation Tables

The mitigation table serves as a means to document the mitigations for each individual hazardous condition and its associated risks. The mitigation descriptions should explain what will be done by whom and any deadlines associated with the actions. The template should include a column to record the end date (if appropriate) for any mitigation. Tables D-15 through D-18 provide examples of mitigation tables used by pilot study airports.

Table D-15 is designed specifically for construction projects. Sample language is provided in the respective columns. Because Table D-15 was developed for a construction project, the users assumed the mitigation(s) will continue over the life of the project, so no end-dates are assigned.

Table D-16 was used by multiple pilot study airports choosing to include a separate table in their SRM Final Reports. This sample table includes some example language that was typical for a specific airport. The Person Responsible column includes departments and organizations, rather than individuals, unless the mitigation involves contract matters. With only one column provided for a proposed completion date, milestone dates were included there as well.

Table D-17 comes from an overall comprehensive worksheet used to document hazards, risk assessments, and mitigation plans. Each hazardous condition is documented on an individual worksheet. The mitigation(s) are included as an individual section on the worksheet.

Table D-18 was used by multiple pilot study airports choosing to include a separate table in their SRM Final Reports. This allowed the airports to use the table as a separate document, to make assignments, work orders, and planning work load for staff.

D-8 Sample Final SRA Report Structure

Thoroughly documenting the SRM and SRA processes is critical to the success of an airport SMS. SRM documentation provides historical data that can be used during future SRAs, holds individuals accountable for required tasks, demonstrates SMS compliance when audits are conducted, and demonstrates to airport staff and stakeholders that the SMS, SRM, and SRA processes are part of the business at the airport.

The airport must have an acceptable and consistent means to document the process. The report format should represent the business practices of the airport and ensure that the necessary information is captured concisely. The following sections present three examples of SRM reports for reference: D-9 Medium-Hub Airport, D-10 Small-Hub Airport, and D-11 Large-Hub Airport.

Table D-15. SRM example mitigation table (construction).

Haz # (1)	Hazard Description (2)	Effect (3)	Risk Mitigating Actions (4)	Planning & Design (5)	Contractor (6)	Ops (7)	ATCT (8)	Other (9)
1	FOD from construction vehicles on taxiways	Damage to aircraft	Sweepers at construction site	✓	✓			
			Establish monitoring procedures by Ops		✓	✓		
			Establish notification procedures between contractor/operations/ATCT		✓	✓	✓	
			Use trained contractor escort to identify FOD and report to Ops		✓	✓		
			Use trained flagmen equipped with brooms and shovels	✓	✓	✓		
			Install rumble strips at hauling route before pavement	✓	✓			

Table D-16. SRM example mitigation table (pilot study airport).

#	Mitigation	Person Responsible	Proposed Completion Date
1.	**Training:** controllers, airfield personnel (GSE and Ops, flight crews (chief pilots) for…	• XXX (airport) operations work with ATCT…	Plan complete by XXX, XXXX Begin familiarization by XXX, XXXX
2.	Improve **communications:** determine…	• XXX operations will address updating publications • XXX operations will create diagram and advertise at FBOs • XXX ATCT will assist with departure card content and provide to XXX operations	All to be completed and in place by XXX, XXXX
3.	**Facility:** install Runway guard lights…	• XXX planning and engineering departments will investigate…	Runway guard light investigation should be concluded with a report of results by XXX, XXXX
4.	**System** changes – Ground based radar…	• The XXX ATCT management will investigate the status of ground based radar for XXX. • XXX operations and XXX ATCT management will form a working group to investigate if there's any benefit to pursuing video cameras and camera analytics…	Form the working group by XXX, XXXX. Provide an interim report of findings by XXX, XXXX Make a recommendation for… XXX, XXXX
5.	Add a brochure to foreign air carriers…	• Individuals named (due to contract issues) will investigate the necessary contents of a brochure and discuss this issue with XXX property department for inclusion in LOA.	Provide an interim report by XXX, XXXX

Table D-17. SRM example mitigation table (pilot study airport).

Action Plan Steps	Milestone Date	Responsible Person	Completion Date
1.			
2.			
3.			
4.			

Table D-18. SRM example mitigation table (pilot study airport).

Hazard #	Mitigation	Person Responsible	Proposed Completion Date
1	(mitigations are numbered to correspond with the hazard, risk, and mitigation table)	Specific individuals are named.	Includes any milestone dates.
2			
3			
4			

D-9 Example of SRA Report from a Medium-Hub Airport

Safety Risk Assessment # **Topic: Represent the Issue or System**	
Date: **Presented by:** **Authored by:**	PHOTOS of Area Assessed

Table of Contents

NOTE: insert a table of contents here for the report as necessary.

Introduction

The introduction should include the reason (trigger) for the SRA, a brief description of what is to be assessed, and who is taking the lead or sponsoring the SRA.

The introduction should also summarize the process that will be used. Because each airport may have a slightly different way of working the SRA process, here is one example:

The SRA facilitation and subsequent documentation is based on the 5-Step Safety Risk Assessment process plus a 6th step for monitoring. The six steps are

1. *Define the System*,
2. *Identify the Hazards*,
3. *Analyze the Risk (Effect)*,
4. *Assess the Risk (through use of a risk matrix)*,
5. *Treat/mitigate the Risk*,
6. *Mitigation and Monitoring Plan, mitigating the risk also includes a monitoring plan that assigns tasks, timelines, and responsibility for implementation and management.*

Background

The background should include what led to the SRA. The background section should describe the actions, reference regulations, and outline how the airport is authorized to conduct the SRA (i.e., if the airport developed and implemented an SMS program and the SRM component of that program requires an SRA to be conducted). The timeline for the SMS development and implementation should be referenced. Any additional information pertinent to the SRA (e.g., any interaction between FAA ATCT and the airport staff that jointly identified this need) should be noted.

Logistics

The logistics should include the date, time, location, and panel members and should briefly mention responsibilities (e.g., facilitation, documentation, and results acceptance).Table D-X provides an example.

Table X. SRA #X participants.

SRA Panelists

Participants	Role	Representing
1		
2		
3		
4		
5		
6		

Define the System

This section should follow a known approach in order to ensure the system is accurately captured. This guidebook promotes the use of the "5M" model. An example of how to document it is provided:

Overall System

In order to focus the discussion, the panel agreed to bound the system and discussion specifically to the issue that was identified . . . The system . . .

The panel employed the 5-M Model as a guide to define the system. The 5-M Model is:

1. Mission
2. Management
3. Machine
4. huMan
5. environMent

Following are examples of the 5-M Model:

Mission

1.1.1 The airfield is intended to provide for the safe movement of aircraft on the ground and during takeoff and landing.
  a. One or two sentence brief statement.

Management

1.1.2 FAA ATCT SOPs
  a. Describe what processes and procedures one of the stakeholders has that need to be accounted for. Such as FAA ATCT procedures.

1.1.3 The Airport's Air Operations Area (AOA) Rules and Regulations
  a. Describe what processes and procedures one of the stakeholders has that need to be accounted for. Such as the Airport's procedures.

Machine

1.1.4 Aircraft
  a. Describe what machines need to be accounted for. Use the number of them if it is appropriate.
  b. Aircraft operations (example)
  c. Type of aircraft (example)

1.1.5 Airport Maintenance and Operations Vehicles
  a. Vehicles (example)

1.1.6 FAA Vehicles
  a. Vehicles: airport snow removal, fuelers, FAA tech ops (examples).

1.1.7 Runways and Taxiways
  a. Runway XXX

huMan

1.1.8 Airport Operations and Maintenance Personnel
  a. Operations Managers
  b. Break it down if needed

1.1.9 Pilots
  a. Airlines (example)

1.1.10 FAA
  a. ATCT personnel (example)
  b. Tech ops personnel (example)

EnvironMent

1.1.11 Weather
  a. Note if the condition being assessed is contingent upon the weather

1.1.12 Time of Day

1.1.13 Time of Year

1.1.14 Other
  a. Terminal area (example)
  b. Parking garage (example)
  c. Public roads (example)

Identify the Hazards

The hazard identification process is essential to the overall SRA. This section should describe the method used to identify the hazards and whether hazards are a result of a proposed change or already exist in the system. This section should also explain any limitations or boundaries the panel members chose to use. An example follows:

The Panel considered the information documented from the system description and focused on the area of

1. *Aircraft movement on the commercial ramp on the south side of Concourse A.*

Refer to where the hazards are being captured (documented): **Table XX** provides the hazards, risks, risks assessment, mitigations, and risk analysis results.

Risk Analysis and Assessment

This section should briefly describe what tool(s) were used to identify and quantify the risk associated with the hazardous condition and should reference where and how they are documented. An example follows:

The Panel used ***Table X*** *to guide and track the discussion through the risk assessment portion of the SRA. The Consulting Team used a projector for Table X, thus allowing the Panel members to track the process and discuss the language used in the documentation as the SRA progressed. The risk matrix and definitions for Severity and Probability are attached in* ***Appendix X****.*

Table X. Hazards, outcome (previously risks), risk assessment, mitigations, and residual risk table (example from a SMS pilot study airport).

#	Hazard	Outcome (previously Risk)	Risk Assessment			Mitigation(s)	Residual Risk
			Severity	Likelihood	Result		(if any)
1	1. Weather, visibility, human accuracy, etc. (including erroneous information)	1. AC accident (AC to AC, AC to V) 2. Incursion 3. Deviation (Pilot or V) 4. Delay in operations	1A – Asset – Catastrophic 1B – People – Catastrophic 1C – Reputation – Major 2A – Reputation – Minor 3A – Reputation – Minor 4A – Reputation – Minor	1A – Extremely Improbable 1B – Extremely Improbable 1C – Extremely Improbable 2A - Remote 3A – Extremely Remote 4A – Frequent	**1A = M** **1B = M** **1C = M** 2A = L 3A = L **4A = M**	1 – **Training** controllers, airfield personnel (GSE vs. Operations), flight crews (chief pilots) for accuracy of location reporting could include discussion with station manager's level of awareness training. Situational awareness to be emphasized. Training focus on staff that are based at XXX. D – Improved **communications**, add information to Airport Facility Directory; no ground radar available, add to Jeppesen chart notes, airport 5010 form, in publications (in general) for safety notes. Advertise at FBOs. Issue airport diagram for all pilots. Automatic terminal information system (ATIS). Include the communication in special event cards, i.e. knee board cards/departure cards add information on the specific area's challenges. D – **Facility** – install in-pavement runway guard lights. This mitigation requires further investigation. Future planning consideration for expansion of the Northeast side of airfield. 4 – **System** changes – Ground based radar, video cameras, camera analytics. **5 – Existing mitigations** – standalone FLM/CIC, heightened awareness, team work emphasis, currently developing scenarios for tower simulator, controller training without visual aids (back turned). Emphasis in On-the-Job Training (OJT). Training program addresses the lack of visual aids and physical limitations without electronic system support. Included in the Indoctrination checklist.	**1ª = M** **1B = M** **1C = M** 2ª = L 3ª = L 4ª = L

Mitigation Plan

The mitigation action plan identifies the item to be investigated and/or deployed; the responsible party for implementing the investigation, documentation, reporting; and the completion date.

Table X. Mitigation plan (example from a SMS pilot study airport).

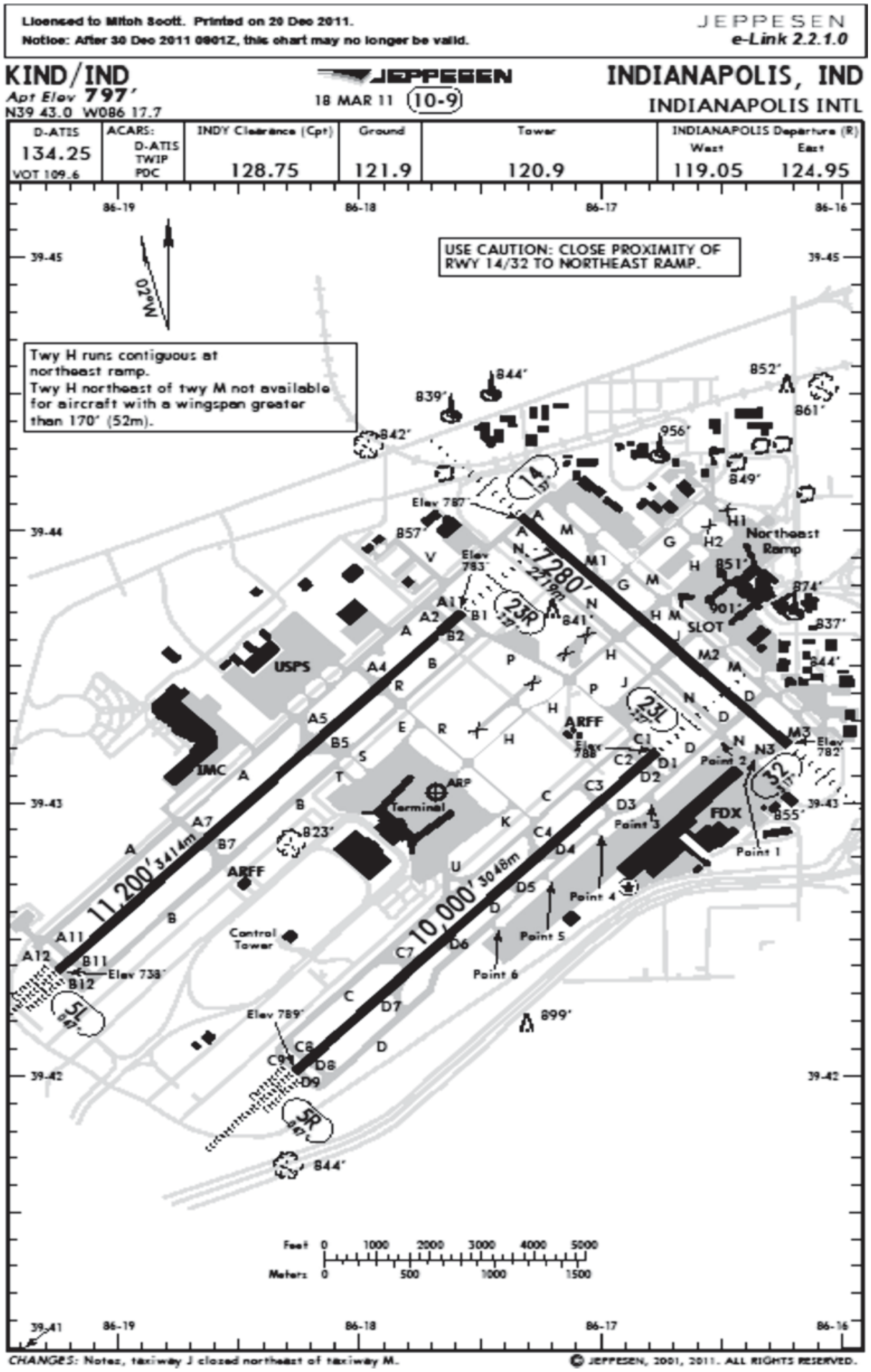
#	Mitigation	Person Responsible	Proposed Completion Date
1.	1 – **Training:** controllers, airfield personnel (GSE and Ops, flight crews (chief pilots) for accuracy of location reporting could include discussion with station managers' level of awareness training. Situational awareness training focus on staff who are based at XXX	• XXX operations work with ATCT management to provide a briefing for those personnel.	Plan complete by April 1, 2012 Begin familiarization by May 1, 2012
2.		•	
3.		•	
4.		•	
5.		•	

SRA Accepting Authority

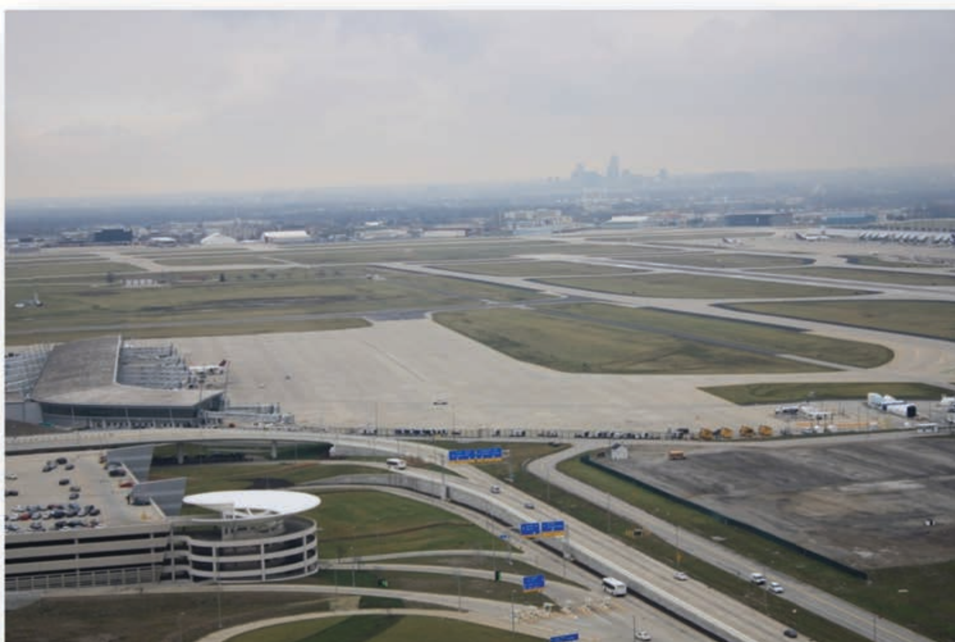
This section documents who is accepting the results of the SRA. By accepting, they are accepting the levels of risk identified and the mitigation plan.

Responsible Person Accepting Residual Risk	SRA Document Preparer
Signature:	**Signature:**
Title:	**Title:**
Date:	**Date:**
Signature:	
Title:	
Date:	

Example Appendix A—Airport Diagram



Example Appendix B—Photos (Document the condition)



Example Appendix C—Draft Definitions of Severity and Likelihood, and Risk Matrix

XXX Definitions for severity and likelihood.

Likelihood:	
Frequently	*Occurs once every* month or 5,600 commercial operations or 336,000 enplanements
Probable	*Occurs once every* year or 68,000 commercial operations or 4,000,000 enplanements
Remote	*Occurs once every* 5 years or 340,000 commercial operations or 20,000,000 enplanements
Extremely Remote	*Occurs once every* 10 years or 680,000 commercial operations or 40,000,000 enplanements
Extremely Improbable	*Occurs once every* 20 years or over 1,360,000 commercial operations or 80,000,000 enplanements

Severity:	**People**	**Assets**	**Environmental**	**Reputation**
Catastrophic	Fatality+	Loss of an aircraft/or over $1,000,000 dollars in damage/or loss of critical system(s) for an extended period of time	A spill or release that is not contained and results in long-term damage to the environment and fines to the airport.	An event or a series of events resulting in the community NOT using XXX for an extended period of time.
Hazardous	Severe Injury, requiring hospitalization	Damage to an aircraft taking it out of service for an extended period of time/or damage in excess of $500,000/or disruption of critical services for extended period of time	A reportable spill or release that requires mitigation.	An event or a series of events resulting in the community lessening the use of XXX causing negative (annual) financial or operational impacts.
Major	Minor Injury requiring medical treatment	Damage to an aircraft that is reparable/or damage to equipment or facility that is reparable within a short period of time.	A reportable spill or release that is contained.	An event or a series of events resulting in the community lessening the use of XXX for a short period of time.
Minor	Minor injury not requiring medical treatment	Minor damage to an aircraft, equipment, or facility not requiring it to be taken out of service	A spill or release that does not require a report.	An event or a series of events resulting in the community questioning the reliability of XXX.
No Safety Risk	No injury	No Damage	No Impact	No Impact

Example Risk Matrix

		Severity				
		No Safety Risk	Minor	Major	Hazardous	Catastrophic
Likelihood	Frequently	L5	M13	H20	H22	H25
	Probable	L4	M12	M15	H21	H24
	Remote	L3	L8	M14	M17	H23
	Extremely Remote	L2	L7	L10	M16	M19
	Extremely Improbable	L1	L6	L9	L11	M18

Low	Medium	High
No Action Required	Monitor, Determine if Risk can be Mitigated to a Low Risk	Must be Mitigated to a Medium Risk

Figure X. Risk matrix.

D-10 Example of SRA Report for Small Hub Airport

1. Background

The XXX airport staff tows aircraft to and from a hangar and relocates aircraft following arrival to ramp parking positions. Some aircraft are towed on the aircraft movement area which raised additional concerns in the review of the processes and procedures. In addition, the YYY Flight School operates and maintains over 50 aircraft ranging from single engine trainers to twin engine aircraft. The Flight School operates several hangars and tows aircraft across ramps and on a nearby taxiway or in close presence to the taxiway. At times the tow routes cross the air carrier operations ramp or in close proximity to it. Minor incidents/accidents have occurred in the past usually resulting in minor damage to the aircraft in tow. A few incidents have resulted in the XXX airport insurance premiums being increased. Causal factors vary from weather related events, training, equipment issues, situational awareness and standard procedures. This SRA report summarizes the safety risk management process conducted at XXX and presents the process, findings and recommendations.

2. SRA Panel

The SRA process was conducted in two steps. A preliminary safety assessment meeting with representatives from XXX airport management, Operations and FBO operations was step one. Step two was the formal conduct of the SRA and convening of a panel. Before the SRA process was carried out, towing procedures and each step of aircraft towing and phases were discussed to identify activities. This preliminary step assisted in facilitating the identification of hazards associated with each step and activity. Following the initial meeting, the SRA panel proceeded with additional analysis and prepared a draft report for review by the participants of the panel.

List of Participants: Name and affiliation of seven participants

3. References

- FAA AC 150/5200-37, Introduction to Safety Management Systems for Airport Operators
- FAA Order 5200.11, FAA Airports (ARP) Safety Management System
- XXX Safety Management System Manual (2008)
- ACRP Report 1—Safety Management Systems for Airports—Volume 2: Guidebook

4. Safety Risk Management (SRM) Process

SRM Process

The risk assessment process conducted for this SRA was that presented in FAA AC 150/5200-37 and incorporated to XXX SMS Manual. The process consists of five steps, as follows:

Step 1—Describe the system

The first step in performing SRM is to describe the system under consideration. The system description includes the functions, general physical characteristics and resources, and operations of the system.

Step 2—Identify hazards

Hazard identification is the act of identifying any condition with the potential of causing injury to personnel, damage to equipment or structures, loss of material, or reduction of the ability to perform a prescribed function.

Step 3—Determine the possible effect

This step is to identify the possible effect associated with each hazard listed in the previous phase. One hazard may have one or more risks associated with it.

Step 4—Assess and analyze the risk

Risk assessment is the process which associates "hazards" with "risks." The process involves both estimating and classifying risks. The simplest way to estimate the risk associated with a specific hazard is to ask the following two questions:

- What possible harm could the hazard present (the risks)?
- How likely is it that harm could occur (the likelihood)?

After estimating the risks and the likelihood, this information is used to classify risk according to XXX Risk Matrix, which follows that presented by the FAA in Order 5200.11. Risk classification is necessary to identify how serious is the risk and to define the priorities to treat these risks.

Step 5—Treat and monitor risk

Risk treatment alternatives should address the risk probability, the risk severity, or both.

More detailed information on these steps is described in ensuing sections of this report.

5. Description of the System

The system includes the phases, steps, location and activities involved with towing aircraft, the XXX airport FBO staff and Flight School for activities, related XXX Aircraft Tow Procedures (see Attachments A and B). These include escorting, coordination, training and SOPs activities performed by XXX staff and the Flight School staff. Towing operations usually take place in the ramp area and inside the hangars of XXX airport.

6. Activities, Major Hazards and Risks Assessment

The table below presents a summary of major hazards, associated effect and risk levels assessed. In addition, the table contains the basic control actions to mitigate the risk levels assessed prior to the control measures. The current risk levels were arrived at after assessing the risks for their associated severity and probability. The treated risk levels were arrived at after mitigation actions were taken into consideration.

Medium and low-risk levels are presented in the table; no high-level risks were identified by XXX staff:

Activity	Hazards	Effect (previously Risk)	Current Risk Level	Treated Risk	Control Actions
Work order-verbal or written containing aircraft data, location and planned tow route	Errors in work order	Damage to aircraft, injury to persons, damage to facilities and equipment	Low	Low	Recheck tow order data before initiating tow actions
Assign tow crew	Inexperienced operator Fatigue Training Awareness	Damage to aircraft and injury to persons, damage to facilities, and equipment	Medium	Low	• Provide training • Promote awareness
Assign tow crew	Insufficient crew staff Sense of urgency/pressure	Damage to aircraft, facilities and equipment, and injury to persons	Medium	Low	• Mandate at least 2 crew staff to each aircraft tow by SOPs
Select tow equipment	Equipment maintenance Obstructed visibility Improper tow bar	Damage to aircraft Injury to persons	Low	Low	• Mark towing safety rules on tug • Add to SOP's, clean windshield of tug • Mark tow bars with list of aircraft that can be towed
Select tow equipment	Obstructed visibility	Injury to persons	Medium	Low	• Improve awareness • Place safety/operating checklist in tugs
Position tug and hook up	Careless driving Approach aircraft too fast	Damage to aircraft, injury to persons, damage to facilities	Medium	Low	• Promote awareness • Review SOP
Tow aircraft	Driving careless	Damage to aircraft and facilities, injury to persons	Medium	Low	• Review SOP and training
	Turn limits exceeded	Damage to aircraft and facilities, injury to persons	Low	Low	• Review SOPs, clearances on ramp, no wing overlaps

Activity	Hazards	Effect (previously Risk)	Current Risk Level	Treated Risk	Control Actions
Maneuver aircraft in/out of hangar	Hangar doors not fully open	Damage to aircraft and facilities, injury to persons	Medium	Low	• Already addressed by XXX, use reflective materials on hangar doors and include recheck in SOP
	Multiple command orders	Damage to aircraft and facilities, injury to persons	Low	Low	• Training and recurrent training
	Lack of conspicuity of obstacles	Damage to aircraft and facilities, injury to persons	Medium	Low	• Training and recurrent training. SOPs • Promote awareness
Park and secure aircraft	Lack of visible centerline marking	Damage to aircraft and facilities, injury to persons	Medium	Low	• Implement centerline markings outside hangar

7. Summary of Risk Mitigation Actions

This section includes a list of safety issues for this particular safety risk assessment that should be addressed by the XXX staff and Flight School. The list of mitigation actions under the responsibility of the XXX staff shall be addressed in the XXX Aircraft Tow Procedures and the Flight School Safety Manual.

XXX List of Risk Control Actions

- Review SOP for towing aircraft
  - Mandate at least two persons to towing of large aircraft, recommend two persons always for all towing
  - Evaluate fatigue conditions of crew due to weather events/other
  - Address specific daily safety issues (hazardous situations, construction, etc.)
  - Confirmation of aircraft tow work order information
  - Develop incident reports to include causal factors
  - Review procedures, training, recurrent training
  - Tow route inspection prior to tow operations to check for obstacles and improve situational awareness
  - Explore development of standard tow routes for approach to and behind aircraft parking/tie-down spots, other factors
  - Reading/completing a checklist for towing safety rules posted in tug prior to each tow operation
- Plan to provide basic safety training to workers addressing:
  - Awareness promotion
  - Equipment inspections
  - Obstructed visibility
  - Escorting (for vehicle drivers)
  - Communication and coordination with tow crews
  - Driving and working in the AOA
  - Obstruction clearance
- Review SOP to include hangar ingress/egress of aircraft
  - Signage, markings and lighting
  - Wing-walker procedures
  - Communication and coordination procedures
  - Reflective materials use as required

XXX FBO List of Risk Control Actions

- Comprehensive review of aircraft tow safety procedures prepared by XXX
- Coordination with ATC, Contractors, airlines, Tenants and XXX FBO services escorting, ingress and egress procedures, airfield closures, marking and lighting, emergency routes
- Ensure coordination with ATC to identify aircraft towing/relocation in close proximity to taxiway boundaries for each tow operation
- Ensure availability of effective communication measures
- Ensure XXX SOPs are followed
- Ensure tow crew is briefed and has clear instructions on tow route and steps
- Identify areas of jet blast potential tow route
- Ensure vehicles are properly marked/lighted inside the AOA

8. Attachments

- XXX Towing Procedures
- XXX FBO Towing Procedures
- Pictures of Accidents

D-11 Example of SRA Report for Large Airport

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Introduction

Background

The Federal Aviation Administration (FAA) is conducting a Part 139 Safety Management System (SMS) Implementation Study. This study serves as a continuation of the Airport SMS Pilot Studies.

The intent of the current implementation study is to examine how airports can implement the SMS pillars of safety risk management (SRM) and Safety Assurance throughout their airfield environment including the aircraft movement and non-movement areas. The study will also evaluate the validity of SMS documentation developed during the first pilot studies.

Scope

This report outlines the conduct of a safety risk assessment (SRA) that is part of the FAA Pilot Study on SMS. The focus areas for this SRA are Winter Weather Operations and this risk assessment was conducted to address only hazards in the aircraft movement and non-movement areas of the airport as applicable.

Methodology

General

The approach followed for the execution of the risk assessment is in line with the phases of SRM described in the FAA Advisory Circular: AC 150/5200-37—*Introduction to Safety Management Systems for Airport Operators*, namely:

1. Describe the System
2. Identify the Hazards
3. Determine the Risk
4. Assess and Analyze the Risk
5. Treat the Risk (i.e. mitigate, monitor and track)

The execution of these phases was achieved by conducting some facilitated workshops held at XXX. Participants in these workshops are provided in the following section.

Table x. Panel participants.

Name	Position	Organization
Name1	Facilitator	Org1
Name 2	SME	Org1
Name 3	Facilitation Assistant	Org2
Name 4	XXX	Operations
Name 5	XXX	Operations
Name 6	XXX	Engineering
Name 9	FAA	FAA airports
Name 10	FAA	XXX ATC
Name 7	Airline 1	Operations
Name 8	Airline 2	Safety
…	…	…

Workshop Participants

The individuals indicated in the table represented XXX Airport and other airport stakeholders and provided SMEs support with respect to the risk assessment focus areas and SRA facilitation.

During the workshops, members of the facilitation team guided the XXX stakeholders through the SRM process described below and documented the SRA.

Bound the Discussion

This phase began with a documentation review by the facilitation team. This was done such that the facilitation team became familiar with XXX operations as they relate to the risk assessment focus area.

Once on site, the facilitation team asked XXX stakeholders to describe the system associated with the risk assessment focus area in terms of their:

- Physical Characteristics
  - e.g.: the physical layout and/or contents of the system (e.g. dimensions, proximity to roads, taxiways or runways, structures, etc.)
- Functional Characteristics
  - e.g.: what is the system used for and who are the users
- Environment
  - e.g.: under which conditions are the activities within the system taking place (weather, operational environment, behavioral stressors)

These system characteristics allowed the facilitation team and XXX stakeholders to have a common mental picture of the systems associated with the risk assessment focus area.

Based on this information, XXX stakeholders were then able to define the specific activities that take place within the system. These activities are the safety-significant activities.

Identify the Hazards

Once XXX stakeholders had described the system, they were asked "what could go wrong?" while performing each of the functions within the different safety-significant activity. Through the conduct of this exercise, XXX stakeholders considered both the system physical and functional characteristics as well as the environment under which they are performed.

This part of the exercise was guided through the use of anchor elements. The anchor elements used were:

- People
- Equipment
- Materials
- Environment
- Procedures

For each of these elements the attributes specific to the system in question were used as a guide (e.g. type of equipment used, personnel in the area, etc.).

Based on these "what could go wrong?" scenarios, the facilitation team and XXX stakeholders were able to identify the conditions or situations that could create adverse safety risks to the airport (i.e. hazard).

A brainstorming tool developed by the facilitation team was used to facilitate the identification of hazards. This tool is provided below.

Figure X. Brainstorming tool.

Determine the Effect (previously Risk)

For each of the hazards identified for each "what could go wrong?" scenario, XXX stakeholders were encouraged to identify the worst reasonable or credible outcome(s) that can occur within the operational lifetime of the system (i.e. effect) for each hazard.

Hazards and risks were documented by the facilitation team to be assessed for severity and probability to determine risk values.

Assess and Analyze the Risk

For each risk determined in the previous phase, XXX stakeholders defined the severity of the stated risk, and then determined the likelihood or probability that each occurrence will take place.

The assigned values were based on the classification criteria given below, which are based on the FAA National Policy, Order 5200.11—*FAA Airports (ARP) Safety Management System.*

It should be noted that the facilitation team also included qualitative classification criteria for likelihood to assist XXX stakeholders during this phase.

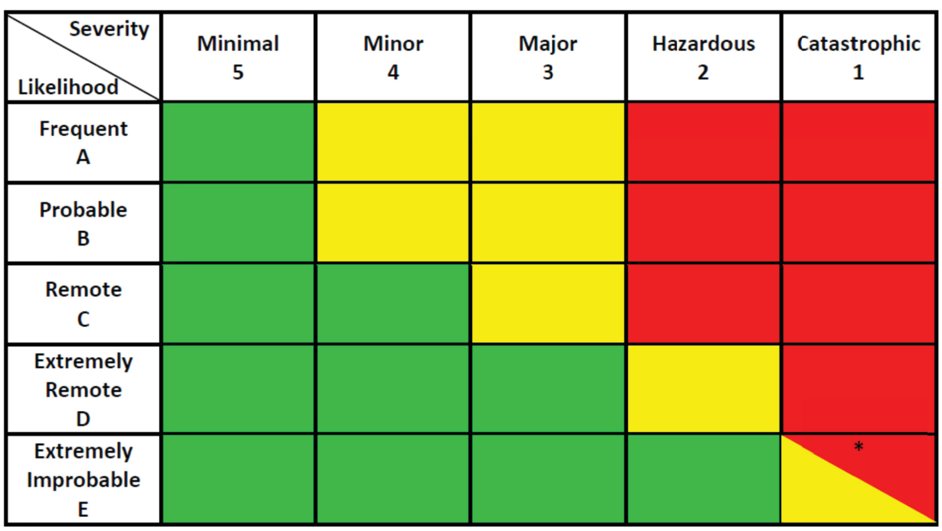
Table X. Probability classification criteria.

	FAA National Policy, Order 5200.11	Qualitative
Frequent A	Expected to occur more than once per week or every 2,500 departures, whichever occurs sooner	Expected to occur frequently for an item
Probable B	Expected to occur about once every month or 250,000 departures, whichever occurs sooner	Expected to occur several times in the life of an item
Remote C	Expected to occur about once every year or 2.5 million departures, whichever occurs sooner	Expected to occur sometime in the life cycle of an item
Extremely Remote D	Expected to occur about once every 10-100 years or 25 million departures, whichever occurs sooner	Unlikely but possible to occur in an item's life cycle
Extremely Improbable E	Expected to occur less than every 100 years	So unlikely, it can be assumed that it will not occur in an item's life cycle

Table X. Severity classification criteria.

Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
• No damage to aircraft but minimal injury or discomfort of little risk to passenger(s) /workers	• Minimal damage to aircraft; or Minimal injury to passengers; or Minimal unplanned airport operations limitations (i.e. taxiway closure); or Minor incident involving the use of airport emergency procedures	• Major damage to aircraft and/or injury to passenger(s)/ worker(s); or Major unplanned disruption to airport operations; or Serious incident; or Deduction on the airport's ability to deal with adverse conditions	• Severe damage to aircraft and/or serious injury to passenger(s)/ worker(s); or Complete unplanned airport closure; or Major unplanned operations limitations (i.e. runway closure); or Major airport damage to equipment and facilities	• Complete loss of aircraft and/or facilities or fatal injury to passenger(s) /worker(s); or Complete unplanned airport closure and destruction of critical facilities; or Airport facilities and equipment destroyed

Following the assignment of likelihood and severity values, each risk was assigned a value based on the risk matrix given in FAA National Policy, Order 5200.11—*FAA Airports (ARP) Safety Management System.*



*Unacceptable with Single Point and/or Common Cause Failures

Figure X. Risk matrix.

Treat the Risk

Upon completion of the assignment of risk values, XXX stakeholders were able to assign mitigation actions based on the following criteria:

- **High Risk (Red)**
  - Unacceptable, mitigating actions required

- **Medium Risk (Yellow)**
  - Medium Risk can be classified in the following three (3) ways:
    - Unacceptable due to the absence of risk control, mitigating actions required;
    - Unacceptable in the presence of existing risk control, mitigating actions required; or
    - Acceptable in the presence of existing risk controls.
- **Low Risk (Green)**
  - Acceptable

Therefore, following these criteria, XXX stakeholders suggested mitigating actions for all high-risk values as well as any medium risk values that were deemed to warrant them.

Following the assignment of mitigating actions, XXX stakeholders derived new values of severity and likelihood for the risk with these mitigating actions in place following the process described in previous sections. These revised risk values were then evaluated for the assignment of mitigating actions following the process described above. If a revised risk value was deemed by XXX stakeholders as requiring further mitigation, actions would be assigned with the risk value being revised once more. XXX stakeholders would repeat this process as long as the risk value was determined to be unacceptable.

In certain cases, XXX stakeholders suggested further actions for risks that were deemed acceptable. These suggestions were documented by the facilitation team and included in the final report for completeness. However, these suggestions were not subject to a further derivation of risk value and should be considered actions to be taken as part of continuous improvement efforts.

Description of the System

Systems Characteristics

The system involved with the analysis of winter weather operations at XXX involves several areas, facilities, equipment and activities that take place within the XXX AOA.

Physical Description

Both XXX aircraft movement and non-movement areas are affected by winter weather operations. It may involve any runway(s), taxiway(s) and ramp(s) where aircraft can be de-iced and where airfield areas require to be cleaned or treated for winter surface contaminants (e.g. snow, ice, slush). The following are the main categories associated with winter weather operations at XXX:

- Airfield operational areas
- Snow removal and deicing equipment staging areas
- Storage of surface treatment material

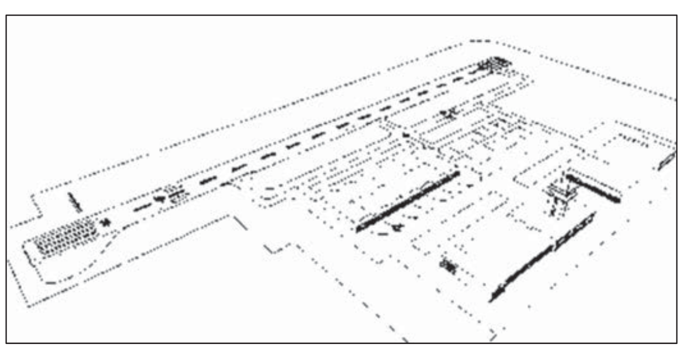


Figure X. XXX AOA and deicing pads.

Functional Description

There are several activities that are associated with winter weather operations at XXX, including the following categories:

- Aircraft inspection and deicing operations
- Snow and ice removal
- Treatment of airfield areas contaminated with ice/snow
- Airfield condition assessment
- . . .

These functions are managed and performed by specific groups of XXX staff and stakeholders, including the following:

- Snow and Ice Control Committee (XXX staff, tenants, and FAA ATC collaboration) convened at the beginning of winter weather season in October then whenever a winter weather emergency is declared for XXX Airport with continuing communications as needed
- XXX Operations Department
  - Airfield Operations
  - SMS Coordinator
  - AOC
- Asset Management
- . . .

Environment

Operational

During winter weather operations several organizations and XXX staff will be performing duties in the AOA specifically related to winter weather operations and will be transiting with various vehicles and equipment.

During special inspections and aircraft deicing operations there will be personnel on foot performing activities in certain areas where aircraft and vehicles may also be present.

Weather

Low temperatures and frozen precipitation are likely conditions during operations with winter weather conditions. The airport area is susceptible to snow and icing conditions, typically from November through March.

<u>Wind</u>

The prevailing winds at XXX are from the south and they average 5 to 10 mph. However, quadrant changes and gusts of 50 mph and above are not uncommon.

<u>Snow</u>

Accumulation with an annual average of 43 inches.

<u>Ice</u>

From October to April it can be expected that temperatures fall below 32°F and ice is encountered.

Behavioral Influences

The following key stressors, which could negatively influence human performance, are possible within the environment of the working area:

<u>Psychological Stressors</u>

Restricted operations under hazardous conditions for aircraft, vehicles and people create an environment prone to many psychological stressors.

Physical Stressors

Very low temperatures, frozen contaminants, deicing fluids and poor visibility will also influence the working environment.

Physiological Stressors

Early shifts, night shifts, weekend shifts, changing working hours, long working hours, very intensive work conditions.

Safety-Significant Activities

Once a description of the system to be assessed was achieved, the hazard identification process was started. As described in the methodology section earlier, the hazards are identified from safety-significant activities, which are derived by the SMEs from the system characteristics above. In this analysis, the SMEs were participants of the workshops held at XXX airport.

The following list is the summary of the key safety-significant activities identified by the SMEs:

Table X. Safety-significant activities.

SAFETY-SIGNIFICANT ACTIVITIES – XXX SRA Winter Weather Ops	
• Mobilization of essential personnel • Aircraft deicing • Airfield anti-icing, deicing or sanding operations • Aircraft towing • Aircraft taxi • Aircraft marshalling • Passenger boarding bridge operation • Passenger handling • …	• Snow and ice removal and control • Management of ASDE-X situational displays • Staff training • Driving on the AOA • Operation of equipment on the AOA • Snow removal • Emergency response • Aircraft incident response • …

Dependencies

During the brainstorming sessions, participants were reminded of the following anchor elements:

Table X. Safety-significant activities—anchor elements.

SAFETY-SIGNIFICANT ACTIVITIES ANCHOR ELEMENTS
PERSONNEL
EQUIPMENT
MATERIALS
ENVIRONMENT
PROCEDURES

Based on these anchor elements, participants were able to generate some system dependencies to consider during the hazard identification process. A sample of some of the dependencies identified can be found in the sections below.

Personnel

Presence of

- XXX staff that is unfamiliar with the Aircraft Movement Area (AMA) and FAA ATC coordination
- Airline personnel operating deicing equipment that has limited experience working in the AOA
- . . .

Types of personnel in the area:

- Airline staff
- XXX Asset Management staff (snow/ice removal)
- XXX ARFF staff
- XXX Airfield Operations staff
- Others

Equipment

Aircraft

- Propeller/Turbine
- Low profile turbine
- Others

Vehicles/Equipment

- Aircraft deicing equipment
- Snow/ice removal and control equipment
- Airfield operations vehicles
- Others

Operational

- Push/tow tractors
- Baggage tractors
- Others

Service vehicles

- Fuel trucks
- Catering trucks
- Maintenance vehicles
- Others

Service Equipment

- Baggage carts
- Cargo dollies
- ULDs
- Others

Other

- Radios
- Telecommunications equipment
- Others

Procedures

- Procedures associated with the safety-significant activities

Materials

- Snow and ice
- Water
- Type I deicing fluid
- Type II deicing fluid
- Type IV deicing fluid
- Sand
- Others

Environment

- Open Area
- Snow
- Ice
- Wind

Results

Hazards, Risks and Risk Values

The following is a summary of the Hazards, Effect (previously Risks), Risk Severities (S) and Probabilities (P) and Risk Values (V) identified during the workshops. Risk Values are given as High (H) in red; Medium (M) in yellow; and Low (L) in green. These risk levels are associated with the risk matrix presented in XXX SMS Manual.

The list is sorted in descending order from the highest to the lowest risk value.

Table X. Hazards, outcome and risk values.

#	Hazard	Outcome (previously Risk)	P	S	R
1.	Inaccurate runway assessment measurements	Takeoff and landing overruns under hazardous conditions leading to runway excursions and aircraft damage/passenger injury	D	1	H
2.	Runway snow removal covering only central portion of runway width	Lateral deviations during landing and takeoff and snow windrows causing asymmetric drag on landing gears and potential lateral runway excursions	C	2	H
3.	…	…	…	…	H
4.	Air crew unfamiliarity with deicing pad layout/operations	Aircraft to aircraft or deicing equipment collision	E	1	M
5.	Miscommunication during emergency call due to equipment failure	Delay in response to an emergency resulting in personnel or passenger fatality	E	1	M
6.	…	…	…	…	M
7.	Non-standardized training program	Shortcomings on the delivery of existing training leading to equipment failure and damage or personnel injury	E	2	L
8.	Improper training for winter operation equipment	Equipment damage/personnel injury	D	3	L
9.	…	…	…	…	L

Mitigating Actions

Once the risk values were determined, a second evaluation took place in light of the mitigating actions associated with the winter weather operations at XXX and other actions XXX will put in place to control the identified risks.

The following table provides a summary of the information derived for each hazard, associated risk and mitigating actions used to reduce the risk value. The information is presented in the following format:

#		
	Hazard	*Identified Hazard*
	Effect	*Possible Effect associated with the Identified Hazard*
	Risk Value	*This section provides the severity, probability and value of the Identified Risk. The field is colored to reflect the color scheme set up in the matrix used for this exercise.*
	Mitigating actions	*This section identifies the Policies, Programs and other measures that XXX already has in place that contribute to the control of the Risk identified.*
	Residual Risk Value	*This section provides the severity, probability and value of the Identified Risk revised in light of the mitigating actions. The field is colored to reflect the color scheme set up in the matrix used for this exercise.*
	Recommended further mitigating actions	*This section provides, when applicable, further actions that could be implemented by XXX to further control the risk and reduced its value.*

Considerations

In some instances, despite the existence of mitigating actions, the risk value presented remains unchanged. This is because the granularity of the matrix suggested by the FAA does not allow for capturing differences within each bracket. For example, if the probability of an identified risk is that it may be expected to occur every 10 years, as per the matrix a probability "D" would be assigned. If mitigating actions implemented are deemed to reduce this probability to occur every 90 years, as per the matrix a value of "D" would remain, even though the probability has been reduced ninefold.

1			
	Hazard	Inaccurate runway assessment measurements	
	Effect	Takeoff and landing overruns under hazardous conditions leading to runway excursions and aircraft damage/passenger injury	
	Risk Value	**1 D - HIGH**	
	Mitigating actions	• XXX training program • PIREPS • Snow & Ice Committee meetings	• Airlines internal training program • Restrict ops after 3 consecutive PIREPs of poor runway friction conditions
	Revised Risk Value	**1 E - MEDIUM**	
	Recommended further mitigating actions		

2			
	Hazard	Runway snow removal covering only central portion of runway width	
	Effect	Lateral deviations during landing and takeoff and snow windrows causing asymmetric drag on landing gears and potential lateral runway excursions	
	Risk Value	**1 D - HIGH**	
	Mitigating actions	• PIREPS • Special inspections	• Airlines internal training program • Snow & Ice Committee meetings
	Revised Risk Value	**1 E - MEDIUM**	
	Recommended further mitigating actions	Increase snow removal capability to reduce probability of partial snow removal	

4	Hazard	Air crew unfamiliarity with deicing pad layout/operations
	Effect	Aircraft to aircraft collision
	Risk Value	1 E - MEDIUM
	Mitigating actions	• XXX Winter Weather Operations Manual • Airlines internal training programs • XXX Non - Movement Area Familiarization Manual
	Revised Risk Value	1 E - MEDIUM
	Recommended further mitigating actions	

5	Hazard	Miscommunication during emergency call due to equipment failure
	Effect	Delay in response to an emergency resulting in personnel or passenger fatality
	Risk Value	1 E - MEDIUM
	Mitigating actions	• Asset management maintenance program • Asset management QA program • Use of backup communication equipment (mobile phones)
	Revised Risk Value	2 E - LOW
	Recommended further mitigating actions	Establish need to use mobile phone for backup

7	Hazard	Non-standardized training program
	Effect	Shortcomings on the delivery of existing training leading to equipment failure and damage or personnel injury
	Risk Value	3 D - LOW
	Mitigating actions	• XXX departmental OJT • Snow & Ice Committee meetings
	Revised Risk Value	3 D - LOW
	Recommended further mitigating actions	Develop standardized training program for winter weather operation conditions

8	Hazard	Improper training for winter operation equipment
	Effect	Equipment damage/personnel injury
	Risk Value	3 D - LOW
	Mitigating actions	• XXX departmental OJT • XXX Winter Weather Operations Manual
	Revised Risk Value	3 D - LOW
	Recommended further mitigating actions	Develop standardized training program (Curriculum, refreshers, etc.)

Conclusions

Main Hazards

The key hazards identified in this analysis as a result of winter weather conditions at XXX can be summarized as follows:

1. Potential runway excursions as result of the following hazards:
   a. Low runway surface friction due to snow/ice accumulated due to partial snow/ice removal or severe weather conditions surpassing XXX capability to remove winter contaminants
   b. Inaccurate reporting of runway surface conditions
   c. Inaccurate assessment of runway conditions
   d. Partial removal of winter contaminants leaving snow banks, drifts or windrows leading to differential drag of landing gear during aircraft operations
2. Loss of situational awareness due to working conditions
   a. Pressure to maintain operational capacity
   b. Exposure to low temperatures, winter precipitation, high noise and possible low visibility and/or night conditions
   c. Need to coordinate with operators of snow/ice control equipment
   d. Fast paced and changing work environment
   e. Non-routine working conditions
   f. Obscured markings and lights making it harder to get oriented in the airfield
   g. Increased communication traffic
   h. High density of personnel, equipment and aircraft in operational areas (e.g. de-ice pads)

3. Limited airport capacity leading to:
   a. Traffic delays and pressure to maintain operational areas open
   b. Pressure to maintain aircraft deicing capacity
4. Non-routine operational conditions
   a. Few winter weather events per year restrict staff from gaining more experience
   b. Limited airport capability to handle very severe and unique winter weather conditions
   c. Limited capability to provide standardized winter weather conditions training to personnel
   d. Pilots unfamiliar with deicing pad layout/operations

Effect Categories

The major effects categories associated with winter weather operations at XXX can be summarized as follows:

1. Runway excursion accidents (overruns and veer-offs) due to poor runway surface friction conditions or asymmetric braking and drag
2. Runway incursion accidents due to loss of situational awareness
3. Aircraft/vehicle/equipment/personnel collisions due to loss of situational awareness under winter weather conditions and limited experience of staff working under such conditions
4. . . .

Mitigation Actions

A series of mitigating actions have been identified to control risks associated with winter weather operations at XXX. The key actions as they refer to the summary risks described above are:

Risk #1: Runway overruns and veer-offs due to poor runway friction conditions resulting from winter weather contaminants and leading to major accidents

Mitigation Actions

- XXX Winter Weather Operations Manual
- Snow & Ice Committee meetings
- XXX Movement Area Familiarization Manual
- XXX Policy - Radio Standards - AO.006.00
- XXX Policy -Runway Crossing by Authorized Ground Vehicles
- …

Risk #2: Runway incursion accidents due to loss of situational awareness

Mitigation Actions

- XXX Winter Weather Operations Manual
- Snow & Ice Committee meetings
- XXX Movement Area Familiarization Manual
- XXX Surface Movement Guidance and Control System Plan
- …

Risk #3: Aircraft/vehicle/equipment/personnel collisions due to loss of situational awareness under winter weather conditions and limited experience of staff working under such conditions

Mitigation Actions

- XXX Winter Weather Operations Manual
- Snow & Ice Committee meetings
- XXX Movement Area Familiarization Manual
- XXX Surface Movement Guidance and Control System Plan
- XXX Policy -Authorized Ground Vehicle Access to AMA safety area
- …

Risk #4: …

- …

Risk Value

As result of applying the identified mitigating actions, and their effect on the risk values, the following conclusions can be drawn:

1. There are no "unacceptable" (HIGH) risks
2. The overall risks associated with XXX winter weather operations can be effectively mitigated using procedural measures developed by XXX and the airlines
3. Additional measures targeting specific risks can further reduce the probability and/or severity of airside accidents during winter weather conditions. These measures are recommended in the ensuing section of this report
4. Figure X summarizes the potential risk levels with and without mitigation actions adopted. Significant improvements to safety associated with winter weather conditions at XXX can be achieved with the actions presented in this SRA.

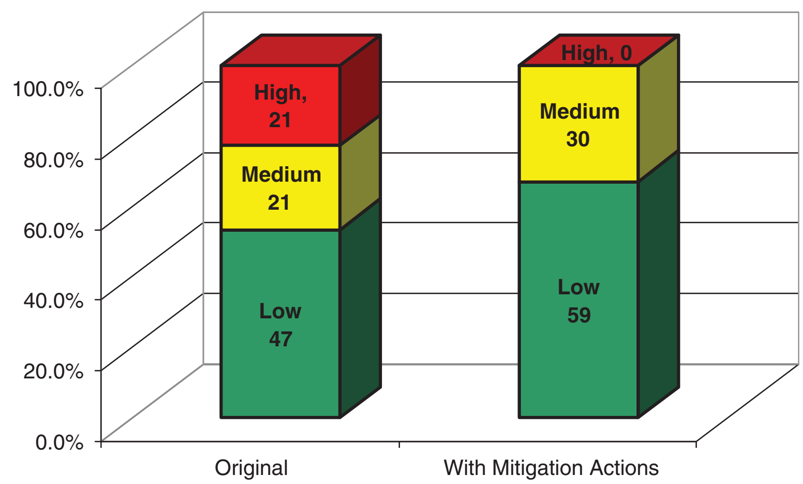


Figure X. Risk reduction.

Recommendations

Further Mitigating Actions

Many risk mitigating actions and procedures listed in previous sections were already implemented by XXX. This section describes additional measures to further reduce risk levels when winter weather conditions arise.

1. Upgrade snow removal equipment to increase XXX capacity
2. Retrofit radios to accommodate headsets plugs
3. Develop standardized training program for winter weather operations and provide refresher training during the fall
4. . . .

Monitoring

It is recommended that XXX ensures that the actions are implemented and monitored for effectiveness over an appropriate period. If monitoring reveals that any action is not effective, new actions should be developed and implemented to maintain the identified risk at an acceptable level.

APPENDIX E

Preliminary Hazard Lists (PHLs)

Airfield Construction

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Airfield Operations		
Haul routes crossing operational areas	Collision with aircraft, vehicles, equipment and ground personnel	Use "flagmen"; Escorts; Traffic control signals; Training; FAA AC for construction safety; Part 139; Construction Safety Phasing Plan (CSPP); SOP
Temporary haul routes crossing rapid exit taxiways	Collision between vehicles and aircraft	Use "flagmen"; Escorts; Traffic control signals; Training; FAA AC for construction safety; Part 139; CSPP; SOW
FOD	Debris causing damage to aircraft	Wheel-wash stations for construction vehicles; training; use of sweepers and FOD crews; CSPP; FAA AC; Part 139
Jet blast	Flying Debris into aircraft, vehicle, or workers	Use "flagmen"; Escorts; Traffic control signals; Training; FAA AC for construction safety; Part 139; Construction Safety Plan (CSPP); SOP
Deficient communication	Runway/taxiway incursion	Training; supervision; Part 139; FAA AC; CSPP; SOP
Deficient coordination between maintenance shifts/workers	Collision with aircraft, vehicles, equipment and ground personnel; runway/taxiway incursion, FOD, obstacles	Training; supervision; SOP; Part 139; CSPP
Construction Safety and Phasing Plan (CSPP)		
Changes to airfield operations	Runway/taxiway incursion, collision, delay responding to emergencies	Training; written distribution of changes and confirmation of receipt; Part 139; FAA AC; SOP; CSPP
Construction worker job related processes, procedures, and tools	Occupational accident	Training; Part 139; FAA AC; SOP; CSPP; OSHA Regulations; supervisory monitor

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Construction traffic crossing airfield areas	Runway/taxiway incursion; Collision; Delay responding to emergencies	Escorts; training; SOP; FAA AC; Part 139; CSPP
Tall equipment	Interference with NAVAIDS or Part 77 surfaces	Training; SOP; internal review process; Part 139; FAA AC; CSPP
Interaction between construction, operations, maintenance, ARFF activities	Runway/taxiway incursion, collision, delay responding to emergencies	SOP; training; daily shift construction safety meetings; Part 139;FAA AC; CSPP
Unfamiliarity of construction workers with airfield activities	Damage to NAVAIDS, runway/taxiway incursions, damage to aircraft	Training; construction manager presence with workers; supervision by airport operations personnel; marked and lighted areas; Part 139; CSPP; FAA AC; SOP
Unfamiliarity of construction drivers with characteristics of airfield traffic	Runway/taxiway incursion, collision	Training; escorts; marked and lighted areas; Part 139; CSPP; FAA AC; SOP
ARFF unaware of changes to access routes	Delay in emergency response	SOP; Part 139; CSPP; FAA AC; Operational briefings
Construction equipment breakdown	Collision, interference with Part 77 surfaces	Training; SOP; internal review process; CSPP; FAA AC; Part 139
Coordination and Communication		
Deficient coordination of construction activities with other airport activities (air traffic, ramp management, security, emergency, etc.)	Runway/taxiway incursion, aircraft collision, obstacles, vehicle accident	SOP; training; daily shift construction safety meetings; notification process; Part 139; CSPP; FAA AC
Pilots unaware of airfield configuration changes, limitations and construction areas	Runway/taxiway incursion, aircraft collision, obstacles, vehicle accident, aircraft, equipment, people, injuries	SOP; NOTAMs; ATIS recordings; notification to chief pilots' offices, FBOs; timely publication change submittals to FAA and Jeppesen chartings; Part 139; FAA AC; Air Traffic Orders
Airport staff and construction workers unaware of hazardous situations	Runway/taxiway incursion, aircraft collision, obstacles, vehicle accident, injuries	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP
Radio failure	Runway/taxiway incursion, aircraft collision, obstacles, vehicle accident, injuries	SOP; training on Air Traffic Control light gun signals; use of cell phones; escorts; CSPP; FAA AC; Part 139
Emergency Response		
Failure to update ARFF of construction areas and temporary access routes and closures	Delay in emergency response	SOP; Part 139; CSPP; FAA AC; daily shift briefings
ARFF unaware of deactivated water lines	Delay in emergency response	SOP; daily shift briefings; FAA AC; CSPP; Part 139
ARFF unaware of emergencies associated with construction activities	Delay in emergency response	SOP; daily shift briefings; FAA AC; CSPP; Part 139

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Security		
Unauthorized access to airfield areas	Runway/taxiway incursion, surface incidents	Continuous inspections of areas as possible; guards at gates/open areas; use of radar or FLIR security and CCTV systems; CSPP; FAA AC; Airport Security Plan; TSA Part 1542
Construction traffic outside defined work area ingress/egress routes	Runway/taxiway incursion, surface incidents	Use of escorts; marked and lighted routes; guards at ingress/ egress points; SOP; CSPP; FAA AC; Part 139
Failure of conspicuous identification of construction workers and equipment	Runway/taxiway incursion, surface incidents	Use of escorts; temporary ID badges and temporary vehicle signage; Part 139; TSA Part 1542; Airport Security Plan; onsite supervisor; CSPP; FAA AC; SOP
Fences and Gates		
Temporary opening in airfield fences or gates due to construction activities	Unauthorized access to AOA, runway/taxiway incursion, surface incident, wildlife strikes	Continuous inspections of areas as possible; guards at open gates/areas; TSA Part 1542; Part 139; CSPP; FAA AC; SOP
Construction equipment outside designated work areas	Runway/taxiway incursion, surface incident	Training; SOP; designated marked and lighted work areas; CSPP; FAA AC; Part 139; escorts/construction managers on site
Haul Routes		
Improper identification of temporary access routes	Runway/taxiway incursion, surface incident	Escorts; training; SOP; CSPP; FAA AC; Part 139
Barricades and fences blocking driver's vision of oncoming traffic	Runway/taxiway incursion, surface incident	Safety inspections by airport and construction management (CM); SOP; training; escorts; Part 139; FAA AC; CSPP
Low-visibility conditions	Runway/taxiway incursion, surface incident	SOP; PART 139; Surface Movement Guidance Control System Plan(SMGCS); FAA AC; training; use of escorts; FAA AC; CSPP; Air Traffic Orders
FOD generated by construction traffic	FOD damage to aircraft, construction equipment, airport equipment	SOP; CSPP; FAA AC; Part 139; FOD patrols; sweepers; wheel-wash stations
Haul routes crossing operational areas	Runway/taxiway incursion, surface incident	Escorts; training; SOP; FAA AC; Part 139; CSPP; FAA AC; Air Traffic Orders; routes marked and lighted
Deficient maintenance of haul routes	FOD damage	SOP; CSPP; FAA AC; Part 139; FOD patrols; sweepers; wheel-wash stations
Vehicles interfering with Part 77 surfaces	Runway/taxiway incursion, surface incident	Training; SOP; internal review process; CSPP; FAA AC; Part 139
Construction workers unaware of ARFF right of way	Emergency response delays	SOP; daily shift briefings; FAA AC; CSPP; Part 139

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Driving		
Vehicle and equipment operators who are unfamiliar with regulations pertaining to vehicle operations on the airfield	Runway/taxiway incursion, collisions	Training; SOP; Part 139; CSPP; escorts; speed limit signs; vehicle speed regulators; supervision monitoring FAA AC
Escorting of construction equipment operators	Runway/taxiway incursion, surface incident	Training; SOP; Part 139; CSPP; speed limit signs; vehicle speed regulators; FAA AC
Driving under low-visibility conditions	Runway/taxiway incursion, surface incident	Training; SOP; Part 139; CSPP; FAA AC; Surface Movement Guidance Control System Plan (SMGCS); escorts
Construction drivers unfamiliar with airfield activities	Runway/taxiway incursion, surface incident	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; escorts; marked and lighted work areas
Operating equipment and or vehicles off of designated construction routes	Runway/taxiway incursion, surface incident, FOD	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; escorts; marked and lighted work areas and routes
Backing dump trucks and other equipment	Occupational accident	Backup walkers/flaggers; FAA AC; CSPP; Part 139
Deficient construction equipment maintenance	Runway/taxiway incursion, FOD	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; escorts; equipment shift inspections
Escorting		
Failure to have "positive control" of escorting procedures	Runway/taxiway incursion, surface incident	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; use of more than one escort; handout of escort route map on airfield and briefing of vehicles being escorted
Low-visibility conditions	Runway/taxiway incursion, surface incident	SOP; PART 139; SMGCS; FAA AC; training; use of escorts; CSPP; Air Traffic Orders
Deficient communication or training of escorting procedures	Runway/taxiway incursion, surface incident	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; use of more than one escort; handout of escort route map on airfield and briefing to vehicle operators being escorted
Earthmoving, Excavation, and Paving		
Excavation close to utilities and cables	Power and system outages, collisions, runway/taxiway incursions and excursions	FAA AC; CSPP; Part 139; excavation plan/ SOP and onsite supervision; daily shift briefings; hand-digging until utilities/cables located
Generation of debris to operational areas	FOD damage	SOP; FAA AC; CSPP; Part 139; training; FOD patrols; sweepers; wheel-wash stations

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Deficient identification of construction areas	Surface accident, aircraft collision	SOP; FAA AC; CSPP; Part 139
Failure to issue timely and accurate NOTAMs	Runway/taxiway incursion, surface incident	SOP’s; FAA AC; CSPP; Part 139; AIM
Low-visibility conditions	Runway/taxiway incursion, surface incident	SOP; PART 139; SMGCS; FAA AC; training; use of escorts; CSPP; Air Traffic Orders
Stockpiling spoils/soil in/near taxilane/taxiway/runway safety/obstacle free areas/zones	Aircraft collision	SOP; PART 139; FAA AC; training; use of escorts; CSPP; Air Traffic Orders; Part 77; FAA AC
Staging equipment in/near taxiway or runway safety areas	Collisions between equipment and aircraft	SOP; PART 139; FAA AC; training; use of escorts; CSPP; Air Traffic Orders; Part 77; FAA AC
Out-of-service obstruction lights	Collisions between equipment and aircraft	Part 139; FAA AC; CSPP; safety inspections
Deficient equipment maintenance	Runway/taxiway incursion, collision, surface incident, FOD	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; escorts; equipment shift inspections; a planned/ preventive maintenance program by the contractor
Dust generated by construction activities	Runway/taxiway incursion, surface incident, FOD	SOP; CSPP; Part 139; contractor dust control plan
Equipment left unattended at night	Collisions	FAA AC; Part 139; Part 77; Air Traffic Orders; CSPP; daily shift construction safety briefings
Deficient construction quality	FOD damage	SOP; training; daily shift construction safety meetings; Part 139; FAA AC; CSPP; Quality control plan
Disruption of weather reporting services	Collision, runway excursion, major system failure, flooding	SOP; training; Part 139; CSPP; FAA AC
Miscommunications	Runway/taxiway incursion, surface incident	Training; supervision; Part 139; FAA AC; CSPP; Air Traffic Orders; SOP
Training		
Construction workers cannot understand English	Runway/taxiway incursion, surface incident	Training; Part 139; FAA AC; CSPP; escorts; onsite supervision
Construction workers in movement area without an understanding of airport rules and regulations for operations in the movement area	Runway/taxiway incursion, surface incident	SOP; PART 139; SMGCS; FAA AC; training; use of escorts; CSPP; Air Traffic Orders

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Construction workers in movement areas	Runway/taxiway incursion, surface incident	SOP; PART 139; SMGCS; FAA AC;training; use of escorts; CSPP; Air Traffic Orders
Deficient communication between contractor and airport operations	Runway/taxiway incursion, surface incident	SOP; FAA AC; CSPP; Part 139; training
Deficient driver and escort training	Runway/taxiway incursion, surface incident	SOP; written and OJT testing; FAAAC; Part 139; CSPP
Lighting, Marking, Signage		
Deficient marking, signaling and lighting of construction areas	Collision, surface incident, runway/taxiway incursion	Part 139; CSPP; FAA AC; SOP; training
Out-of-service obstruction lights	Collision	Part 139; CSPP; FAA AC; SOP; training
Incorrect use/installation of temporary marking and lighting	Collision, surface incident, runway/taxiway incursion	Part 139; CSPP; FAA AC; SOP; training
Power outage	Runway/taxiway incursion, surface incident, collision	Part 139; CSPP; FAA AC; SOP; training
Off-Peak Construction		
Failure to build temporary ramps when resurfacing runways	Blown tires, broken landing gear	Part 139; CSPP; FAA AC; SOP; training
Deficient procedures to open closed areas to operations	Runway/taxiway incursion, collision	Part 139; CSPP; FAA AC; SOP; training; supervision and monitoring
Temporary ramps not complying with FAA recommendations	Blown tires, broken landing gear	Part 139; CSPP; FAA AC; SOP; training
Aircraft operations in opposite direction of paving operations	Blown tires, broken landing gear	Part 139; CSPP; FAA AC; SOP; training; Air Traffic Orders
Stockpiling		
Height and location of stockpiles close to safety areas	Collision	Part 129; Part 77; CSPP; FAA AC; SOP; training
Generation of FOD	FOD damage	SOP; CSPP; FAA AC; Part 139; FOD patrols; sweepers; wheel-wash stations
Work in Safety Areas, Object Free Areas (OFA), Object Free Zone (OFZ)		
Height of equipment	Collision	Part 139; Part 77; CSPP; Air Traffic Orders; FAA AC; SOP; training
Equipment breakdown	Collision	Part 139; CSPP; FAA AC

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Deficient coordination with ATO	Runway/taxiway incursion, surface incident	Part 139; CSPP; SOP; FAA AC; Air Traffic Orders; training
FOD	FOD damage	SOP; CSPP; FAA AC; Part 139; FOD patrols; sweepers; wheel-wash stations
Loose maintenance tools and parts	FOD damage	SOP; CSPP; FAA AC; Part 139; FOD patrols; escorts following vehicles
NAVAIDS		
Construction workers unaware of NAVAIDS restrictions	Aircraft accident, NAVAID damage	SOP; CSPP; Part 139; Part 77; Air Traffic Orders; training; onsite supervision; FAA AC
Proximity of construction vehicles to NAVAIDS	Aircraft accident, NAVAID damage	SOP; CSPP; Part 139; Part 77; Air Traffic Orders; training; onsite supervision; FAA AC
Changes to airside aircraft traffic patterns due to construction	Runway/taxiway incursion, surface incident, collision	SOP, NOTAMs; Part 139; Air Traffic Orders; FAA AC; CSPP
Trash from Construction		
Trash as wildlife attractants	Wildlife strikes	SOP, NOTAMs; Part 139; FAA AC; CSPP; FOD/ trash patrols
Generation of FOD	FOD damage	SOP; CSPP; Part 139; FAA AC; FOD patrols
Wildlife Movement		
Installation of temporary gates	Wildlife strikes	Guards; Part 139; Wildlife Hazard Management Plan (WHMP); CSPP; FAA AC; TSA Part 1542; SOP
Temporary removal of fences	Wildlife strikes	Guards; Part 139; WHMP; CSPP; FAAAC; TSA Part 1542; SOP
Drainage		
Construction debris obstructing drainage systems	FOD damage	Part 139; CSPP; FAA AC; SOP
Excavation close to utilities and other systems	Circuit light outages on AOA	FAA AC; CSPP; Part 139; excavation plan and onsite supervision; daily shift briefings; hand-digging until utility/cables located; SOP
Flooding or ponding in movement areas	FOD damage, closed areas resulting in delay in operations	CSPP; Part 139; FAA AC; SOP; sweepers on call

Wildlife Hazards

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Birds		
Landfill close to the airport	Birdstrikes	Local ordinances; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP
Wastewater treatment facilities near the airport	Birdstrikes	Local ordinances; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP
Wetlands, grasslands, wooded areas at or near the airport	Wildlife strikes	Local ordinances; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC
Dredge spoil containment areas near the airport	Birdstrikes	Local ordinances; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC
Development of favorable habitat conditions for certain species	Wildlife strikes	Local ordinances; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC
Agricultural activities on and off airport	Wildlife strikes	Local ordinances; leases; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC; training; crop control and clean up after harvest
Urban areas at or near the airport	Wildlife strikes	Local ordinances; leases; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC
Construction and demolition (C&D) debris facilities at or near the airport	Wildlife strikes	Local ordinances; leases; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC
Uncovered garbage cans and dumpsters	Wildlife strikes	Local ordinances / Airport Rules & Regulations; leases; Wildlife Hazard Management Plan (WHMP); local Letter of Agreement; FAA AC; Part 139; SOP; FAA AC; training
Construction workers leaving food in open areas	Wildlife strikes	CSPP; FAA AC; Part 139; FOD patrols; training; daily shift briefings; SOP
High grass	Wildlife strikes	SOP's; Part 139; Wildlife Hazard Management Plan (WHMP); FAA AC; SOP
Low grass	Wildlife strikes	SOP; Part 139; Wildlife Hazard Management Plan (WHMP); FAA AC
Grass type attracts certain species of wildlife	Wildlife strikes	SOP; Part 139; Wildlife Hazard Management Plan (WHMP); airport design standards; FAA AC
Type of vegetation attracts certain species of wildlife	Wildlife strikes	SOP; Part 139; Wildlife Hazard Management Plan (WHMP); airport design standards; FAA AC
Earthworm presence in airfield areas	Birdstrikes	SOP; Part 139; Wildlife Hazard Management Plan (WHMP); FAA AC
Nesting on or near the airport, areas that allow for ease of roosting animals	Wildlife strikes	SOP; Part 139; local ordinances; Federal laws and regulations; FAA AC
Delay removing dead animals	Wildlife strikes, disease	Local Letter of Agreement with USDA/ SPCA animal control; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Migratory season for certain species	Birdstrikes	SOP; Part 139; local ordinances; Federal laws and regulations; FAA AC; training; Wildlife Hazard Management Plan (WHMP); NOTAMs; ATIS
Feeding of wildlife	Wildlife strikes	SOP; Part 139; local ordinances; FAA AC; training; Wildlife Hazard Management Plan (WHMP)
Flocks of birds frequently seen in airfield areas	Birdstrikes	SOP; Part 139; local ordinances; FAA AC; training; Wildlife Hazard Management Plan (WHMP); NOTAMs; ATIS
Large species (raptor birds, deer, wild boars, etc.) frequently seen in airfield areas	Wildlife strikes	SOP; Part 139; local ordinances; FAA AC; training; Wildlife Hazard Management Plan (WHMP)
Approaching season of high frequency for certain bird species	Birdstrikes	SOP; Part 139; local ordinances; FAA AC; training; Wildlife Hazard Management Plan (WHMP); NOTAMs
Presence of rodents (food) attracting birds of prey	Birdstrikes	SOP; Part 139; local ordinances; FAA AC; training; Wildlife Hazard Management Plan (WHMP); grass height; vegetation control
Golf courses near the airport	Birdstrikes	Local Letter of Agreement; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP
Livestock production operations near the airport	Birdstrikes	Local Letter of Agreement; local ordinance; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP; NOTAMs
Open aquaculture operations	Wildlife strikes	Local Letter of Agreement; local ordinance; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP; NOTAMs
High frequency of most hazardous birds to aircraft: vultures, geese, cormorants/pelicans, cranes, eagles, ducks, osprey, turkey/pheasants, herons, hawks, gulls, rock pigeons and owls	Birdstrikes	SOP's; Part 139; FAA AC; Wildlife Hazard Management Plan (WHMP); training; depredation; SOP; NOTAMs
Other Wildlife		
Low fences	Wildlife strikes	Airport design standards; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP
Type of fence does not restrain wildlife from entering airfield	Wildlife strikes	Airport design standards; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP
Topography and vegetation allow wildlife to enter airfield areas	Wildlife strikes	Airport design standards; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP
Culverts without grids	Wildlife strikes	Airport design standards; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP
Presence of most hazardous mammals to aircraft: deer, coyote	Wildlife strikes	Airport design standards; training; Wildlife Hazard Management Plan (WHMP); Part 139; FAA AC; SOP; catch and relocate release program; depredation

Foreign Object Debris

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Pavements and Safety Areas		
Surface cracking with generation of lose fragments, chips	FOD damage	SOP; FAA AC; Pavement Management Program (PMS); Part 139; training; sweepers; FOD patrols
Raveling of pavement surface with generation of lose aggregates	FOD damage	SOP; FAA AC; Pavement Management Program (PMS); Part 139; training; sweepers; FOD patrols
Loose dirt blown by aircraft engines	FOD damage, injuries	SOP; FAA AC; Part 139; training; sweepers; FOD patrols; special inspections
Loose material from freshly mowed areas	FOD damage	SOP; FAA AC; Part 139; training; sweepers; FOD patrols; escorts; special inspections
Proximity of helipads to unpaved areas	FOD damage	SOP; FAA AC; Part 139; training; sweepers; FOD patrols
FOD generated by construction activities	FOD damage	SOP; FAA AC; CSSP; Part 139; training; sweepers; FOD patrols
Weathering during freeze-thaw cycles	FOD damage	SOP; FAA AC; Pavement Management Program (PMS); Part 139; training; sweepers; FOD patrols
Loose rubber joint materials	FOD damage	SOP; FAA AC; Pavement Management Program (PMS); Part 139; training; sweepers; FOD patrols
Maintenance		
Tools and parts left after maintenance operations	FOD damage	SOP; FAA AC; FOD patrols; training; special inspections
Open garbage cans or dumpsters	FOD, wildlife strikes	SOP; FAA AC; FOD patrols; training; Wildlife Hazard Management Plan (WHMP)
Personnel		
Trash in open areas	FOD, wildlife strikes	SOP; FAA AC; FOD patrols; training; Wildlife Hazard Management Plan (WHMP); Part 139
Trays, bags and trash from catering services	FOD, wildlife strikes	SOP; FAA AC; FOD patrols; training; Wildlife Hazard Management Plan (WHMP); Part 139
Loose flight line items (wheel chalks, badges, pens, tags, etc.)	FOD damage	SOP; FAA AC; FOD patrols; training; Part 139
Other		
Loose branches and vegetation	FOD damage	SOP; FAA AC; FOD patrols; training; Part 139
Rain water and drainage streaming mud, pebbles and other debris	FOD damage	SOP; FAA AC; FOD patrols; training; Part 139
Pieces of aircraft tires or parts	FOD damage	SOP; FAA AC; FOD patrols; training; Part 139; NOTAM's
Winter contaminants (snow, ice)	FOD, runway excursion, surface accident	SOP; FAA AC; FOD patrols; training; Part 139; Environmental regulations; Snow Plan for aircraft deicing; NOTAMs

Airfield Configuration

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Hotspots		
Complex airfield configuration and intersections	Runway/taxiway incursion	Hotspots map; Letter of Agreement with Air Traffic; MOS special lighting; signage, markings; Runway Safety Action Team (RSAT) team recommendations; Air Traffic Orders; NOTAMs; training; SOP; FAAAC; ATIS; Part 139
Nearness of taxiway intersections to runway thresholds	Runway/taxiway incursion	Hotspots map; Letter of Agreement with Air Traffic; MOS special lighting; signage, markings; Runway Safety Action Team (RSAT) team recommendations; Air Traffic Orders; NOTAMs; training; SOP; FAAAC Part 139
Joint use of runway as taxiway	Runway/taxiway incursion, surface accident	Hotspots map; Letter of Agreement with Air Traffic; special lighting; signage, markings; Runway Safety Action Team (RSAT) team; Air Traffic Orders; NOTAMs; FAA and Jeppesen charting; training
Environment		
Deficient weather conditions	Runway/taxiway incursion, surface accident	SOP; FAA AC; Air Traffic Orders; training; escorts; Part 139; halting all AOA construction; Letter of Agreement
Low visibility	Runway/taxiway incursion, surface accident	Surface Movement Guidance Control Plan (SMGCS); SOP; FAA AC; Air Traffic Orders; training; escorts; Part 139; halting all AOA construction; Letter of Agreement
Nighttime conditions	Runway/taxiway incursion, surface accident	SOP; FAA AC; Part 139; Letter of Agreement; training
Other		
Construction and temporary markings, signs and lighting	Runway/taxiway incursion, surface accident, collision	CSSP; Part 139; ATIS; NOTAM's; training; Air Traffic Orders; Letter of Agreement; FAA AC; SOP
Deficient airfield driver training	Runway/taxiway incursion, surface accident, collision	Part 139 recurrent driver training; Airport/City policies on punishment; FAA AC; SOP
Deficient taxi route planning	Runway/taxiway incursion	Part 139; Air Traffic Orders; Letter of Agreement; ATIS; NOTAMs; "standard taxi routes" chart publishing; signage, lighting, marking; FAA AC; SOP
Temporary closures, construction, and changes in status of NAVAIDS	Runway/taxiway incursion, surface accident, collision	Part 139; Air Traffic Orders; Letter of Agreement; ATIS; NOTAMs; "standard taxi routes" chart publishing; signage, lighting, marking; CSPP; training; maps provided to airport departments, construction crews and airlines, FBOs and pilots; FAA AC; SOP

Winter Operations

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Airfield Operations		
Snow removal ops in airfield areas	Runway/taxiway incursion, runway excursion, surface accident	Part 139; Air Traffic Orders; Letter of Agreement; ATIS; NOTAMs; training; FAA AC; SOP; escorts; Snow Plan
Adverse weather elements and extended shifts	Runway/taxiway incursion, surface accident	Part 139; Air Traffic Orders; Letter of Agreement; ATIS; NOTAMs; training; FAA AC; SOP; escorts
Slippery pavement conditions	Runway excursion, surface accident	Part 139; Air Traffic Orders; Letter of Agreement; ATIS; NOTAM's; training; FAA AC; SOP; escorts; treat or close areas
Radio failure	Runway/taxiway incursion, surface accident	SOP; training on Air Traffic Control light gun signals; use of cell phones; escorts; FAA AC; Part 139
Deficient coordination between maintenance shifts and/or airport operations and/or FAA ATC	Runway/taxiway incursion, runway excursion, surface accident	Training; supervision; record of shift briefings; SOP; Part 139
Shortage of personnel due to inability to report to work	Runway/taxiway incursion, runway excursion, surface accident	SOP; training; Snow Plan; IROPS Plan; cross training of personnel
Deficient coordination during snow removal ops	Runway/taxiway incursion, runway excursion, surface accident	SOP; FAA AC; training; Snow Plan; shift safety briefings; supervision on site
Snow / Ice Plan		
Deficient planning to mitigate impact to airport operations	Runway excursions, runway/taxiway incursions	SOP; Snow Plan; IROPS Plan; training; FAA AC
Deficient coordination between tenants, airlines and airport departments	Runway/taxiway incursion, runway excursion, surface accident	SOP; Snow Plan; IROPS Plan; training; FAA AC; scheduled conference call briefings
Deficient Irregular Operations Plan (IROPS)	Runway/taxiway incursion, runway excursion, surface accident	FAA AC; Snow Plan; SOP; training
Airfield condition reports that are not accurate	Runway excursion, surface accident	FAA AC; Snow Plan; Air Traffic SOP and Orders; ATIS; NOTAMs; notification to airlines/FBOs
Missing contact info for key operational and emergency recall personnel	Delay emergency response	Activate emergency recall through Airport Emergency Plan list; SOP; news media announcements
Deficient training of airport maintenance workers on airfield winter operations	Runway excursion, surface accident	SOP; Snow Plan; IROPS Plan; escorts
Deficient training of contractor personnel to support snow operations	Runway excursion, surface accident	SOP; Snow Plan; conduct emergency training; onsite supervision
Deficient coordination to notify ARFF/EMS/Police when access routes have changed	Delay emergency response	SOP; notification recording; FAA AC; temporary signage
Deficient coordination to prioritize clearing of runways and taxiways	Runway excursion, surface accident	Snow Committee and Air Traffic notification; SOP; FAA AC

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Coordination and Communication		
Deficient coordination to notify ARFF/EMS/Police when access routes have changed	Delay emergency response	SOP; notification recording; signage; FAA AC
Deficient coordination to prioritize clearing of runways and taxiways	Runway excursion, surface accident	Snow Committee and Air Traffic notification; SOP; FAA AC
NOTAMs not submitted in a timely and coordinated manner	Runway excursion, surface accident	Snow Committee and Air Traffic notification; SOP; FAA AC; ATIS
Deficient communication to pilots on airfield condition reports, closed areas and limitations to operations	Runway excursion, surface accident, collision	Snow Committee and Air Traffic notification; SOP; FAA AC; ATIS; NOTAMs; scheduled conference call briefings
Failure to monitor deice fluid capture tank levels	Impact on environment	Monitoring system with alarms for pre-critical, critical areas; physical monitoring of tank/system levels; water/deice fluid water shed volumes reporting; Storm Water Pollution Prevention Plan (SWPPP)
Insufficient coordination of AOA/AMA inspections with airline representatives (Chief Pilots)	Runway excursion, surface accident	Snow Committee; SOP; training; scheduled conference call briefings
Emergency Response		
Changes to status of access roads/AOA routes	Delay of emergency response, surface accident	Scheduled conference call briefings; SOP
AOA Security		
Unauthorized access to airfield areas	Runway/taxiway incursion, surface accident, wildlife strike	Security radar, FLIR systems; airfield CCTV; SOP; FAA AC; TSA Part 1542
Open fence or gates due to weather damage	Runway/taxiway incursion, surface accident, wildlife strike	SOP; post guards; use temporary fence/ gates to secure
Fencing and Gates		
Open AOA gate	Runway/taxiway incursion, surface accident, wildlife strike	SOP; training; post guards
Open construction gate or fence area	Runway/taxiway incursion, surface accident, wildlife strike	SOP; training; post guards
Absence of security guards due to weather	Runway/taxiway incursion, surface accident, wildlife strike	Secure/close open area to no access
Environmental Issues		
Stockpiling location of contaminated snow/ice	Environmental impact	Identify predetermined stock pile locations and mark; training; SOP; FAA AC
Improper deicing fluid runoff	Environmental impact	Monitoring and reporting of deice operations; shutdown deice operations until corrected; training; sweep /contain deice fluid runoff and collect

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Low visibility	Environmental impact	Monitoring and reporting of deice operations; shutdown deice operations until weather improves; training
Deficient trained contract personnel	Environmental impact, occupational accident, collision, surface accident	Monitoring and reporting of deice operations; shutdown deice operations until deice operations properly conducted; onsite supervision; training; SOP
Deicer fluids and other contaminants outside of containment system	Environmental impact	Sand contaminated areas, boom fluids and collect later; monitor and assess if contaminants will have regulatory impact; SOP
Radio failure in deice vehicles	Runway/taxiway incursion, surface accident	SOP; training; Part 139; cell phone use; backup radios/onsite supervision with radio
Breakdown of deice vehicles	Collision, surface accident	SOP; close area; mark/light area of vehicle
Driving and Escorting		
Operating equipment outside of accepted regulations	Collision, surface accident	Training; SOP; Part 139; escorts; speed limit signs; vehicle speed regulators; supervisory monitoring; FAA AC
Improper escort training for drivers	Runway/taxiway incursion, surface accident	Part 139; FAA AC; SOP; use of other qualified personnel
Impaired road signage on ramps due to snow/ice/low visibility	Runway/taxiway incursion, surface accident, collision	Part 139; FAA AC; SOP; monitor and correct issue
Towing of Aircraft		
Slippery surfaces	Surface accident, collision	Part 139; FAA AC; SOP; training; pre-check tow route and sand/treat
Training		
Deficient training of personnel involved with deicing	Environmental impact, collision, surface accident	SOP; FAA AC; Part 139; use of other qualified personnel
Snow clearing crews and equipment in movement areas	Surface accident, collision	Escorts; close runway and taxiways to be cleared; NOTAMs; conference call briefing; ATIS; training; SOP; FAA AC
Deficient communication between snow clearing crews and airport/airfield operations crews	Surface accident, collision	Training; SOP; FAA AC; onsite supervision and monitoring
Deficient SMGCS training	Surface accident, collision	Training; SMGCS Plan review; SOP; FAA AC; use escorts
Lighting, Marking, Signage		
Deficient conspicuity of markings, lights and signs	Surface accident, collision	Part 139; FAA AC; SOP
Out-of-service obstruction lights	Surface accident, collision	Part 139; FAA AC; SOP
Equipment and Stockpiling		
Large equipment parked on/near safety areas	Collision	Part 139; FAA AC; SOP; Part 77; training
Large stockpiles of snow on/near safety areas	Collision	Part 139; FAA AC; SOP; Part 77; training; Snow Plan
Snow accumulated in proximity of NAVAIDS	Aircraft accident, loss of operational capabilities	Part 139; FAA AC; SOP; Part 77; training
Ruts or wash-outs and ponding of water	Runway excursions	Part 139; FAA AC; SOP

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
NAVAIDS		
Snow clearing crews unaware of NAVAIDS location	Aircraft accident, loss of operational capabilities	Part 139; FAA AC; SOP; Snow Plan; training; onsite supervision
Snow clearing vehicles near NAVAIDS	Aircraft accident, loss of operational capabilities	Part 139; FAA AC; SOP; Snow Plan; training; onsite supervision
Changes to traffic routes causing aircraft to interfere with NAVAIDS	Aircraft accident, loss of operational capabilities	Part 139; Air Traffic Orders; Letter of Agreement; SOP; Snow Plan; training
FOD		
Ice/snow debris from aircraft and vehicle routes	FOD damage	Part 139; FAA AC; SOP; Snow Plan; training
FOD sweepers inoperative	FOD damage	Part 139; FAA AC; SOP; training
Drainage		
Ponding and slippery surfaces due to melting/freezing snow/ice	Runway/taxiway excursions, collision	Part 139; FAA AC; SOP; Snow Plan; training

Severe Weather

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Airfield Operations		
Strong winds, flooding, or hail impacting aircraft, airline equipment stored on ramps	Aircraft damage, equipment damage	Part 139; Severe Weather Plan; SOP; FAA AC; Emergency Plan; training
Deficient lightning and flood notifications to outside workers, tenants, airlines	Damage to equipment, aircraft, worker injuries or death	Part 139; Severe Weather Plan; SOP; FAA AC; Emergency Plan
Changes to operation conditions	Aircraft or vehicle accidents	Part 139; Severe Weather Plan; SOP; FAA AC; Emergency Plan; conference call briefings
Coordination and Communication		
Deficient coordination between airport activities (e.g., air traffic, ramp management, security, emergency)	Delay of emergency response, surface accident, runway/taxiway incursion	Part 139; Severe Weather Plan; SOP; FAA AC; Airport Emergency Plan; IROPS Plan; FAA AC; training; shift or special conference calls
Airport staff and construction workers unaware of hazardous situations	Delay of emergency response, surface accident	Part 139; Severe Weather Plan; SOP; Weather radios; CSPP; FAA AC; Emergency Plan; training; shift or special conference calls

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Emergency Response		
Changes to emergency routes	Surface accident	Part 139; Severe Weather Plan; SOP; FAA AC; Emergency Plan; training; shift or special conference calls
Impact of weather on water lines	Reduction of ARFF capacity	Part 139; Severe Weather Plan; SOP; FAA AC; Emergency Plan; training; conference call
Security		
Damaged gates and broken fences	Runway/taxiway incursion, surface accident, wildlife strikes	Part 139; Severe Weather Plan; SOP; FAA AC; Security Plan; TAS Part 1542; provide guards at open areas

Airside Driving

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Airfield Driving		
Extended shifts, distractions, weather conditions, etc., impacting situational awareness	Runway/taxiway incursion, surface accident	Part 139; FAA AC; SOP; proper rest periods; onsite supervision; cross–train personnel; training
Vehicle improperly marked, lighted, equipped and not inspected prior to operation	Runway/taxiway incursion, surface accident	Part 139; FAA AC; SOP; shift safety briefings; training; supervisory monitoring
Jet blast/prop wash on vehicles	Damage to vehicle, injury to personnel	Part 139; FAA AC; SOP; shift safety briefings; training
Changes to procedures affecting airfield service routes	Runway/taxiway incursion, surface accident	Part 139; FAA AC; SOP; shift safety briefings; training; shift conference calls
Deficient equipment/vehicle maintenance	Surface accident, FOD	Part 139; FAA AC; SOP; shift safety briefings; training; vehicle inspections
Shared service/emergency/haul routes and crossings	Surface accident	Part 139; FAA AC; SOP; shift safety briefings; training; escorts
Vehicle operators unaware of regulations regarding vehicle operations on the airfield	Runway/taxiway incursion, collision	Training; SOP; Part 139; escorts; speed limit signs; vehicle speed regulators; physical monitoring; FAA AC
Nighttime driving conditions	Runway/taxiway incursion, surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings
Coordination and Communication		
Deficient coordination with other airport activities (e.g., air traffic, ramp management, security, emergency)	Runway/taxiway incursion, surface accident, damage to aircraft	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls; IROPS Plan

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Changes to operations conditions and service routes	Runway/taxiway incursion, surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls
Use of improper aviation phraseology	Runway/taxiway incursion, surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; supervision monitoring
Loss of communication with ATC	Runway/taxiway incursion, surface accident	Training; Part 139; FAA AC; SOP; training in use of alternative communication methods
Emergency Response		
Shared service/emergency routes and crossings	Surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls
Security		
Unauthorized vehicle access to airfield areas	Runway/taxiway incursion, surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls; Airport Security Plan; TSA Part 1542
Weather		
Adverse weather conditions (heavy rain, snow, moderate ice)	Runway/taxiway incursion, excursion or surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls; GPS (with alarm capability for infringement of safety area, etc. surfaces) tracking vehicles operating on airfield
Low-visibility conditions	Runway/taxiway incursion or surface accident	Training; Part 139; FAA AC; SOP; shift safety briefings; shift conference calls; GPS (with alarm capability for infringement of safety area, etc. surfaces) tracking vehicles operating on airfield; SMGCS Plan
Escorting		
Speeding during escorting operations	Collision	Training; SOP; Part 139; speed limit signs; vehicle speed regulators; physical monitoring; FAA AC; CSPP
Deficient escort training	Runway/taxiway incursion or surface accident	Recurrent training; SOP; Part 139; supervision; FAA AC; driving simulators; OJT
Unfamiliarity with airfield plan and service routes	Runway/taxiway incursion or surface accident	Training; SOP; Part 139; speed limit signs; vehicle speed regulators; FAA AC; airfield maps with escort route provided to vehicles being escorted; use of 2 or more escorts
Deficient communication with Ops and ATC	Runway/taxiway incursion or surface accident	Training; SOP; Part 139; FAA AC; Letter of Agreement; conference call

Hazard	Outcome	Common Mitigations or Source Material for Mitigations
Safety Areas/Obstacle Free Zones/NAVAIDS		
Interference with NAVAIDS	Aircraft accident, loss of operational capabilities, delay in operations	Training; SOP; Part 139; FAA AC; escort briefing prior to start of escort; map of escort route provided to vehicle operators being escorted
Vehicle breakdown in aircraft operations or safety areas	Collision, loss of operational capabilities, delay in operations	SOP; FAA AC; training; notify supervision for action and close area to aircraft and emergency operations
Changes to traffic routes causing interference with NAVAIDS	Runway/taxiway incursion or surface accident	Training; SOP; Part 139; FAA AC; escort briefing prior to start of escort; map of escort route provided to vehicle operators being escorted
FOD		
Transition from unpaved areas to operational areas, carrying FOD	FOD damage	Training; SOP; Part 139; FAA AC; escort briefing prior to start of escort; map of escort route provided to vehicle operators being escorted; inspection of escorted vehicles prior to entering AOA operational areas; sweeper on call

APPENDIX F

Typical Accident and Incident Rates

Risk Category	Subcategory	Rate	Source	Data Period
Runway/Taxi way Incursion	Towered airports	2.5 runway/taxiway incursions per day in the U.S.	GAO, 2008	Partial data from 2008
	Towered airports	1 incursion per 167,000 operations	GAO, 2008	1998 to 2007
	Towered airports	1 collision per 37,500,000 operations	FAA, 2004	2000 to 2003
	Towered airports	1 fatality per 65,500,000 operations	FAA, 2004	2001 to 2003
Runway Excursion	Overrun - landing	1 overrun in 1,050,000 landings	ACRP Report 50, 2010	
	Overrun - takeoff	1 overrun in 4,120,000 takeoffs	ACRP Report 50, 2010	1982-2009
	Undershoot	1 undershoot in 4,160,000 landings	ACRP Report 50, 2010	1982-2009
	Veer-off - landing	1 veer-off in 840,000 landings	ACRP Report 51, 2010	1982-2009
	Veer-off - takeoff	1 veer-off in 3,860,000 takeoffs	ACRP Report 51, 2010	1982-2009
Fuel Spills	Hydrant airport - high pressure	1 spill per 6,700 operations	WS ATKINS, 2000	1994-1998
	Hydrant airport - low pressure	1 spill per 1,100 operations	WS ATKINS, 2000	1994-1999
	Refueler airport - low pressure	1 spill per 1,460 operations	WS ATKINS, 2000	1994-1999
	Ignition probability	1 ignition per 10,000 spills	WS ATKINS, 2000	1994-1999
	Risk of passenger fatality - hydrant airport	1 fatality per 8,130,000,000 movements	WS ATKINS, 2000	1994-1999
	Risk of passenger fatality - refueler airport	1 passenger fatality per 379,000,000,000 movements	WS ATKINS, 2000	1994-1999
Ground Handling	Incidents with aircraft damage	1 incident per 5,000 movements	NLR, 2008	NA
	Damage rate in North America	1 damage per 10,000 movements	ACRP Report 62	2006-2007
	Damage rate in Europe	1 damage per 3,000 movements	ACRP Report 62	2006-2007

Risk Category	Subcategory	Rate	Source	Data Period
Birdstrikes	Birdstrikes with damage to commercial aircraft	1 birdstrike with damage to commercial aircraft per 75,200 movements	FAA, 2012	1990 to 2011
	Birdstrikes with damage to GA aircraft	1 birdstrike with damage to GA aircraft per 417,000 movements	FAA, 2012	1991 to 2011
	Birdstrikes commercial aircraft	1 birdstrike to commercial aircraft per 7,300 movements	FAA, 2012	1992 to 2011
	Birdstrikes GA aircraft	1 birdstrike to GA aircraft in 132,000 movements	FAA, 2012	1993 to 2011
Foreign Object Damage	Annual cost to aerospace industry	USD 4 billion	Boeing, 1998	
	Annual direct cost to global aviation industry	USD 1.26 billion	ACRP Synthesis 26, 2011	
	Annual direct cost to US aviation industry	USD 474 million	ACRP Synthesis 26, 2011	
	Annual total cost to global aviation industry	USD 13.9 billion	ACRP Synthesis 26, 2012	
	Annual total cost to aviation industry	USD 5.2 billion	ACRP Synthesis 26, 2013	
	Total no. of engine FOD events	1 event per 3,200 aircraft movements	McCreary, 2008	
	Tech test/inspection	1 test/inspection per 6,700 movements	McCreary, 2008	
	Blade pairs replaced	1 blade pair replaced per 5,900 movements	McCreary, 2008	
	Tire FOD events	1 tire FOD event per 1,030 movements	McCreary, 2008	
	Tires replaced due to FOD	1 tire replaced per 2,940 movements	McCreary, 2008	
	Aircraft fuselage damage	1 aircraft fuselage damage per 3,850 movements	McCreary, 2008	

APPENDIX G

Typical KPIs and Associated Data

G-1 Introduction

KPIs are quantifiable measures that a company or industry uses to gauge or compare performance in terms of meeting strategic and operational goals. KPIs vary among companies and industries, depending on priorities and performance criteria. KPIs are also referred to as "key success indicators (KSIs)." When measuring safety performance, some organizations use safety performance indicators (SPIs). Regardless of the term used, an airport must be able to assess safety performance. The indicators need to be measurable and in line with an organization's goals and objectives. Indicators can change and should be updated as progress is made. In this appendix, the term KPI is used.

For airports, KPIs represent known data sources and existing data collected through the normal course of business. If an airport is Part 139 certificated, the airport operator is obligated to collect, document, and retain certain safety data points, including Part 139 daily inspections, ARFF inspections, driver training, and incursions. For airports that are not Part 139 certificated, operators must consider the data points they already have in place and those missing that might provide a more complete safety performance picture. Two lists of KPIs or potential KPIs that all airports should consider including in their SMS and subsequently use to support their SRM process follow.

Part 139 KPIs

1. Part 139 self-inspection results
   a. Completed as described in the ACM
   b. Number of discrepancies documented
   c. Time to correct noted discrepancies
   d. Trends
2. ARFF inspections
   a. Number of discrepancies by location and tenant
   b. Time to correct noted discrepancies
   c. Trends
3. ARFF run reports (non-medical related)
   a. Trends
4. ARFF medical run reports
   a. Trends
5. Airfield driver training
   a. The number of individuals trained (used to put data in context)
6. AOA access training (badging)
   a. The number of individuals trained (used to put data in context)

7. FOD program results
   a. Completed inspections and documentation (as appropriate)
   b. Results of FOD inspections
   c. Trends
   d. Level of tenant and airline participation in the program

Non-Part 139 KPIs

8. Baggage area program results (as appropriate)
   a. Completed inspections and documentation (as appropriate)
   b. Results of baggage area inspections
   c. Trends
   d. Level of tenant and or airline participation in the program
9. Ramp inspection program results
   a. Completed inspections and documentation as described in Appendix C
   b. Results from inspections
   c. Trends
   d. Level of tenant and airline participation in the program
10. Terminal and Landside inspections (if appropriate)
    a. Results from inspections
    b. Trends
    c. Level of tenant and airline participation in the program
11. Airport operator employee incident and accidents
    a. OSHA Reportable (if applicable)
    b. OSHA non-reportable (if applicable)
    c. Trends
12. Property damage reports
    a. Trends
13. Hazard reports
    a. Public reports
    b. Internal Authority reports
    c. Tenant and airline reports
    d. Time to investigate
    e. Time to corrective action(s) completion
14. Incident and accident reports (non-aircraft related)
    a. Public reports
    b. Internal airport operator reports
    c. Tenant and airline reports
    d. Time to investigate
    e. Time to corrective action(s) completion
15. Safety Training
    a. Number of tenants and or airlines employees trained in SMS orientation
    b. Airport operator staff and employees trained in SMS orientation, SRM process, and Assurance
    c. Test results
    d. Trends

APPENDIX H

Basic Probability and Statistics for SRM

Introduction

SMS and SRM are terms that have been recently introduced to the airport industry—they highlight the need to understand some basic principles of probability because risk has two components: severity and likelihood. While the meaning of severity is straightforward, understanding the term likelihood requires some basic understanding of probability.

This appendix will help airport workers understand basic principles and notations used to describe the chance of an accident or incident occurring. Reviewing these principles will help airport workers understand and participate in discussions about risk and in panels assembled for safety assessments.

Catastrophic accidents in aviation are rare and estimating the probability of occurrence is best estimated using historical data. However, many types of incidents are frequent, particularly at larger airports, because of the associated volume of operations and activities. Birdstrikes and FOD incidents may occur daily at some airports.

The initial sections of this appendix describe basic concepts that airport staff can use in dealing with SMS at the airport. The last section presents mathematical operations with probabilities to help staff understand more advanced concepts.

Likelihood vs. Probability

The words *probability* and *likelihood* are often used as synonyms, but in statistical use, there is a clear technical distinction. To illustrate the statistical difference between these terms we can use a die. If we roll a die 6 times, what is the **probability** that we will get a "4" in every roll? If we roll the die 6 times and we get a "4" in every roll, what is the **likelihood** that the die is fair?

Statistically, it would be incorrect to switch **likelihood** and **probability** in the two sentences. Probability has to do with the chances of an observation, and likelihood refers to the chances of the parameters being correct, given an observation. However, for this guidance, no distinction will be made between likelihood and probability and the terms will be used interchangeably.

Probabilities fall on a scale between 0, or 0%, (impossible) and 1, or 100%, (certain). There is no such thing as a negative probability (i.e., less than impossible) or a probability greater than 1 (i.e., more certain than certain). Some types of accidents are very rare and the probability may be very small (e.g., 0.00000001%), however, probability is never negative.

Determining Probability Values

Three methods typically are used to determine probability values.

1. **Subjective Probability**
   This value reflects the best available knowledge (which may be an educated guess). This is a common method used by SRA panels. For example, to estimate the probability that an airfield worker will be injured by jet blast, it is not possible to use baseline values because each situation is unique and will depend on variables (e.g., is it in an area that aircraft will power up engines or is FOD present in the area between the aircraft and the construction area). For this scenario, an educated guess is the best alternative.
2. **Empirical Probability**
   This value is determined by experimentation or historical data. An example of this is the probability of a runway veer-off. Based on the total number of runway veer-offs that occurred between 1982 and 2009 in the United States, and the number of aircraft operations during the same period, it was found that the probability of an aircraft veering-off during the takeoff is 1 in 3,861,000 departures (*ACRP Report 51*, 2009).
3. **A Priori Probability**
   This value can be determined prior to any experimentation or data collection. For example, the probability of obtaining a tail in tossing a coin once is 50%. The coin is not actually tossed to determine this probability. It is simply observed that there are two faces to the coin, one of which is tails and that heads and tails are equally likely. This type of probability is seldom used in the aviation industry.

Understanding Probability Language

This section presents basic concepts associated with risk analysis and the language used by the FAA to characterize the likelihood of an accident or incident. When taking the risk matrix defined by the FAA for its internal SMS and to illustrate SMS guidance and advisory material for Part 139 airports, likelihood definitions are presented in two forms: expected period for one event to occur and expected number of departures to occur, as shown in Table H-1.

For example, "Remote" likelihood characterizes an event "expected to occur about once every year or 2.5 million departures." The first part of this definition describes the chance that an event may occur within a certain period—in this case, 1 year. The second part presents the odds that the event will occur in 2.5 million departures (or approximately 5 million operations).

Table H-1. FAA likelihood definitions.

Likelihood Classification	1 Event in Every	
Frequent	Week or less	2,500 departures or less
Probable	1 Week – 1 Year	250,000 departures
Remote	1 – 10 Years	2.5 million departures
Extremely Remote	10 – 100 Years	25 million departures
Extremely Improbable	100 Years or more	N/A

Table H-2. Number of ramp accidents at example airport.

Year	# of Ramp Accidents	Year	# of Ramp Accidents
1	0	9	0
2	0	10	2
3	0	11	1
4	1	12	2
5	3	13	2
6	1	14	0
7	2	15	1
8	1	16	2

The interpretation is simple; however, it is sometimes misleading. That an event is expected to occur in 1 year does not mean that the event will take at least 1 year to occur. The event may occur today or it may be many years before it happens. The period is an average period if the time to obtain the data was long enough to measure the frequency of occurrence and the conditions remained the same. When reviewing the number of accidents on the ramp over a period of 15 years, an airport found that 18 accidents had occurred in that period, as shown in Table H-2.

If we divide the number of events by the total observation period (18 events divided by 15 years), the result is approximately 1.1 events per year, which is about one event per year. In this case, the probability of that event is ranked as "Remote." However no event occurred in the first 3 years, three events occurred in the 5th year, and so on.

Given two options to classify likelihood, which one should we use? Should we use the criteria based on the number of operations or that based on the period? When the risk is associated with aircraft operations, the likelihood definition to be applied will depend on the volume of operations at the airport. If the volume of operations is small, the likelihood definition based on time should be used. At larger airports, a criterion based on the number of departures is the correct one to apply. As a rule of thumb, airports with less than 200 departures per day should use likelihood definitions based on the expected period for an event to occur.

Another important aspect is that risk management at an airport may be associated with other operational areas of the airport. For example, many airports have extended the SMS scope to terminal operations and landside. In addition, some airside risks, like collision between vehicles/equipment at the ramp are not directly associated with the total number of operations at the airport. For such cases, likelihood definition based on the period or criteria defined by the airport may be the best alternative.

As a rule of thumb, those airports having less than 200 departures per day may use only the criteria based on the expected period for an accident or incident, rather than the rate based on the number of operations.

Notations for Likelihood or Probability

Different notations can be used to represent the likelihood or probability of an accident or incident as follows.

Events per operation.

Notation Example	Description	Note
1 in 100 (incidents/operation)	One event (incident) per 100 operations (takeoffs and landings)	1 incident per 100 operations is approximately 1 incident in 50 departures
0.01 incidents per operation	One percent chance of occurring an accident/incident per operation	0.01 chance incidents per operation is similar to saying 0.02 incidents per departure
1% incidents per operation	One percent chance of occurring an accident/incident per operation	1% incidents per operation is similar to saying 2% incidents per departure
1×10^{-2} incidents per operation	One incident per 100 operations (takeoffs and landings)	This is scientific notation and 1×10^{-2} is similar to 1/100, or 0.01, or 1%
5×10^{-3} incidents per operation	Five incidents per 1,000 operations	This is scientific notation and 5×10^{-3} is similar to 5/1000, or 0.005, or 0.5%

Events per period.

Notation Example	Description	Note
1 incident in 10 years or 1 in 10 years	One incident is expected to occur in 10 years assuming conditions remain constant	It is wrong to assume that no event is expected in the next 10 years. The event may take place tomorrow or it may take many more years beyond 10 years to occur

Although smaller airports with less than 400 movements per day should use the FAA likelihood criteria based on the period, the probability may still be calculated using a baseline risk based on the number of operations. For example, based on historical data, the probability of birdstrikes with damage to GA aircraft is 1 in 417,000 movements. If the airport has 4,000 annual operations of GA aircraft, it may take over 100 years for an incident with aircraft damage due to birdstrike. In this situation, the likelihood is assumed to be extremely improbable.

Types of Events

Mutually Exclusive Events: These are events that cannot occur at the same time. It is unlikely that a runway overrun will occur following a runway undershoot and these two events can be assumed as mutually exclusive. In another example, aircraft damage and injury to passengers may result from an aircraft accident; in this case, the events are not mutually exclusive.

Complementary Events: These are events that have two possible outcomes. The probability of event A plus the probability of A′ equals one. $P(A) + P(A') = 1$. Any event A and its complementary event A′ are mutually exclusive. Heads or tails in one toss of a coin are complementary events.

Independent Events: These are two or more events for which the outcome of one does not affect the other (i.e., the events are not dependent on what occurred previously). Each toss of a fair coin is an independent event.

Conditional Events: These events are dependent on what occurred previously. If a plane catches fire on the ground during a taxiway operation, there is a chance of fatalities due to the fire. The number of fatalities depends on the severity of the fire and the effectiveness of the emergency response.

Probability Calculations

Sometimes it is necessary to calculate the total probability that two events will occur simultaneously or in succession. For example, if we know that the probability of an aircraft overrunning a runway is 1 in 1 million operations and that approximately 20% of those incidents result in accidents, we can calculate the probability that an overrun accident occurs. In this case, the probability is calculated by the product of the two probabilities.

The first step is to identify different types of events for which the probability will be calculated, as follows:

- **Mutually Exclusive Events:** These are events that cannot occur at the same time. It is extremely improbable that a runway overrun will occur following a runway undershoot and these two events can be assumed as mutually exclusive. In another example, aircraft damage and injury to passengers may result from an aircraft accident; in this case, the events are not considered mutually exclusive because damage to aircraft may cause injury to passengers.
- **Complementary Events:** These are events that have only a few possible outcomes. For example, an event may have outcome A or B. The probability of event A plus the probability of B equals one. $P(A) + P(B) = 1$. Any event A and its complementary event B are mutually exclusive. Heads or tails in one toss of a coin are complementary events.
- **Independent Events:** These are two or more events for which the outcome of one does not affect the other. They are events that are not dependent on what occurred previously. Each toss of a fair coin is an independent event.
- **Conditional Events:** These are events that are dependent on what occurred previously. If a plane catches fire on the ground during a taxiway operation, there is a chance of fatalities due to the fire. The number of fatalities depends on the severity of the fire and the effectiveness of the emergency response.

Sometimes an airport wants to estimate the total probability of an accident occurring at the ramp. It involves accidents involving people, aircraft, vehicles, and equipment that have occurred on the ramp within a certain period.

Total Probability

Sometimes it is necessary to calculate the total probability that an event may occur and it is possible to add the probabilities if the events are mutually exclusive. An airport may define a safety performance indicator as the probability of an accident at the ramp. The probability is estimated by adding the probabilities for each type of accident on the ramp.

P (A) is the probability that accident A type occurs

P (B) is the probability that accident B type occurs

P (C) is the probability that accident C type occurs

P (A or B or C) = P (A) + P (B) + P (C)

For example, historical data available at an airport were used to calculate the probability of birdstrikes. The chance of a birdstrike during a landing operation is approximately 1.3 birdstrikes per week and the probability that a birdstrike takes place during a departure is 1.1 per month. The airport wants to find the probability of a birdstrike during any movement (arrival or departure). In this case, the events are mutually exclusive; either a landing or takeoff operation and the total probability can be calculated by adding the probabilities.

However the probabilities are presented in different units: incidents per week, and incidents per month. The first step is to make the units uniform. We can say that 1 month has approximately 4 weeks and 1.3 birdstrikes per week represents 5.2 birdstrikes per month. We can now add the probabilities and obtain 6.3 birdstrikes per month as the chance of a birdstrike during any operation.

Probability of Simultaneous Events

As shown in the example presented for aircraft overruns, sometimes it is necessary to estimate that two events take place during the same incident. The probability of events A and B occurring simultaneously is the probability of event A multiplied by the probability of event B, if the events can be assumed independent. In mathematical notation:

P (A & B) = P (A) × P (B)

Using the example for runway overrun:

P (A) = 1/1,000,000 = 0.000001 overruns per operation (probability of a runway overrun)

P (B) = 20% = 0.2 (percentage of overruns that result in accidents)

P (A & B) = P (A) × P (B) = 0.000001 × 0.2 = 0.0000002 overrun accidents per operation (probability of an overrun accident)

Although the consequences of an overrun are associated with the speed that the plane departs the runway, we are using two independent probabilities for the calculation: the rate (or probability) of overruns and the percentage of accidents during overruns.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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