ACRP

REPORT 1

AIRPORT
COOPERATIVE
RESEARCH
PROGRAM

Sponsored by
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Safety Management Systems for Airports

Volume 1: Overview

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 1

Safety Management Systems for Airports

Volume 1: Overview

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

ACRP REPORT 1

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FOREWORD

By Robert E. David
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ACRP Report 1: Safety Management Systems for Airports, Volume 1: Overview, explains what a safety management system (SMS) is and how a systems approach to safety management will benefit both the safety and business aspects of airports. The implementation of SMS represents a change in the safety culture of an organization. In this regard, airport directors and members of their governing boards will find this document particularly useful since the successful implementation of SMS is dependent on the commitment of the highest levels of management.

This report provides a brief description of a safety management system (SMS) and is intended to be an easy-to-read, quick introduction to SMS for airport directors and their governing boards. It describes the advantages associated with instituting such a system and explains the four components or pillars (safety policy, safety risk management, safety assurance, and safety promotion) that are part of an SMS. The report also provides background information on the International Civil Aviation Organization's requirements for SMS at airports and relates the experiences of airports located outside the United States in implementing SMS.

Although the concept of safety management systems has been around for several years, it is relatively new to airports. The good news for U.S. airport operators is that many of the procedures and practices that they have been using to comply with the current requirements of Title 14 Code of Federal Regulations Part 139 will provide the basis for establishing an SMS.

It was not intended that this overview explain how SMS will be incorporated into the Part 139 regulation. The Federal Aviation Administration (FAA) is considering several different options on how SMS will be implemented at U.S. airports. Section 6 of this report provides their current thinking on this subject but also recognizes that the FAA is conducting a pilot program with several U.S. airports on SMS implementation. Undoubtedly, FAA's final proposal will reflect the knowledge gained from the experiences of airports participating in the pilot program.

The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) prepared this SMS overview for TRB under ACRP Project 11-02/Task 4. CAASD has a long history in aviation safety-related projects and has provided support to both the FAA and international aviation organizations in SMS development and implementation.

Readers are advised that this overview is the first step that ACRP is undertaking regarding SMS. The second step is to develop for airport operators a *Guidebook for Airport Safety Management Systems* under ACRP Project 04-05. This guidebook will provide detailed information on how to develop SMS at an airport. This guidebook is expected to be completed in the last quarter of 2008 and published as Volume 2 of this report in 2009.

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Purpose of This Document

This document introduces the application of Safety Management Systems (SMS) to airport operations. It is a resource intended for U.S. airport executives, managers, and safety officials and is a companion document to the *Guidebook for Airport Safety Management Systems,* which will be developed under ACRP Project 4-05. The guidebook will be published as *ACRP Report 1, Volume 2*.

This overview of SMS describes how a systems approach to safety management will benefit both the safety and business aspects of airport operations. It describes the essential components of SMS and also introduces the International Civil Aviation Organization (ICAO) mandate and anticipated Federal Aviation Administration (FAA) policy for airport SMS. Furthermore, it includes valuable lessons learned from case studies in SMS implementation efforts at various airports and in other industries.

It should be noted that at the time this overview goes to press, the FAA has not finalized all of its policies and plans for the implementation of SMS for airports. The Guidebook and future FAA guidance material are expected to provide further details.

Introduction

Why Safety Management Systems?

Historically, aviation safety has been built upon the reactive analysis of past accidents and the introduction of corrective actions to prevent the recurrence of those events. With today's extremely low accident rate, it is increasingly difficult to make further improvements to the level of safety by using this approach. Therefore, a proactive approach to managing safety has been developed that concentrates on the control of processes rather than solely relying on inspection and remedial actions on end products. This innovation in aviation system safety is called a Safety Management System (SMS), an expression indicating that safety efforts are most effective when made a fully integrated part of the business operation.

It is now generally accepted that most aviation accidents result from human error. It would be easy to conclude that these errors indicate carelessness or incompetence on the job, but that would not be accurate. Investigations are finding that the human is only the last link in a chain that leads to an accident. These accidents will not be prevented by merely changing people; increased safety can only occur when the underlying causal factors are addressed.

Enhancing overall safety in the most efficient manner requires the adoption of a systems approach to safety management. Every segment and level of an organization must become part of a safety culture that promotes and practices risk reduction.

Safety management is based on the premise that there will always be safety hazards and human errors. SMS establishes processes to improve communication about these risks and take action to minimize them. This approach will subsequently improve an organization's overall level of safety.

© John Alexanders

There will always be hazards and risks in the airport environment. Proactive management is needed to identify and control these safety issues before they lead to mishaps.

Section 1

System Safety and the Benefits of Safety Management Systems

Today's U.S. aviation industry has achieved a remarkably high level of safety. Maintaining this success will prove challenging as air traffic increases. FAA projections anticipate 1.4 million additional domestic takeoffs and landings each year from 2007 until 2020. This changing aviation environment will therefore require an even more effective approach to reducing risk.

A Safety Management System (SMS) is a formal, top-down business-like approach to managing safety risk that is built on basic system safety principles. This section describes those principles, outlines the differences between SMS and traditional approaches to safety, and details the benefits to be gained from SMS implementation.

System Safety and SMS

System safety is the application of engineering and management principles, criteria, and techniques to achieve an acceptable level of safety throughout all phases of a system.

Achieving this definition of system safety is the primary objective of SMS. A well-structured SMS provides a systematic, explicit, and comprehensive process for managing risks. This process includes goal setting, planning, documentation, and regular evaluation of performance to ensure that goals are being met.

SMS PROVIDES A SYSTEMATIC, EXPLICIT, AND COMPREHENSIVE PROCESS FOR MANAGING RISKS.

SMS includes several key system safety principles as shown below:

- **Management commitment to safety**

  Because the attitudes and actions of management can significantly influence the entire staff, it is therefore critical that these leaders commit to the success of an SMS implementation.

- **Proactive identification of hazards**

  Early identification and reporting of hazards can save a significant amount of time and resources down the road.

- **Actions taken to manage risks**

  A system must be in place to determine logical approaches to counteract known risks to safe operation.

- **Evaluation of safety actions**

  An ongoing evaluation of the impacts of risk management actions is necessary to determine if further remedial activities are required.

Differences from Traditional Safety Approach

Most of these principles exist in some form in current safety systems. SMS is not intended to be a new safety management system; rather it builds upon an organization's existing safety processes. However, there are a number of ways in which SMS differs from the traditional approaches. One of the key differences is that SMS takes a proactive approach to safety management—it goes beyond prescriptive audits and checklist-based inspections to develop procedures and indicators that anticipate safety risks.

SMS SPREADS RESPONSIBILITY FOR SAFE OPERATIONS THROUGHOUT ALL LEVELS OF THE ORGANIZATION.

SMS spreads responsibility for safe operations throughout all levels and segments of the organization. This increase in the number of people watching for safety issues makes it less likely that a hazard will go undetected and possibly lead to an accident. This is depicted in Figure 1.1, where each "slice" represents a different segment or layer of the organization. In the diagram, a generic organization is represented by four segments—in an airport setting, this could include such groups as facilities, operations, safety, and management. Each SMS implementation will have its own customized set of layers that coordinate to create the safety culture of SMS. Each slice has holes that symbolize the potential for a safety hazard to go unnoticed, because the layer does not deal with that type of hazard, or due to human error. However,

when these layers are unified by SMS principles, it becomes less likely that a hazard makes it through all the levels without being identified and mitigated.

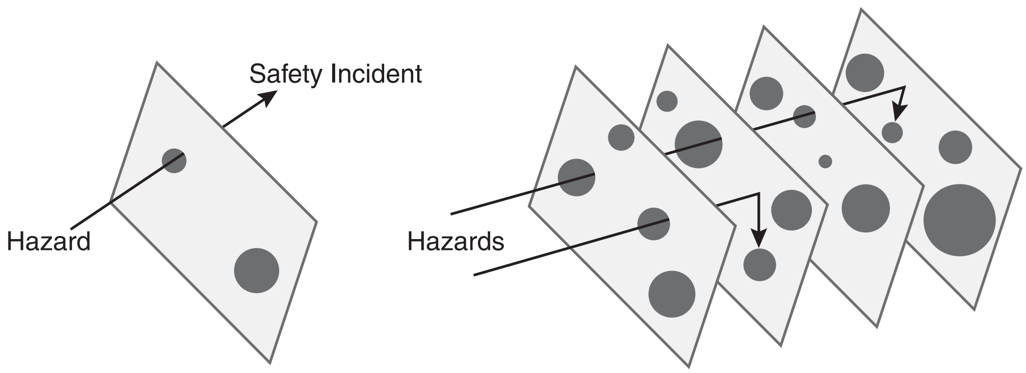


Figure 1.1: SMS Layers (Adapted from James Reason, *Human Error,* Cambridge University Press [1990])

SMS has much in common with Quality Management (or Quality Assurance) systems in that they both require planning, performance monitoring, communication, and the participation of all employees. Moreover, SMS recognizes that human and organizational errors can never be entirely eliminated and seeks to reduce them by developing a safety-oriented culture. This kind of environment focuses on eliminating hazardous conditions before they can become something more serious.

It is important to note that implementing SMS does *not* involve imposing an additional layer of oversight or regulations on the organization. Rather, it is an organizational shift that is seamlessly integrated into the routine day-to-day operations.

Benefits of SMS

Clearly, the ultimate goal of SMS is increased safety—in particular, fewer accidents and injuries. Moreover, increasing a system's level of safety leads to reduced material losses and enhances productivity. This makes the case that safety is good for business.

Some further benefits include:

- Reduction of the direct and indirect costs of accidents
  - Fines, repair costs, damage claims, and increased insurance premiums are a few of the potential economic consequences of an airport mishap.
- Improved employee morale and productivity
  - Promoting communication between management and the rest of the organization prevents disenfranchisement and lifts morale.

- Establishing a marketable safety record
  – A record of consistently safe operations can be used to attract new business and investment.
- Logical prioritization of safety needs
  – SMS emphasizes risk mitigation actions that provide the biggest impact on both safety and the bottom line.
- Compliance with legal responsibilities for safety
  – Airport certification requirements mandate a number of safety processes and standards that can be included in an organization's SMS.
- More efficient maintenance scheduling and resource utilization
  – Effective hazard reporting in SMS allows proactive scheduling of maintenance tasks when resources are available, increasing the likelihood that maintenance is performed on time and more efficiently.
- Avoiding incident investigation costs and operational disruptions
  – Improved communication and risk mitigation will prevent many accidents from ever occurring.
- Continuous improvement of operational processes
  – SMS allows for lessons learned to be incorporated into the system and lead to superior operations.

"A safety management system necessitates a cultural change in an organization so that the safety of operations is the objective behind every action and decision by both those who oversee procedures and those who carry them out. The system leads to standardized and unambiguous procedures for each crewmember, during both routine and emergency operations. Duties and responsibilities are specified for each staff member and for standard and emergency operations. Supervisory and subordinate chains of command are also delineated."
—Mark Rosenker, chairman of the National Transportation Safety Board

Finally, ICAO and the FAA have announced or proposed requirements or plans to implement safety management systems for air traffic services, airline oversight, and airports. This demonstrates their confidence in the safety management capabilities of SMS.

Section 2

The Components of SMS

Every SMS implementation is based on four primary components, or pillars, as shown in Figure 2.1. This section describes how each one contributes to improving safety and briefly details the activities that make up each pillar.

Figure 2.1: The Pillars of SMS

Safety Policy

SMS will only be effective when a Safety Policy is developed and communicated to the organization. A policy statement should be issued to clearly reflect top management's commitment to safety. The Safety Policy also

must indicate how safety management principles will be integrated into the organizational structure and define the procedures necessary for a successful SMS implementation.

Policy Statement

The Safety Policy is a written document from senior management that is communicated to all employees. Other affiliated entities with a stake in organizational safety should also be informed. In an airport environment these might include airlines and other operators, local police, and concourse vendors. The Safety Policy should include the following:

- Commitment to implementation of the SMS.
- Assurance that executives are monitoring safety performance just as keenly as financial performance.
- Encouragement for all employees to report potential safety issues without fear of reprisal.
- Establishment of clear standards for acceptable behavior related to safety.
- Commitment to providing the necessary resources.

SMS WILL ONLY BE EFFECTIVE WHEN A SAFETY POLICY IS DEVELOPED AND COMMUNICATED TO THE ORGANIZATION.

Organizational Structure

The Safety Policy also includes the organizational structure that will be relied upon to achieve and maintain the stated safety objectives.

The organizational structure should be appropriate to the size, complexity, and operating environment of the organization. Large organizations may be best served by a formal SMS that utilizes a cross-functional Safety Committee, while smaller organizations may adequately perform the same functions with a more informal approach.

Regardless of the size of the organization, a Safety Manager should be designated as the focal point for implementation and maintenance of the SMS. While it is preferable for the Safety Manager to have no additional roles, this may not be possible in smaller organizations. In that case, the Safety Manager's other responsibilities should not present a conflict of interest with safety management. The Safety Manager should be high enough in the organization to be able to communicate directly with top management.

Procedures

Safety procedures will lay out the process by which the organization identifies and remedies safety risks. They are subject to revision as circumstances change or more effective procedures are developed. It is critical that any changes be clearly communicated to all affected staff, and that the procedures be easily accessible to all for reference or continuing education purposes.

Safety Promotion

Safety Promotion is necessary to ensure that the entire organization fully understands and trusts the SMS policies, procedures, and structure. This pillar is achieved by establishing a culture of safety, training employees in safety principles, and allowing open communication of safety issues.

Culture

The main goal of safety promotion is to create a "safety culture" that allows the SMS to succeed. Having a safety culture means that all employees are responsible for safety. Such a culture is led by top management example, especially in the manner with which they deal with day-to-day activities. Employees must fully trust that they will have management support for decisions made in the interest of safety, while also recognizing that intentional breaches of safety will not be tolerated. The result is a non-punitive environment that encourages the identification, reporting, and correction of safety issues.

Training

In order to fulfill their responsibilities in an SMS-based organization, each employee must be trained in, or at least be aware of, safety principles. All personnel must understand the organization's safety philosophy, policies,

procedures, and practices. They must also know their roles and responsibilities within the safety management framework. The depth of the training should be appropriate to each individual's position and vary from general safety familiarization to expert-level training for safety specialists. Recurrent training may also be necessary to keep personnel up to date on any changes to SMS procedures.

IN ADDITION TO WRITTEN COMMUNICATIONS, IT IS IMPORTANT FOR EMPLOYEES TO WITNESS EVIDENCE OF THE COMMITMENT OF TOP MANAGEMENT TO SAFETY.

Communication

Individual safety training is supplemented by an ongoing two-way communication process that helps ensure that employees benefit from safety lessons learned, see the results of their actions, and continue to improve their understanding of the organization's SMS. When new procedures are introduced, the associated underlying safety analysis should also be communicated to the appropriate employees. In addition to written communications, it is important for employees to witness evidence of the commitment of top management to safety.

Safety Risk Management

Aviation is an activity that faces numerous risks on a daily basis. It is impossible to completely eliminate all risks; however, risk can be reduced to an acceptable level through Safety Risk Management (SRM) techniques. These consist of hazard identification, risk assessment, and risk mitigation and tracking.

SAFETY RISK MANAGEMENT

- **Hazard Identification**
- **Risk Assessment**
- **Risk Mitigation and Tracking**

Hazard Identification

The first step in Safety Risk Management is to identify hazards that the organization faces in its operational environment. A description of the system or operation that is going to be changed or

implemented must be developed as part of this step in order to be able to identify what could go wrong. A hazard is any existing or potential condition that can lead to an accident or incident. In an SMS, all identified hazards are documented and analyzed to determine what action is required to eliminate or reduce the safety risk associated with the hazard.

> **Identifying hazards is a key step to managing safety risk.** Safety researcher James Reason has estimated that for each major accident there are as many as 360 incidents that might have identified an underlying problem in time to prevent the accident had they been properly reported and investigated.

Risk Assessment

Each identified hazard undergoes a risk assessment to determine its potential consequences. The assessment considers both the severity of the consequences and the probability of such an event occurring. A risk assessment matrix like the one shown in Figure 2.2 could be used in this analysis. The assessment may show that certain hazards have an acceptable level of risk, while others require mitigation.

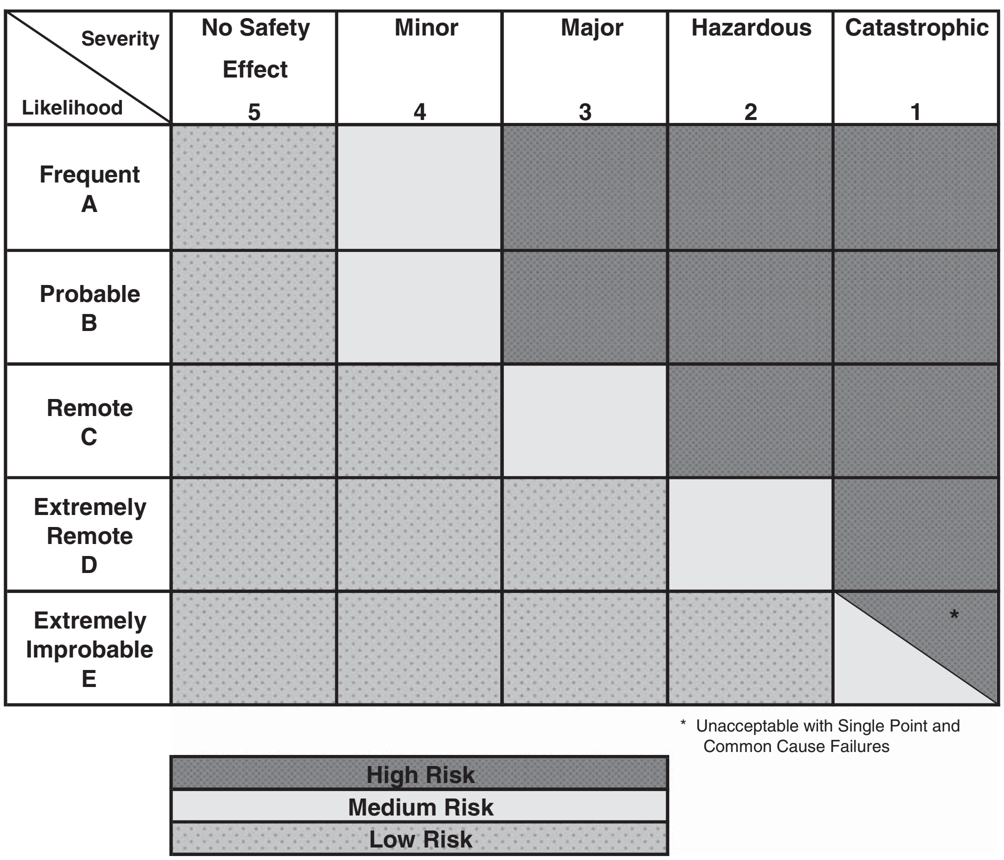


Figure 2.2: Risk Assessment Matrix

Risk Mitigation and Tracking

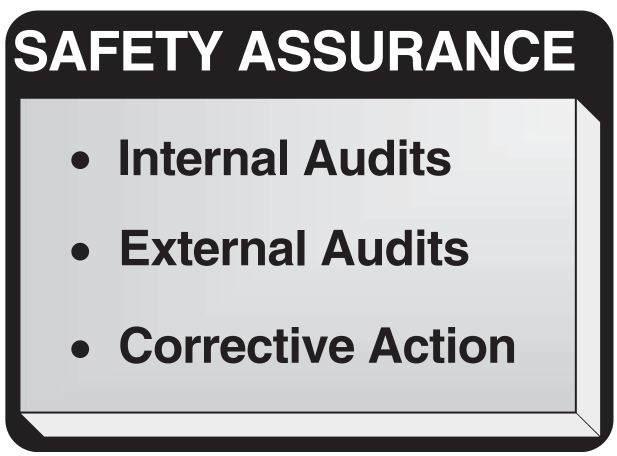
Mitigating actions should be fully analyzed to ensure that they address the root cause of the hazard. It may be beneficial to explore a range of mitigating strategies before choosing the preferred option, basing the decision upon factors such as timeliness, cost, organizational capabilities, and overall effectiveness. It is essential that management provide adequate resources to address the identified safety concerns.

A system must be in place to determine logical approaches to counteract any risks to safe operation. This can be accomplished by reducing or eliminating a hazard's likelihood of occurrence. Alternatively, a risk might be managed by reducing the severity of its effects. Occasionally, both may be possible.

Finally, the mitigations that have been put in place must be monitored and tracked in order to ensure that the control strategies are working correctly.

Safety Assurance

Safety Assurance functions provide confidence that the organization is meeting or exceeding its safety objectives. The functions—internal audits, external audits, and corrective action—provide feedback on the performance of the organization, as well as the effectiveness of implemented risk mitigation strategies.



Internal Audits

Internal audits are performed by each department within the organization to ensure that they are following the proper procedures and are achieving their safety objectives. These audits should be performed on a regular basis and may include surveys of employees and formal or informal inspections performed within a department. Both short- and long-term effectiveness of safety actions should be evaluated.

External Audits

External audits are conducted as part of the independent safety oversight of the organization. Audits can be scheduled or unscheduled and they provide a means for ensuring compliance with SMS standards, policies, and processes. For example, in a regulatory environment, the regulatory agency may conduct external audits.

Corrective Action

If an audit finds that prescribed procedures are not being followed, then corrective action should be taken by that department within the framework of Safety Assurance. Corrective action may also be taken to ensure that identified safety hazards are resolved.

Section 3

SMS in Other Industries and Aviation Segments

System safety principles have been used in many industries other than aviation. The examples in this section summarize safety experiences in the petroleum, nuclear, railroad, marine, and chemical industries, as well as other segments of the aviation industry. They illustrate how past mishaps have led to the development and adoption of critical components of SMS. The evolution of system safety has been predicated on the need to avoid the injuries, loss of life, and financial consequences experienced by the entities highlighted here.

Background

Safety regulation of industry has traditionally been reactive and prescriptive. It generally occurs in response to a significant safety failure and only addresses the issues that directly led to the failure. Although this has led to an improved level of safety, the current rate of growth in the aviation industry in particular requires a more systematic approach.

In fact, in today's dynamic industries with increasingly complex production processes and high-volume operations, prescriptive regulations become less effective because they primarily seek to prevent the reoccurrence of failures. In many industries, prescriptive measures have been replaced by SMS processes, which are better suited for these dynamic systems.

Lessons from Other Industries

Petroleum Industry

A good example of a change from prescriptive safety to an SMS approach can be found in the British offshore oil drilling industry.

Piper Alpha Oil Rig, July 1988

The Piper Alpha oil pumping station accounted for 10% of the UK's North Sea oil production at its peak. It experienced a fire that caused 167 deaths, loss of oil production, and an insurance payout equivalent to $2.8 billion. The public inquiry found the management company directly responsible for a series of preventable failings and errors. The report recommended a change from a prescriptive safety system to a safety risk management approach based on Quantitative Risk Assessment. This approach assesses risk by determining the likelihood of an event and identifying the severity of the consequences. This is the basis of the Safety Risk Management pillar of SMS.

Nuclear Industry

Safety has always been a primary concern in the nuclear industry. There have been two significant historical accidents: Three Mile Island in the United States and Chernobyl in the Ukraine. Both events have led to improvements in nuclear technology and the safety culture required to use it effectively.

Three Mile Island, March 1979

The nuclear plant's reactor core was starved for coolant and about half of the fuel melted. Containment was not breached, and fortunately the accident did not cause any deaths. However, the cost for the cleanup was around $975 million and the reactor was permanently closed. The investigation called for a restructuring of the Nuclear Regulatory Commission with more emphasis on the agency's responsibilities for reactor safety. In particular, it called for improving person-to-machine interfaces and risk assessment procedures.

After this accident, the Nuclear Regulatory Commission increased its focus on a formal risk assessment approach, which has been the basis for many subsequent improvements in plant design and operation. In addition, changes were made in the area of control room operations, such as licensee training, program certification, and simplified procedures to mitigate a hazard.

Chernobyl, April 1986

A mismanaged electrical engineering experiment by the operators caused the reactor to lose its coolant. The reactor design was poor from a safety perspective, the operators were not aware that the test performed was potentially dangerous, and they did not comply with established operational procedures. There were 56 immediate deaths, and much more harm due to the release of radiation. According to investigators, the cause of the accident was the "lack of a safety culture."

After Chernobyl, remedial measures to enhance nuclear safety were implemented at existing plants with similar reactors. Safety upgrades essentially removed the design deficiencies that contributed to the accident. Progress was also achieved in plant management, training of personnel, non-destructive testing, and safety analysis. As a result, a repetition of the same accident scenario seems no longer practically possible.

The new generation of nuclear plants is much safer, due in large part to the lessons learned from these industrial accidents. Several elements of today's SMS were developed as a result, and the strict safety culture of today's nuclear industry is an excellent model for other industries that perform high-risk operations.

Railway Industry

In recent years, the railroad industry safety record has improved. However, from 1994 to 2005 train accidents increased from 3.67 to 4.09 per million train miles, leading to a mandate for adopting system safety measures.

Graniteville, NC, January 2005

A freight train traveling through Graniteville, NC, encountered an improperly laid switch that diverted the train onto an industry track where it struck a parked train. The collision derailed 16 cars of the moving train. One car was breached, releasing chlorine gas. Nine people died as a result of chlorine inhalation and total damage exceeded $69 million. The National Transportation Safety Board found that the probable cause of the accident was the failure of the crew of the parked train to return a main line switch to the normal position after the crew completed work at an industry track.

An appropriations bill currently before Congress specifically calls for the establishment of a safety risk reduction program. The program shall “require each railroad to systematically evaluate safety risks, manage those risks and implement measures to eliminate or mitigate risks in its processes and procedures. The safety risk reduction program . . . requires different skills than the activities previously undertaken in the railroad safety program . . .” In this way, SMS will allow continued improvement in railway safety to avoid future accidents.

Marine Industry

Several maritime accidents in the 1980s and 1990s led to a push for a uniformly applicable formal safety management approach.

Belgium, March 1987

One of the most notable accidents was the Herald of Free Enterprise disaster—a car and passenger ferry that capsized. The Herald had doors at both the bow and stern, and due to operator negligence the bow doors had not been closed before leaving the harbor. 193 passengers were killed in the ensuing accident. A public inquiry was conducted, and the resulting report identified a “disease of sloppiness” and negligence at every level of the company’s hierarchy.

In response, the International Maritime Organization adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention. This code “establishes safety management objectives

and requires SMS to be established by ‘The Company.’ ” The procedures required by the code should be documented and compiled in a Safety Management Manual, a copy of which should be kept on board. Such documentation of procedures is a cornerstone of SMS.

Chemical Industry

The chemical industry’s experience in SMS is exemplified by the DuPont Corporation. DuPont has been a leader in the implementation and promulgation of SMS for almost 200 years. Ever since an 1818 explosion at its gunpowder mill in Delaware, industrial safety has been a major focus of the DuPont culture, and it has received many awards in the field. This promotion of system safety is the first pillar of SMS.

DuPont has established a consulting branch, DuPont Safety Resources, to help other businesses and industries integrate safety management practices, including SRM, into all aspects and phases of their operations. For example, DuPont helped Qantas Airline establish a safety improvement program with the goal of “No Injuries to Anyone at Any Time.” Achievements at Qantas include a 50% reduction in lost work days, and $500 million in projected cost savings over 5 years.

DuPont issues annual safety awards for individual and collective initiatives in Europe, the Middle East, and Africa for significant projects in workplace safety. The common thread among the winners is that they understand the strong link between creating a safer workplace and improved business performance.

Aviation Industry

Aviation safety is a fundamental mission of the FAA. The Federal Aviation Act of 1958 created the agency and charged it with establishing and operating the United States’ Air Traffic Control system in order to maintain a safe National Airspace System. In 2000, the FAA Administrator commissioned a team to study SMS. Management concluded that the design, development, and implementation of SMS are important next steps in aviation safety.

Additionally, in November 2001, the International Civil Aviation Organization (ICAO) amended Annex 11 to the Convention, *Air Traffic Services,* to require that member states establish an SMS for the provision of air traffic services. The SMS requirements described in Annex 11 are further detailed in ICAO Document 4444, *Procedures for Air Navigation Services, Air Traffic Management.*

While there were no specific aviation incidents that triggered the move toward SMS in the industry, there are several accidents in recent history that support the need for system safety, including some recent ones that are still being investigated. Two examples follow.

France, July 2000

An Air France Concorde on a charter flight from Paris to JFK struck a 16-inch strip of metal that was left behind by a previous departure. The Concorde's left main landing gear was damaged and debris impacted the wing structure, which led to a rupture of the fuel tank. A major fire under the left wing broke out almost immediately, possibly ignited by electrical arcing due to debris damage and fueled by the leak. 113 people were killed in the ensuing crash, including four on the ground. A rigorous analysis of previous Concorde incidents involving burst tires and resulting debris might have provided insight into these structural vulnerabilities and subsequent remediation. The Safety Assurance pillar of SMS includes audits and corrective actions to ensure that procedures and materials are in place to pre-emptively mitigate a once-identified hazard.

New Taxi Into Position and Hold (TIPH) Procedures

Safety risk is increased any time an aircraft is holding on a runway and waiting for release under TIPH procedures. The recently announced TIPH procedures are designed to avoid hazardous situations that arise from last-minute arrival runway changes. This effort to lower safety risks associated with TIPH procedures was not triggered by one event or incident, but rather is due to continued efforts by the FAA to increase safety. Through the SMS Safety Risk Management (SRM) process, a panel reviewed TIPH operations across the National Airspace System and presented the new proposed procedures in an SMS-defined SRM document. The panel consisted of a staff controller; procedures experts; flight standards personnel; operational safety personnel; a technical operations interface expert; a safety engineer; and personnel from safety assurance, human factors, and FAA contract towers.

While SMS will never be able to prevent all incidents and accidents, it does provide an approach that has already resulted in numerous improvements to aviation safety. It encourages proactive behavior that can help prevent mishaps that might have otherwise occurred. Many airlines and airports already have elements of SMS incorporated into their current organizational safety system.

Section 4

ICAO Guidance for Airport SMS

Background

A global shift in airport management began in 1987 when the British Airports Authority was privatized. As airports continued to evolve from public utilities to businesses concerned with making a profit, the International Civil Aviation Organization (ICAO) took steps to promote safety management as a prerequisite for a sustainable aviation business.

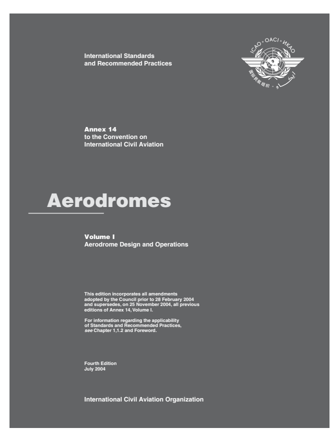
In 2000, the ICAO Air Navigation Commission commenced the process to amend Annex 14, Volume I, *Aerodrome Design and Operations.* New airport licensing and certification requirements called for the development and implementation of a safety management system. To address the lack of guidance material concerning SMS at airports, ICAO subsequently issued Standards and Recommended Practices (SARPs) for airport safety management systems. This section outlines the ICAO publications that regulate and guide SMS implementation in airport operations. Note that ICAO refers to airports as aerodromes, and uses “States” to refer to ICAO signatory countries.

The following three ICAO references contain information pertaining to airport SMS:

- Annex 14, *Aerodromes,* Volume I, Aerodrome Design and Operations, July 2004, Section 1.4, Certification of Aerodromes; Section 1.5, Safety Management
- Document 9774, *Manual on Certification of Aerodromes,* First Edition, 2001
- *Safety Management Manual* (SMM) 9859, First edition, 2006, Chapter 18, Aerodrome Operations

Annex 14

The SMS requirements in Volume I of Annex 14 became applicable in November 2005. The following are its key points:

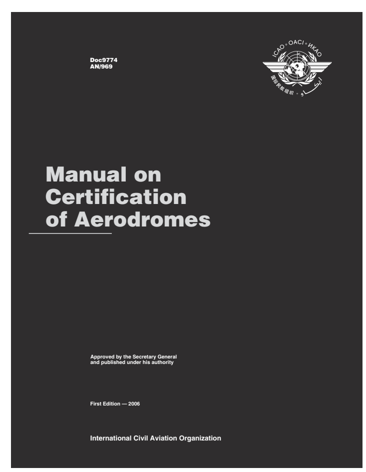


🔑	Aerodromes used for international operations shall be certified by States. As part of the process, States shall ensure that an aerodrome manual—which will include all pertinent information on organization and management, including a safety management system—is submitted for approval.
🔑	States shall req uire, as part of their safety programme, that a certified aerodrome operator implements a safety management system accepted by the State that, as a minimum: – Identifies safety hazards – Ensures that remedial action necessary to maintain an acceptable level of safety is implemented – Provides for continuous monitoring and regular assessment of the safety level achieved – Aims to make continuous improvement to the overall level of safety”
🔑	“A **safety management system** shall clearly define lines of safety accountability throughout a certified aerodrome operator, including a direct accountability for safety on the part of senior management.”

Manual on Certification of Aerodromes

This document outlines SMS requirements and stipulates the following:

- Implementation of SMS *is essential* for the certification of aerodrome operators
- SMS is an *integral* part of the Aerodrome Operations Manual



The SMS elements identified for inclusion in the Aerodrome Operations Manual are:

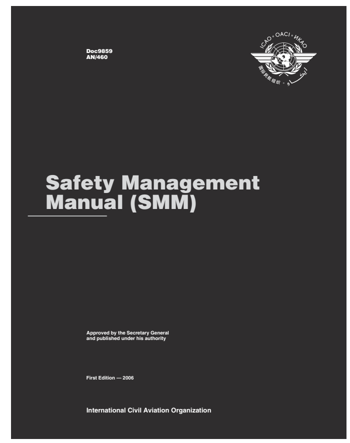
- Safety policy
- Structure of the organization
- Individual and group responsibilities for safety issues
- Setting of safety performance targets
- Internal safety audit and review systems

Safety Management Manual, Chapter 18

The Safety Management Manual can be found at http://www.icao.int/anb/safetymanagement/Documents.html.

The chapter of the Safety Management Manual dealing with airports consists of four sections. They are outlined below.

“Aerodrome Safety Management” describes:



- Scope for aerodrome safety management
- Aerodrome operator SMS
- Safety manager and safety committee(s)
- Safety occurrence reporting
- Safety oversight
- Safety audits

“Aerodrome Emergency Planning” includes:

- Coordinated response—participation of those agencies which the aerodrome operator believes would be actively involved in an emergency
- Aerodrome emergency exercises

The “Aerodrome Apron Safety” section characterizes all facets of the apron, including:

- Work environment
- Accident causes
- Safety management
- Vehicle operations

Finally, a section entitled “Role of Aerodrome Safety Managers in Ground Safety” focuses on how the Safety Manager might assess the adequacy of defenses against accidents on the airport surface.

A sample Aerodrome Operator Safety Policy and a list of some factors contributing to hazards in the apron work environment are provided in the appendices (not published herein).

Section 5

SMS Implementation at Airports Outside the United States

SMS has only recently been implemented at airports around the world, so effectiveness data and lessons learned are still being collected. This section summarizes literature searches and interviews regarding SMS implementation with representatives of several non-U.S. airports, Civil Aviation Authorities (CAAs, the foreign version of the FAA), and ICAO. The information gathered for this document shows that there is wide variation in the way that SMS principles have been adopted and managed.

Summaries of the individual interviews can be found at http://www.trb.org/news/blurb_detail.asp?id=7918.

Approaches to SMS Implementation

A range of implementation styles have been undertaken by those airports practicing SMS today. This variety is due in part to the extent of customization required to suit the airport size and safety experience. Although most airports are new to SMS as outlined here, many have considerable experience with related system safety processes. These airports may require a less time-consuming transition. Implementation approaches can be grouped into one of the following categories:

- **Evolutionary style**

  In this approach, an airport implements SMS principles over a period of several years. Over the course of this time, the safety culture gradually becomes ingrained in employees' attitudes and actions.

- **Phased methodology**

  This approach uses dates and milestones to implement the various aspects of SMS. It allows time to address any issues that arise before advancing to the next stage.

- **"Fast Track" adoption**

  This style implements SMS at a relatively rapid pace. Although this approach may bring the airport into compliance with SMS regulations, it may not result in a sufficiently fundamental change in safety practices and attitudes. An aggressive employee training program will be required to achieve this sort of quick transition.

The CAAs interviewed tend to let airports institute safety management processes themselves using some or all of the following methods:

- Gathering best practices and lessons learned from more experienced organizations
- Enlisting independent consultants or other airport operators to verify proposed safety programs
- Compelling airports to initiate SMS self-education programs
- Seeking software vendors to supply airport-specific data collection systems

Process and Gap Analyses

Process analysis is generally the first step in SMS implementation. Not every airport has a complete understanding of all the processes and procedures that should be monitored as part of SMS—it is critical to "know what you don't know." Once this initial identification step is complete, an airport can begin a gap analysis to determine where the safety deficiencies lie. This step may also reveal ways in which airport operations can be made more efficient.

> ***IN A 2005 BERLIN UNIVERSITY OF TECHNOLOGY STUDY PERFORMED BY HENDRICK SCHORCHT, APPROXIMATELY 1,600 SAFETY-RELEVANT AIRPORT OPERATIONS PROCESSES WERE IDENTIFIED AND VERIFIED.***

Data Collection

The backbone of any SMS is data collection and management. Many airport organizations possess an insufficient background in databases and other information system elements and may benefit from outside consultants for the development of this capability. Furthermore, safety data standardization should be promoted across a CAA.

Hazard-Reporting Systems

Voluntary and confidential incident-reporting programs are a cornerstone of SMS. Some aviation organizations approach non-punitive reporting systems cautiously. There are several options for reporting safety hazards and potentially dangerous practices, including internally to the airport, to the CAA, or even to an NTSB-type entity. Some methods cut out the airport operator entirely in order to ensure protection for whistleblowers. The integrity of a hazard-reporting system is an important aspect of the safety culture that is developed under SMS practices.

Benefits Identified

The CAAs of Australia, Canada, Hong Kong, Ireland, Italy, Kuwait, Singapore, Switzerland, the United Kingdom, and elsewhere have identified SMS as the most effective system for ensuring that accident rates do not increase in correlation with the expected increase in global air traffic. Cardiff, Wales; Perth, Australia; Calgary, Canada; Copenhagen, Denmark; and Changi, Singapore are just a few of the airports that have

started to work toward improving their safety records using SMS principles. The following are some of the benefits of an airport SMS as identified by officials at these airports:

- Achieving safer airport operations and compliance with regulations—SMS serves as an efficient means of dealing with regulators and legal systems
- Enhancing the ability to anticipate and address safety issues before they lead to an incident or accident
- Reducing the number and severity of collisions by focusing attention on safety needs that will result in a higher payback
- Allowing the airport to prioritize issues that are most appropriate for its size and goals
- Maximizing the effect of safety investments by ensuring that the highest priority needs are identified
- Emphasizing process management and continuous improvement
- Promoting a collaborative, stakeholder-focused approach to develop sound safety practices
- Building a safety culture by increasing airport staff awareness of safety and risk
- Making staff more responsible for incident processing—assessment and management of incidents is more robust
- Formalizing processes and meetings

SMS Lessons Learned at Airports Outside the United States

Several interviewed airport officials in other countries shared their experiences implementing SMS. The following lessons learned were provided by respondents:

Do not wait until legislation is in place – start the process *now*.
Some or much of what you have in place today can be used in an SMS framework.
Documentation is the key SMS component to ensure and demonstrate an airports d ue diligence to requirements.
Tackle SMS in stages, rather than trying to do everything at once.
If not already done, establish and maintain a good working relationship with your partners and members of the airport community, including the regulator.

Critical Challenges

Based on the interviews with airport authorities in other countries, the following aspects of SMS implementation were deemed both difficult and critical to success. They merit substantial research and planning.

- Determining legal liability/accountability.
- Identifying a trained and qualified Safety Manager.
- Instituting data collection methodologies.
- Developing a workable non-punitive hazard-reporting system.
- Integrating airport SMS with other domains, particularly air traffic control and airlines.

Summary of Airport Implementation Outside the United States

It is widely recognized in the aviation community that safety is key to sustaining dynamic global economies. However, based on the experience of airport operators outside the United States, it takes more effort to enact significant change in airport environments than many realize. This is especially true if one desires to integrate safety management among the airline, air traffic control, and airport segments. There is no universal solution for improving airport safety, but SMS offers a customizable method that has been shown to work in various industries, including aviation.

Section 6

Vision of SMS Implementation at U.S. Airports

This document has described in a broad sense the benefits that SMS can provide to an airport organization. Incorporating SMS is not an overnight activity—managing safety to a level that is an improvement on today's already remarkable system requires commitment and a thorough reevaluation of existing processes and procedures. This section describes the actions that are being undertaken by the FAA to attain the goal of SMS implementation at the airports certificated under 14 CFR Part 139, *Certification of Airports.* Furthermore, it suggests actions that an airport executive or manager might take to synchronize with the FAA initiatives.

As previously mentioned, SMS is intended to build upon, not replace, existing safety processes. Many airports will likely have processes in place that go a long way toward developing an SMS. SMS integrates these processes and ensures that safety actions and processes are documented.

FAA Activities

There are number of activities that the Office of Airports has already undertaken or plans to commence. The first was issuing an Advisory Circular (AC) to introduce SMS. This AC can be found at http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/index.cfm?template=homepage. The FAA has selected a number of airports to participate in an SMS Pilot Study to develop SMS-based safety plans and learn from their experiences. The FAA Office of Airport Safety and Standards is also participating in an agency-wide initiative to implement SMS in all FAA organizations. Finally, a rulemaking project will be commenced in order to define the timeline and scope of SMS adoption at U.S. airports.

Advisory Circular

Advisory Circular AC 150/5200-37, *Introduction to Safety Management Systems for Airport Operators* was released on February 28, 2007. It states that the agency anticipates issuing a notice of proposed rulemaking for public comment in 2008. The Advisory Circular goes on to briefly define the four pillars of SMS and provides an example showing the application of SRM to improve safety during a runway construction project.

SMS Pilot Study

The FAA Office of Airport Safety and Standards has selected a number of airports of varying size for a study into how SMS might best be incorporated into airport processes and procedures. Participants will benefit from being an early adopter of a program that will likely be mandated in the future. Feedback from these

airports on implementation lessons learned will assist the FAA in providing future guidance to other airports developing elements of SMS.

Participants will be responsible for developing and documenting SMS in a Safety Program Manual (SPM). It is the FAA's intent to eventually incorporate SMS into the Airport Certification Manual. This Pilot Study will occur over the course of approximately 6 to 8 months, depending on airport size and complexity. It will consist of three phases as follows:

- Phase 1: Gap Analysis
- Phase 2: Development of Draft Safety Program Manual
- Phase 3: Development of Final Safety Program Manual

One of the primary goals of the SMS Pilot Study is to identify the gaps between current airport regulations—as contained in 14 CFR 139 and associated FAA guidance material—and the intent of SMS. It is anticipated that there will be significant overlap between current safety plans and SMS principles. The findings of the Pilot Study will help FAA develop future guidance on SMS that will ultimately benefit the airports that subsequently implement SMS.

Rulemaking

The FAA supports harmonization of international standards and has worked to make U.S. aviation safety regulations consistent with ICAO standards and recommended practices. The agency intends to implement the use of SMS at U.S. airports to meet the intent of the ICAO standards in a way that complements existing FAA airport safety regulations. A decision on the final rule will take into account comments from industry and the public, as well as the experience of airports that have already implemented SMS. The AC also states that any decision to issue a final rule on SMS would:

- "Consider the benefits and costs of the rule and tailor the rule to impose the minimum burden and costs necessary for effective implementation."
- "Consider whether the requirement should apply to all certificated airports or only to airports above a certain activity level."
- "Consider, for airports subject to an SMS requirement, how SMS program elements would apply to airports of different sizes and resources."
- "Acknowledge the existing requirements of Part 139, and avoid duplication of safety programs."
- "Consider the appropriate degree of FAA oversight of individual SMS plans by FAA airport certification safety inspectors."
- "Review SMS training needs for FAA employees and airport operators."

Other Activities

The Airport Cooperative Research Program of the Transportation Research Board is producing a *Guidebook for Airport Safety Management Systems* in coordination with the FAA. This task is expected to be completed in late 2008 and will be published as Volume 2 of this report.

Airport Activities

The following list should provide airport management with a general idea of the steps required to implement SMS in the entire organization. Although the rulemaking process is expected to take a couple years, there are some activities that airport operators can commence in the near term to prepare for the transition to the type of safety management systems that ICAO and the FAA have envisioned.

Steps to Establish an Airport SMS

Establish a safety policy and assign safety responsibility
Responsibility for overseeing the SMS implementation must be assigned at an early stage. At smaller airports, this may be an individual with other duties as well. For larger organizations, a team of safety professionals supporting a safety manager may prove more effective. The first task is establishing a safety policy that reflects SMS principles.

Perform a gap analysis
Compare existing safety components with SMS program requirements and identify all elements that require development. A gap analysis frequently begins with a list of all the current operations and procedures that occur at the airport. One can then verify whether they are performed in accordance with SMS philosophies.

Develop a strategy for SMS implementation
This is essentially a roadmap that lays out the steps required to fully implement SMS. The experience of other airports using SMS may prove helpful in determining an efficient phased approach and transition plan.

Develop individual SMS elements
Following the roadmap, the processes that make up SMS must be developed, documented, reviewed, and verified.

At U.S. airports, many of the airport operators' actions are governed by standards issued by the FAA. The FAA would not expect an airport operator to conduct an independent risk analysis of an action or condition directed by a mandatory FAA standard or specification. However, if the airport operator proposes to deviate from the standard, then risk analysis will likely still be required.

Conclusions

Aviation entities around the world—CAAs, airlines, and airports—will benefit from the adoption of SMS. Other industries have shown it to be an effective method for improving safety in the face of rapid growth and increasing technical complexity. It is hoped that this document will provide airport operators with a useful introduction to SMS and will help prepare them to transition to a safety management system that will enable them to systematically and proactively manage safety.

Abbreviations and acronyms used without definitions in TRB publications:

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	Air Transport Association
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
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
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
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