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16. Abstract

The general objective of this research study was to develop a model to measure and test safety management system (SMS) effectiveness. Various methods were explored through review of a broad array of literature from both inside and outside the field of aviation; existing models used in aviation; and extensive interviews of 22 aviation safety experts. The model was developed using the data envelopment analysis (DEA) method based on data collected from personal interviews and surveys administered online. The reliability and validity tests indicated that the survey instrument was reliable and had a high level of convergent validity. DEA models were tested with Frontier Analyst® software. The models produced efficiency scores of organizations, identified inefficient organizations, and determined improvements needed to increase efficiency scores.

Overall, four DEA models were developed for four SMS components. The models calculated efficiency scores for participating organizations and identified inefficient organizations and potential improvements needed for them to become more efficient. The method provided important results pertaining to an organization's SMS effectiveness, how it performs in comparison to other organizations, and the strength of its program components. Organizations' executives could use these results to determine their position in the industry, identify potential issues with SMS inputs and outputs, and develop corrective actions to improve their SMS effectiveness. Overall, the survey instrument and DEA model have been determined to work well and provide useful results to each participant. The small sample size of the responding organizations limits the findings and does not necessarily accurately depict the populations represented. A larger sample, including more organizations with a variety of types and sizes, is recommended for future research.

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AVE	Average variance extracted
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Continuous improvement
CR	Construct reliability
DEA	Data envelopment analysis
DMU	Decision-making unit
DoD	Department of Defense
ERP	Emergency response plan
FTE	Full-time equivalent
GFI	Goodness of fit index
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IEP	Internal evaluation program
IOSA	IATA Operational Safety Audit
KPI	Key performance indicator
NFI	Normed fit index
OSHA	Occupational Safety and Health Administration
QA	Quality assurance
QMS	Quality management system
RMSEA	Root mean square error of approximation
SA	Safety assurance
SKA	Skills, knowledge, and attitude
SMS	Safety management system(s)
SOP	Standard operating procedure
SP	Safety promotion
SPO	Safety policy and objectives
SPI	Safety performance indicator
SRM	Safety risk management
SWOT	Strengths, Weaknesses, Opportunities, Threats
TC	Transport Canada
TQM	Total quality management

EXECUTIVE SUMMARY

The international aviation community has been focused on Safety Management Systems (SMS) for the past 8 to 10 years as the primary means for assuring aviation safety. The International Civil Aviation Organization (ICAO) published its standards in 2006, requiring member states to establish SMS, and the FAA began publishing advisory circulars and other guidance material later that year.

In January 2015, the FAA released a congressionally mandated final rule on SMS for Title 14 Code of Federal Regulations Part 121 air carriers. The FAA has stated that its intention is to eventually mandate SMS for other certificate holders, including, presumably, air taxi operations, airports, flight schools, training centers, design and manufacturing organizations, and 14 CFR 145 repair stations.

Given the international attention on SMS, the new regulations requiring SMS for an increasing number of certificate holders throughout the aviation industry, and the considerable resources being expended on SMS, it is vital that a sound, valid means of determining whether or not an SMS is effective is available and used in the industry. An initial search of the literature revealed an abundance of guidance on developing and implementing SMS; however, research on measuring the effectiveness of implemented SMS is scarce.

The general objective for this research study was to develop a model to measure and test SMS effectiveness. Various methods were explored through a review of a broad array of literature, both inside and outside the field of aviation; existing models used in aviation; and extensive interviews of aviation safety experts. The model was developed through a systematic series of steps to ensure accomplishment of all objectives:

- A thorough review of relevant literature was performed by using resources from the FAA, the Occupational Safety and Health Administration (OSHA), ICAO, numerous Web sites, and the Embry-Riddle Aeronautical University Hunt Library.
- Safety experts from the United States, Canada, and Europe were selected to respond to a series of structured interview questions designed to help the researchers develop a strong model for measuring SMS effectiveness. Twenty-two structured interviews were performed. All results were carefully analyzed using both qualitative and quantitative methods (appendices A–N).
- A preliminary survey was designed and pre-tested with five participants. A modified survey based on results of the pre-test was then administered to a predetermined group of aviation experts. In addition, the survey was made available to the aviation community via an aviation safety listserv. More than 250 surveys were initiated; 33 were fully completed. The results of the completed surveys were used to test the reliability and validity of the instrument. The instrument was found to be reliable and determined to have a high level of convergent validity. There was insufficient evidence to confirm discriminant validity; therefore, respondents may have perceived overlap among the questions pertaining to the various components of SMS. This issue was addressed in the design of the final survey instrument (appendix S).

- Data envelopment analysis (DEA) was used to evaluate the information collected from the survey. Frontier Analyst® software was used to calculate the efficiency score of each organization, determine inefficient organizations, and identify improvements needed to increase efficiency scores.

In summary, a systematic approach has been used to develop and provide available tools (a survey instrument and DEA model) designed to aid organizations in measuring the effectiveness of their SMS.

1. INTRODUCTION

Note: Portions of this section borrow heavily from *Safety Management Systems in Aviation*, 2nd Edition, 2016[1], as the author was engaged in the present grant work and writing the book concurrently.

The overall goal of Safety Management Systems (SMS) is to ensure safe operation of aircraft through effective management of safety risk [1]. The system should continuously improve safety by identifying hazards, collecting and analyzing data, and continuously assessing risks. In spite of best efforts, there are some potential problems or pitfalls. It has been proposed that there must first be a thorough understanding of the system, its components, and the operating environment [2]. This implies the establishment of performance expectations, setting goals related to that performance, identifying activities to reach those goals, and continuously measuring and improving performance to ensure that goals are, in fact, being met. There are four components of SMS: safety policy and objectives, risk management, safety assurance, and safety promotion. The third component of SMS—safety assurance (SA)—requires safety performance to be compared to appropriate metrics and targets. A mandatory or voluntary incident-reporting system must be in place along with other controls, such as safety studies, reviews, audits, and investigations [1]. Organizations must be able to determine whether the SMS they have in place is effective and working properly.

In some cases, companies have no formal method of assessment. Some organizations evaluate the effectiveness of their SMS by reviewing data and considering trends. In most cases, trends and data are reviewed at regular intervals by safety departments and mid-level management (e.g., monthly), and less frequently by members of top management (e.g., quarterly). In some cases, organizations establish acceptable levels of accidents and incidents, and only when problems in a given area exceed those levels do they intervene. As long as they are not observing excessive numbers, they operate under the assumption that the SMS is performing effectively.

More sophisticated organizations have sought evaluation tools to help determine their effectiveness and, in some cases, they have turned the evaluation over to the auditors. Some use tools provided by the FAA, Department of Defense (DoD), and IATA Operational Safety Audit (IOSA). Some companies also hire outside auditors or evaluators to help them determine effectiveness. The evaluators check the overall performance of the SMS at different levels within the system. Companies are audited as often as semi-annually or as infrequently as every 2–4 years. The time between checks may vary, depending on the division in the company and its perceived criticality.

Although the specific components of SMS are clearly defined and its phases outlined, there is no clear path toward evaluating its effectiveness. Some efforts have been made toward building evaluation tools, but close examination of those tools always reveal shortcomings. Clear indicators of success also appear to be lacking. For example, Transport Canada's (TC's) assessment tool [3]

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[1] Stolzer, A. J. & Goglia, J. J. (2016). SMS Effectiveness. *Safety Management Systems in Aviation* (325–352). Routledge Taylor and Francis Group. London and New York: Routledge Taylor and Francis Group.

simply evaluates an enterprise based on whether it has a policy in place and a few other criteria that really do little to help evaluate its effectiveness. There are few performance criteria in any evaluation tools; therefore, much is left to the judgment of the person performing the assessment.

By integrating information found in the literature with information supplied by aviation organizations through interviews and surveys, a strong evaluation tool has now been developed. The tool is both valid and reliable.

2. METHODOLOGY

The overarching objective for this research project was to develop a model for determining SMS effectiveness in an organization. Several questions guided this research:

- Do methods exist in other industries that could inform and enhance the development of an SMS effectiveness model? Can they be adapted for purposes of this project?
- What components are essential in a common model scalable to the size of the organization?
- What processes are necessary to evaluate the model for validity and reliability?
- What factors are essential for incorporation into a tool for determination of whether an organization has the necessary components in place and whether they are operational for SMS?

A comprehensive literature review was conducted using several databases. SMS effectiveness studies pertaining to various industries, in particular transportation, were identified and analyzed. A comprehensive report regarding those findings was constructed and is included herein. In the course of conducting an initial literature review and preparing the project proposal, the researchers conceived a potential straw-man effectiveness model to help determine SMS effectiveness.

Using this model, structured interviews were conducted with experts knowledgeable in SMS effectiveness to gain an understanding of industry best practices. On-site interviews were also conducted with various experts. The individuals selected represented a broad cross section of the aviation industry. Twenty-two industry representatives were interviewed, and the researchers analyzed the results using NVivo, a qualitative research tool that allows the researchers to collect, organize, and analyze content from interview discussions and then perform pattern matching to uncover subtle trends and other analyses. All of these analyses are included in this report.

Based on findings, a preliminary survey was designed and, following approval by the Embry-Riddle Aeronautical University Institutional Review Board, administered to numerous participants via Survey Monkey. A total of 33 completed surveys were returned. Information gained from these and an additional 269 uncompleted surveys was used to refine and design the final instrument. Chi-square was used to test the nonresponse bias using demographic information. Results of the survey appear in section 4. The results of the completed surveys were used to test the reliability and validity of the instrument. The instrument was tested for reliability using Cronbach's alpha and construct reliability (CR) coefficients. The instrument validity was assessed using convergent and discriminant validity tests. Issues identified as resulting from these tests (next section) were addressed in the design of the final survey instrument (appendix S). Data envelopment analysis (DEA) was used to evaluate the information collected from the survey. Frontier Analyst® software

was used to calculate the efficiency score of each organization, to determine inefficient organizations, and to identify improvements needed to improve efficiency scores.

2.1 RELIABILITY

The purpose of a reliability test is to evaluate the internal consistency of the measurement instrument for SMS components. Internal consistency measures how well question items measure a particular characteristic within the test [4]. If the raters or judges are used to evaluate the measurement instrument, the inter-rater reliability of their judgments can be assessed using the Kappa coefficient.

The original intent of this research was to use faculty and students to evaluate individual questions and SMS constructs and calculate the Kappa coefficient based on their judgment; however, as the project progressed, this method presented some potential issues. For the large number of questions and four different constructs included in the questionnaire, the inter-rater reliability test requires a substantial amount of time to train the judges and some items may require a separate calculation for each pair of judges [5]. In addition, the time requirement to rate all question items, structure of the questionnaire (multiple question items and four different constructs), and nature of the questions may cause bias and affect the validity of the scores. These difficulties suggested that the inter-rater reliability using the Kappa coefficient was not the best approach to evaluate the reliability of measured items and a more quantitative and robust reliability test could be used for the purposes of this project. Because the data were collected from a survey of SMS professionals, a more popular and appropriate method was to use the internal consistency coefficient calculated from the empirical data. Cronbach's alpha is one of the best methods for testing the internal consistency of a measurement instrument [4]. A Cronbach's alpha of 0.7 or higher indicates good reliability of measured items [6]. In addition, a more conservative reliability coefficient and CR, which is derived from the confirmatory factor analysis (CFA), has been suggested [7]:

$$CR = \frac{\left(\sum_{i=1}^{n} L_i\right)^2}{\left(\sum_{i=1}^{n} L_i\right)^2 + \left(\sum_{i=1}^{n} e_i\right)} \quad (1)$$

where:

L_i = standardized factor loading
e_i = error variance terms for a construct
i = number of items

Further details concerning the above are discussed in the next section.

A CR of 0.7 or higher also suggests good reliability, indicating that internal consistency exists, which means all measures consistently represent the same latent construct [7]. In this project, both Cronbach's alpha and CR were used to evaluate the reliability of measured items.

2.2 VALIDITY

The construct validity of the measurement instrument was evaluated in multiple ways.
Construct validity has been defined as the extent to which measured items actually reflect the theoretical construct that those items are designed to measure [7]. First, the face validity of the

survey instrument was evaluated by qualitatively reviewing the readability, wording, and relevance of each question item. Researchers reviewed all question items, discussed them, and made changes as needed. The survey was also shared with SMS experts from across the industry and then revised in accordance with their comments. Because this method used subjective judgment of reviewers, further construct validity tests were needed.

It has been suggested that construct validity could best be evaluated through convergent validity and discriminant validity [8]. Convergent validity refers to the extent to which measures of the same construct are correlated, whereas discriminant validity refers to the extent to which constructs are distinct. It has also been suggested that the CFA method be used to evaluate the convergent and discriminant validity [7, 9]. In this project, these validity tests were performed quantitatively using the empirical data collected from the survey. First, the CFA was performed to test how well measured variables represented the four SMS constructs. The CFA model, with four SMS constructs and corresponding measured items, was constructed and tested using AMOS® Graphic software. The model fit was obtained to assess how well the proposed model captured the covariance among all items [9].

For the pilot study conducted in this project, the small sample size may affect some model fit indices. Fit indices, such as goodness of fit index (GFI), normed fit index (NFI), and root mean square error of approximation (RMSEA), are very sensitive to the sample size. Accordingly, the project used CMIN (chi-square value)/df and comparative fit index (CFI) as major fit indices to evaluate the measurement model because they are less affected by the sample size. If the model fit was not satisfactory, a post-hoc analysis would be performed to modify the CFA model to make it fit better. Items with high error covariance would be eliminated, as necessary. The final CFA model with an acceptable model fit would be used to evaluate the convergent and discriminant validity.

Using average variance extracted (AVE) to evaluate the convergent validity of each construct has been suggested [7]. AVE is calculated as the mean variance extracted for the item loading on a construct. Item loadings were derived from the CFA. An AVE of 0.5 or higher indicates adequate convergence:

$$AVE = \frac{\sum_{i=1}^{n} L_i^2}{n} \tag{2}$$

where:

L_i = standardized factor loading
i = number of items

There are several ways of testing the discriminant validity, but the most rigorous and popular method is to compare the square root of AVE values for any two constructs with the correlation estimate between these two constructs [10, 11, 7]. The square root of AVE values should be greater than the correlation estimate to provide good evidence of discriminant validity.

On completion of the reliability and validity assessment, the SMS instrument was used to develop DEA models for four SMS components. These models were used to measure and test the SMS effectiveness of participating organizations. Details of this method are discussed in the next section.

2.3 DEA METHOD

DEA is a mathematical programming technique, which can be used to determine the boundary of an efficient frontier [12]. It is a multifactor analysis model that measures the relative efficiencies of decision-making units (DMUs). Efficiency is the ratio between the outputs produced with the amount of inputs used. The performance of a DMU is calculated by comparing its efficiency with the best observed performance in the data set, the efficient frontier.

If there are *n* DMUs, solving the following model will determine the efficiency score of a DMU *p*:

$$\max \sum_{i=1}^{n} u_i y_{ip}$$

s.t.

$$\sum_{j=1}^{m} w_j x_{jp} = 1 \tag{3}$$

$$\sum_{i=1}^{n} u_i y_{ik} - \sum_{j=1}^{m} w_j x_{jk} \leq 0 \ \ \forall k$$

$$u_i, w_j \geq 0 \ \ \forall i, j$$

where:

y_{ik} = amount of output i produced by DMU k
x_{jk}= amount of input j utilized by DMU k
u_i = weight given to output i
w_j = weight given to input j

This linear programming model determines the optimal weights for inputs and outputs that are needed to maximize the efficiency. The optimal solution consists of a set of weights, u_i and w_j, that ensure the efficiency of any other DMUs with these weights will not exceed 1, the value at which a DMU is considered efficient [12].

DEA is suited to this project as it allows researchers to evaluate the efficiency/effectiveness of organizations for SMS criteria based on predefined inputs and outputs and to compare this between organizations and with the best performance (efficient frontier or benchmark). Based on DEA results, ineffective organizations may be identified and a determination made as to how to improve their effectiveness.

In this project, DEA was performed for four SMS components within multiple aviation organizations to determine the efficiency of individual organizations. First, inputs and outputs were collected from the survey sent to respondents from different aviation organizations. Then, the data were examined and prepared as necessary. The inputs included Likert-scale questions asking respondents to identify how their organizations were implementing SMS in four major areas: safety policy and objectives (SPO), safety risk management (SRM), SA, and safety promotion (SP). The outputs included questions about SMS output performance in each of the four

SMS components. For organizations to be included in the DEA model, they needed to meet the minimum requirements. The organizations that were not currently using SMS were eliminated from the analysis. The organizations that answered zero for all input/output variables were also removed. Additionally, data from unverified respondents or respondents who were not SMS experts currently working at an aviation organization were also omitted to ensure the usability of the data.

In the next step, data were converted as necessary. Because SMS performance varies depending on the size of the organizations, the number of full-time equivalent (FTE) employees was collected and used as the basis to make the outputs comparable. In addition, the DEA method assumes that outputs are measured on scales in which larger numerical values correspond to greater safety performance [13]. In some cases, however, greater output values mean less safety performance. This is called a reverse output and the reciprocal conversion is needed to meet the DEA assumption.

Finally, the DEA method requires non-negative and non-zero values, and this requirement is enforced by Frontier Analyst software. Non-negative values were enforced by the survey tool. Zero values were substituted with relatively small values that were determined based on known values in other units to ensure the comparability. After the data examination and preparation were completed, DEA models were built for four SMS components (SPO, SRM, SA, and SP). These models were built with, and tested using, Frontier Analyst software to determine the efficient frontier and calculate the efficiency score for individual organizations. The results indicated which organizations were efficient in applying SMS and which ones were not. Finally, potential improvements were identified for inefficient organizations based on which decision makers can develop necessary corrective actions.

3. LITERATURE REVIEW

3.1 INTRODUCTION

The purpose of the literature review is to explore and summarize existing publications addressing SMS, particularly as they relate to the development of an evaluation tool. Although efforts have been made in the development and use of an SMS evaluation tool, serious shortcomings still exist. This review attempts to acquaint the reader with existing research and serves as a point of reference for the project.

Note: Portions of this section borrow heavily from Chapter 12 of *Safety Management Systems in Aviation*, 2nd Edition, 2016[2], as the author was engaged in the present grant work and writing the book concurrently.

An SMS is a system that ensures safe operation of aircraft through effective management of safety risk [1]. The system is designed to continuously improve safety by identifying hazards, collecting

[2] Stolzer, A. J. & Goglia, J. J. (2016). SMS Effectiveness. *Safety Management Systems in Aviation* (325–352). Routledge Taylor and Francis Group. London and New York: Routledge Taylor and Francis Group.

and analyzing data, and continuously assessing risks. The primary goal of SMS is to proactively contain or mitigate risks prior to resulting accidents and incidents.

> "Sound safety planning, including hazard identification, risk management and safety assurance must be based on a thorough understanding of the processes and activities of people in the system, and the other components of the systems and environments in which they work" [2].

Measuring and controlling performance are part of the process. Setting goals, identifying activities to reach those goals, and improving performance are all subcomponents of that process. This requires measuring performance against pre-established performance-level expectations and implementing changes to adjust to acceptable levels. Safety performance is now measured with the same tools and techniques used in total quality measures. The standards against which they are measured are global [14].

The safety program should be scaled to the size and complexity of the operation and incorporate a mechanism for maintaining and evaluating its effectiveness based on the four safety management components [1]:

1. SPO
2. SRM
3. SA
4. SP

3.2 COMPONENT 1: SPO

Under the first component, SPO, service providers should seek input from key stakeholders as they develop their SMS. Those providing input may include aviation professionals, regulatory and administrative authorities, industry trade associations, professional associations and federations, international aviation organizations, subcontractors or principals of a service provider, or representatives of the flying public. As the SMS program is developed, these inputs can help define the scope supporting various phases of operations.

They can be vital in assuring that critical components are addressed. As part of the first component, with appropriate inputs, the service provider is expected to define a safety policy [1] by:

- Including a clear statement about the provisioning of necessary resources for implementation of the policy.
- Specifying safety reporting procedures.
- Providing a description of unacceptable behaviors and noting exceptions to disciplinary actions.
- Having the policy endorsed and communicated throughout the organization.
- Having the policy periodically reviewed for relevance and appropriateness.
- Committing the organization to achieving the highest safety standards.

Research suggests the following are essential components of safety policy: accountability for safety, established safety standards, zero tolerance for unsafe acts, senior management review of safety performance, and contractual language binding all contractors to compliance with all safety rules [15]. All safety standards and safety performance objectives must be linked to safety performance indicators (SPIs), safety targets, and SMS mitigation actions [1].

Although there is no universally accepted set of total quality management (TQM) principles, the following, which is derived from a number of different TQM promoters, has been suggested and provide a strong core for any SMS program [16]:

- There must be a clearly defined and documented quality policy.
- There is an effective and documented quality management system (QMS).
- Documented quality plans are an integral part of the strategic business plan.
- The organization's focus is customer satisfaction, both internal and external.
- The organization's culture is teamwork-oriented at all levels.
- Senior managers actively demonstrate, and are committed to, quality in all their actions.
- Everyone knows his or her role and responsibilities in enhancing quality.
- Education and training are planned and comprise a series of continuous activities.
- There is a well-developed measurement system that is actively used to measure quality performance and direct improvement efforts.
- All organization functions are viewed as interdependent processes in an integrated system.
- There is a general attitude of continuous effort to reduce errors and defects, discover and eliminate waste, and simplify all processes.
- There is a continual effort to reduce variation in routine operations.

The service provider shall develop an SMS implementation plan formally endorsed by the organization that defines its approach to the management of safety in a manner that meets the safety objectives [1]. Documentation will include descriptions of:

- SPO.
- SMS requirements.
- SMS processes and procedures.
- Accountabilities, responsibilities, and authorities for SMS processes and procedures.
- SMS outputs.

Senior leadership commitment is essential to the success of the risk management process. Qualities such as passion, dedication, engagement, and persistence are often exhibited by leaders committed to safety. These become part of the visible commitment demonstrated by the safety leadership, and this visible commitment can make a significant difference in the overall success of the safety program [15]. Integrity is the first quality employees want in their leader is integrity [17]. Other important behaviors are empathy, team play, and recognition sharing. Leaders should also be willing to recognize and admit mistakes, collaborate, and recognize the contributions of others [17]. Leadership competence or the ability to get things done is also important. Competence also

encompasses the ability to make difficult decisions and take appropriate actions. Leaders who value their employees and practice serving their employees are also valued. This involves being a good listener and team player, often demonstrating appreciation for employee contributions. Good leaders will also be visionaries and will lead by example [15].

As part of the overall process, an accountable executive shall be identified and, depending on the size, structure, and complexity of the organization, this person may be [1]:

- The CEO of the organization.
- The chair of the board of directors.
- A partner.
- The proprietor.

The accountable executive will ultimately be held accountable for the overall performance of the SMS and ensuring that appropriate corrective actions are taken to addresses hazard reports and respond to accidents and incidents [1]. The accountable executive's authorities and responsibilities include at least the following:

- Provisioning and allocation of human, technical, financial, or other resources necessary for the effective and efficient performance of the SMS.
- Direct responsibility for the conduct of the organization's affairs.
- Final authority over operations under the certificate approval of the organization.
- Establishment and promotion of the safety policy.
- Establishment of the organization's safety objectives and safety targets.
- Acting as the organization's safety champion.
- Having final responsibility for the resolution of all safety issues.
- Establishing and maintaining the organization's competence to learn from the analysis of data collected through its safety reporting system.

In addition to the accountable executive, the appointment of a qualified safety executive is key to the success of the SMS. The service provider must appoint a qualified safety manager to be responsible for development, implementation, and operation of the SMS. Typical qualifications are outlined in the International Civil Aviation Organization (ICAO) document. This person will also advise the accountable executive and line managers on safety management issues. The safety manager is responsible for coordinating and communicating safety issues inside the organization and with external stakeholders [1]. The safety manager's functions include the following:

- Managing the SMS implementation plan on behalf of the accountable executive.
- Performing/facilitating hazard identification and safety risk analysis.
- Monitoring corrective actions and evaluating their results.
- Providing periodic reports on the organization's safety performance.
- Maintaining records and safety documentation.
- Planning and facilitating staff safety training.

- Providing independent advice on safety matters.
- Monitoring safety concerns in the aviation industry and their perceived impact on the organization's operations aimed at service delivery.
- Coordinating and communicating (on behalf of the accountable executive) with the oversight authority and other agencies, as necessary, on issues relating to safety.
- Coordinating and communicating (on behalf of the accountable executive) with other organizations on issues relating to safety.

In essence, the safety manager's responsibilities are monitoring safety and advising the accountable line executive who has ultimate responsibility for the overall safety performance within the organization.

All responsibilities in any safety-related position, including those of senior managers, must be clearly defined, documented, and communicated throughout the organization. In the event subcontractors are used, the service provider is also responsible for ensuring they meet all safety performance requirements, whether or not they implement an SMS. Policies, reporting systems, and safety/quality indicators should reflect this. In addition, the service provider should ensure the subcontractor's emergency response plan (ERP) is developed, relevant to operations, and tested [1].

According to Manuele [18], "Safety is culture-driven, and management establishes the culture" [18]. This culture is comprised of numerous factors, including values, beliefs, rituals, mission, and performance measures. These factors result in a system of expected behaviors, ultimately resulting in overall safety performance—a direct outcome of the culture created. Only the board of directors and senior management are in a position to establish, integrate, and maintain an effective SMS. The role of the person assigned the responsibility for safety within the organization is to monitor safety activities within and to advise and influence management toward achieving a superior safety culture. "Safety considerations must permeate all business decision making." Superior results depend on open communications so that information regarding hazards and risks is unfiltered and considered by top decision makers [18].

Within this first component, ICAO also promotes the development and testing of an ERP within the organization to ensure appropriate actions are taken by individuals to make certain there is an orderly transition from normal operations to those required in an emergency. Under this first component, it is critical that thorough documentation is maintained to include descriptions of SMS components and elements as well as current, related SMS records and documents [1].

3.3 COMPONENT 2: SRM

SRM, the second component of SMS, requires the service provider to have a formal process in place to continuously identify hazards in reactive, proactive, and predictive data-collection modes. Risks are then assessed according to their potential consequences; when deemed to be unacceptable, safety risk controls are built into the system. A follow-up risk management process must be in place to identify and document hazards and eliminate or mitigate the related risks [1].

As part of this second component, management controls the activities of personnel and resources and mitigates safety risks by:

- Setting organizational priorities and assigning tasks.
- Prescribing procedures on how to perform activities or processes.
- Allocating necessary resources.
- Ensuring safety directives and controls are embedded in standard operating procedures (SOPs).
- Ensuring employees adhere to SOPs and safety directives.

To be effective, the service provider shall ensure that all of the following occur [1]:

- Identifying the accountable executive having ultimate responsibility and accountability for the implementation and maintenance of the SMS.
- Clearly defining lines of safety accountability throughout the organization, including direct accountability for safety on the part of senior management.
- Identifying the accountabilities of all members of management with respect to the safety performance of the SMS.
- Documenting and communicating safety responsibilities, accountabilities, and authorities throughout the organization.
- Defining the levels of management with authority to make decisions regarding safety risk tolerability.
- Ensuring safety controls and procedures are embedded in SOPs and that employees comply with them.

According to the ICAO [19], measures of safety performance should focus on how well the system can manage risk. Emphasizing system behaviors to reduce risk allows for meaningful safety performance metrics. The Safety Management International Collaboration Group proposes a safety-measurement method promulgated by Malcolm Sparrow in [20], who proposes the central purpose of regulation is the abatement of risks to society. He suggests the goal is to find the critical problems and fix them. Sparrow's three-tier model follows:

Tier 1—Measures event rates and risk areas or common cause hazards.

Tier 2—Measures the behavior of service provider systems with respect to safety outcomes.

Tier 3—Consists of process and outcome measures to gauge safety interventions of the regulator. Sparrow offers the premise that the requirement for an SMS falls in the overlap between compliance and effective regulation, and, therefore, the need for an SMS is common to all service providers.

Santos-Reyes and Beard [21] considered SMS as it applies to a particular field—namely, fire safety. Their purpose was to develop a proactive system for assessing fire risk through a systemic method of understanding the nature of risk.

A key point in their research was the study of the interaction of the component parts of the system, largely dependent on the environment in which it operates. Key environmental factors influencing the system include physical conditions surrounding the operation, such as weather; economic conditions created by the marketplace and competition; and socio-political characteristics, such as government-imposed regulations. Channels of communication are sometimes constrained by these factors, but necessary messages responding to strengths, weaknesses, opportunities, and threats must not be delayed because they cross necessary system boundaries created by either environmental factors or organizational structure.

Prompt and complete communication requires each part of the organizational system to maintain a somewhat autonomous level of safety. The implication is that the authority to make safety-critical decisions must be maintained at every level in the organizational hierarchy. At the same time, a high level of cohesiveness within the SMS is maintained throughout the enterprise. A strong organizational structure will permit decision-making to be performed throughout by recognizing the independence of decision makers at lower levels, yet they will not forego their interdependence with higher levels throughout the enterprise. Decisions made at every level and within numerous channels of the organization all play a role in creating or minimizing risk. This is particularly true among those designing, managing, or operating the system [21].

Lee [22] developed a model to assess risk by integrating different approaches, including the fuzzy linguistic scale method; the failure mode, effects, and criticality analysis principle; and the as-low-as-reasonably-practical approach. His is a proactive, quantitative methodology that attempts to identify risk before a serious accident occurs. Previous studies had indicated risk factors among airlines categorized in numerous ways. According to Lee, Boeing selected the crew, airline-flight operations, airplane design and performance, airplane maintenance, air traffic control, airport management, and weather information as the seven categories of risk factors. Heinrich [23] had identified human, machine, mission, management, and environment as the appropriate categories, whereas Edwards [24] chose livewire, hardware, software, and environment as the only ones. The International Air Transport Association (IATA) identified five categories: human, organization, machine, environment, and insufficiency of slots [25, 26]. After consideration of those approaches, Lee [22] chose to identify 14 aircraft-specific risk factors. His findings were based on a series of surveys administered among experts, including 21 airline safety supervisors, 10 academics, 13 research departments and Aviation Safety Council experts, and 11 directors of safety management departments in the Taiwanese CAA and two international airports. He listed each according to its importance, hazardousness, and detectability. Risk factors identified include airplane structure; engine system; landing gear and tire system; flight control system; navigation system; hydraulic pressure system; fuel system; automatic driving system; defending ice, eradicating ice, or rain system; fire and smog warning system; cabin pressure, lubrication, and electrical system; ground proximity warning system; auxiliary approaching system; and early-alarm measures.

In terms of risk management, it has been suggested that a strong safety record and experience may be poor predictors of future performance [16]. With the rapid changes in technology being

experienced by the industry, there must be a systemic approach to effectively manage safety. This approach cannot be merely compliance oriented, but must rely on continuous improvement (CI). A TQM approach relying on the following philosophies of Feigenbaum [27] provides the infrastructure for this approach:

- Safety is built in at the beginning.
- Safety is conformance to appropriate specifications.
- All accidents are preventable.
- The goal is zero accidents.
- All employees are involved in accident prevention.
- The focus is customer satisfaction in safety.
- The objective is continuous safety improvement.

The infrastructure becomes a critical part of the overall safety culture. Janicak [14] suggests the culture can be measured through the use of various assessment tools, including perception surveys to measure attitudes and acceptance of the program by employees. They are particularly useful for establishing baselines and monitoring improvements over time. Quizzes are useful for employee demonstration of safety knowledge. Discrete observation of performance may be an indicator of knowledge/ability/ attitude. Economic analysis is also useful in determining gains or losses due to investments in safety.

3.4 COMPONENT 3: SA

SA, the third component of SMS, consists of three distinct elements: safety performance monitoring and measurement, management of change, and CI of SMS [1]. It is important that all three elements are addressed. Safety performance monitoring and measurement require use of a means to verify safety performance and validate the effectiveness of safety risk controls. Safety performance will be compared to performance indicators and SMS safety performance targets. This requires a mandatory or voluntary incident-reporting system to be in place, along with other controls, such as safety studies, reviews, surveys, audits, and internal investigations. Krause reports that all employees, including managers, supervisors, and front-line workers, should be engaged. Indicators are of three types [14]. Trailing indicators are the traditional rulers indicating what the performance has been over a period of time. These include accident records, loss reports, statistics, and cost reports. Current indicators tell how well the organizational processes are currently working. Examples include measures of safe and unsafe acts, incident investigation reports, and safety audits. Leading indicators are measures that can be effective in predicting future safety performance and assessing the outcome actions taken before accidents occur, including such factors as measures of the quality of an audit program, schedule adherence, numbers of repeat incidents, and analysis of process hazard reviews. In every case, performance indicators should be directly tied to the goals and objectives of the safety program. Although it is difficult to demonstrate cause and effect relationships between safety initiatives and goals, if the correct tools are used, it can be done effectively [14].

The second element within this component, management of change, requires the service provider to identify changes that may affect the level of safety risk and proactively manage the risks associated with those changes [1]. Anticipated use of new products or technologies, or redesign of

critical elements already in use, may influence risk. Changes in procedures and methodologies may do the same.

The third element within this component requires the service provider to monitor and assess the effectiveness of the overall SMS process to enable CIs [1]. This requires an ongoing system of internal evaluations and audits. TC has created an assessment guide [3] that attempts to measure the effectiveness of an SMS by considering each of six critical areas to include the safety management plan, documentation, safety oversight, training, quality assurance (QA), and emergency preparedness. Each component is broken into elements; expectations for each of those elements are clearly identified.

Associated questions are then coupled with the expectations. For example, the expectations listed in table 1 are in place for the SMS.

Table 1. Expectations: SMS

Component Element	SMS
Expectations: • An SMS with defined components is established, maintained, and adhered to. • A single SMS is established for holders of multiple operator's certificates with integrated operations. • The SMS is coordinated with the SMS of organizations providing services. • The SMS is appropriate to the size and complexity of the organization.	

The questions listed in table 2 relate directly to the expectations listed in table 1.

Table 2. Questions: SMS

Component Element	SMS
Questions: To the accountable executive: • Has an SMS been established for your organization? • How do you maintain it? • How do you ensure that it is adhered to? • Are you a multiple certificate holder? If so, explain how you have established a single SMS with integrated operations. • How is your SMS coordinated with the SMS of organizations providing services? • How do you ensure that your SMS procedures are appropriate to the size and complexity of your organization? To functional department heads: • Is your organization a multiple certificate holder? If so, explain how you have integrated SMS activities with departments under other certificates. • How are your SMS activities coordinated with the SMS of organizations providing services? To employees: • What is your understanding of your organization's SMS?	

The questions in table 3 are criteria for each of the responses and scores associated with those criteria.

Table 3. Criteria: SMS

Score	Criteria
1	The organization has no aspects of SMS in place.
2	(3) some aspects.
3	A. The organization has an SMS, which has defined components that are established, maintained, and adhered to. B. The SMS is appropriate to the size and complexity of the organization.
4	All of (3) plus some aspects of (5)
5	The organization is a recognized leader in SMS within the aviation industry. A single SMS is established for holders of multiple operator- certificates with integrated operations, and it is coordinated with the SMS of organizations providing services.

There is a clear mapping process from the expectations of TC in the form of components or elements to the questions associated with each and to the criteria used to assess how well the enterprise has conformed to expectations. Responses are compared to measurement criteria and scores assigned according to the responses received. Scores are based on whether criteria are appropriately met and, if they are not, what corrective actions must be taken [3]. Scores are assigned as follows:

1—No documentation or implementation.

2—Partial implementation but not effective.

3—Minimum levels have been met.

3.5, 4, 4.5—Minimum levels have been exceeded and some parts of criteria for a score of 5 have been met.

5—All regulatory requirements have been met and industry best practices have been demonstrated at a very high level.

On any required element for which a score of 3 or more is not achieved, the organization must take corrective action within a specified period of time or have its certificate suspended.

Mathis [28] suggests that early metrics for measuring the effectiveness of programs were failure metrics; that is, they were reactive and measured accidents or incidents after they occurred. As the enterprise fails less, statistical significance deteriorates until there is no longer direction provided as to where to focus efforts. There is a serious lack of evidence as to how to prevent future problems from occurring. This has caused organizations to seek what are referred to as leading indicators to better predict and prevent problems from occurring. These leading indicators are categorized into five topics:

1. Leadership, measured in terms of criteria (such as the percentage of official communications featuring safety topics, reinforcement of safety topics in interactions and

performance appraisals, contributions to safety strategy development, and attendance at safety meetings and training sessions).

2. Supervision, measured in terms of safety-coaching training session numbers, numbers of safety feedbacks to employees, numbers of specific worker behaviors addressed, and employee perceptions regarding supervisor practices.
3. Conditional control of safety issues, measured by safe versus unsafe conditions in the workplace; percentage of unsafe conditions actually addressed and resolved; the discovery of new or previously undetected risks; or projected probabilities that the risk could actually cause harm.
4. Onboarding practices to include the selection, screening, training, and mentoring of new employees.
5. Knowledge/skill-building activities to include coaching and training activities.

Performances are typically evaluated on a numerical scale, with higher numbers representing better performances [28].

Three ways to measure the effectiveness of SMS have been suggested: the results-based approach (analyzes the numbers of accidents, injuries, incidents, etc.), the compliance-based approach (audits the degree of compliance of the SMS using a standard), and the process-based approach (measures the performance of each independent management process that constitutes the SMS). The results-based approach is commonly used because it is easy to implement, inexpensive, and not very time-consuming. The problem is it is limited in scope and does nothing to assess important elements of SMS [29]. At the same time, OSHA prohibits the use of programs that intentionally or unintentionally provide incentives discouraging workers to report hazards or other safety-related problems [30].

The compliance-based approach, dependent on audits to determine level of compliance, is believed to provide the appearance of performance but does not adequately address the way the SMS influences the working environment or conditions created by the organization influencing safety at work. The process-based approach actually measures the component processes within SMS to determine the effectiveness of SMS within the organization, whether the SMS is resilient, and whether it is accepted and actively used by the enterprise. The priority in this approach is performance and actual compliance with prescribed practices is not a significant consideration [29]. The authors suggest that the Tripod method is the most effective evaluation system. It is based on the idea that the most effective way to control risk is to control the environment. The Tripod method recognizes that risks occur as a result of latent errors, as suggested by Reason's Swiss Cheese model. By controlling the environment, latent errors in place prior to any accident, and the ways they can lead to an accident, may be anticipated through various techniques, such as brainstorming, accident scenario inquiries, and field studies. In their work, they identify the 10 basic risk factors and discuss how the Tripod method can be used to identify areas of weakness that may lead to potential accidents. The Tripod method will also indicate whether management is truly committed to the overall SMS operational performance. The main element of the Tripod method is a survey that is administered anonymously to workers in an organization; there are 1500 validated questions in the central database. The tools provide an assessment of the level of compliance of the company's SMS with a specified standard as well as an "assessment of its influence on the working environment and people's working practices." The results measuring the

structural performance and the operational performance are displayed on a radar graph using established SMS criteria.

Gholami reports that rapid changes in technology create hazards and complex risks [31]. A strong evaluation program must identify both the strengths and weaknesses of safety programs as they attempt to compensate for those risks. Evaluations should be done regularly and formally. They must consider both reactive and proactive indicators, and other key performance indicators (KPIs). Evaluations must look for gaps between the existing safety program and the desired one. This gap is not necessarily evident in most organizations because they often attempt to determine effectiveness based largely on performance—and this is not necessarily a strong indicator. Gholami looked at different evaluation tools that considered total safety performance and served to identify gaps in the program. It was found that the tools identified and rated specific elements through audit-type processes by comparing specified standards against actual performance in categories that vary somewhat among the administering organizations. In some cases, the goals are extravagant, but there is usually a passing level provided with guidance toward how to achieve that level and exceed it. The process typically involves an evolutionary approach that guides the organization toward stronger performance over time.

Following a series of studies of audits and their apparent usefulness based on safety incidents, Petersen [32] stated there is little correlation between accident rates and audit results. Virtually no relationship was found between the two, and two cases were found with a negative correlation. The only categories in which strong, positive relationships were found were monetary resources and hazard control. Petersen concluded that a "better measure of safety program effectiveness is the response from the entire organization to questions about the quality of the management systems, which have an effect on human behavior relating to safety." Among other instruments, he proposed surveys to measure employee perceptions to determine strengths and weaknesses of the safety program. In addition to perception surveys, Petersen suggests behavior sampling results, percentage to goal on system improvements, and dollars (claim costs, total costs of safety, etc.) may also be useful indicators of the effectiveness of the safety program.

In terms of an evaluation of the overall program, Janicak [14] suggests using the audit tool. The audit process consists of gathering data on the physical condition of the workplace and on the safety performance. A deficiency tracking system should be devised involving accountable personnel, appropriate standards for correction, a hazard rating according to potential consequence and probability, corrective actions required, and a timetable showing estimated and actual dates of correction. Audit findings should be disseminated throughout the enterprise. Findings should also be compared against performance standards.

Ford [33] indicates that a key component in any performance measurement is establishing a baseline before the intervention begins, stating that this provides the most valid and reliable form of measurement. It is the only way to demonstrate that the intervention had any impact on the organization. Data gathered through the evaluation process should be used to improve the system by eliminating errors and waste. The measurement of error and waste reduction will point to future system improvements. Key questions the evaluation should address include the following:

- Are we addressing the true root causes of the problems?
- Are we staying on budget and schedule?

- How can we improve acceptance of the interventions?
- How can we improve the outcomes?
- Are we following a defined process?
- How can we improve the process?

Ford also points out that the effects of training should be considered using pre- and post-intervention measures [33]. Other factors to review, as pointed out by Brinkerhoff [34], include the following:

- Goal setting to determine if intended organizational and individual benefits are identified in advance.
- Program design to ensure the design for complete, feasible, and organizational compatibility.
- Program implementation to determine if the proposed interventions are working as planned and, if needed, revisions are being made.
- Immediate outcomes to determine if participants achieved the intended level of skills, knowledge, and attitude (SKA).
- Usage outcomes to determine if participants are correctly applying new SKA on the job.
- Impacts and value to determine if the organization is benefiting and whether interventions produced a positive return on investment.

In any case, stakeholders, including customers, should be queried to determine if they are also satisfied with the implementation process, interventions, and outcomes. When there are others with a stake in the process, they should also be embracing the changes
implemented [33].

The Australian Institute of Management [35] applies a systematic approach toward assessment as a part of CI. Their approach consists of selection of data based on its relevance to standards. Evaluators are particularly concerned with satisfaction rates, competency completion rates, outcomes of complaints and appeals processes, outcomes of management processes, and opportunities for improvement by staff and stakeholders. Data are collected using a variety of methods to help ensure validity. Their primary method is through written surveys of participants and employers. Quantitative data are collected online and evaluated in key service areas. Performance indicators from a learner or employee perspective include training quality, work readiness, training conditions, and learner engagement. From the employer perspective, performance indicators include training quality, work readiness, and training conditions. Qualitative data are collected from evaluations, complaints and appeals, and audit results. Findings are used to identify opportunities for improvement. Once improvements have been identified, they are clearly defined with responsibilities and guidance. Data continue to be collected to ensure improvements as delineated. A CI reporting procedure remains in place throughout in terms of regular (at least monthly) CI meetings and CI forms collected and reviewed at the periodic meetings [35].

In CI process evaluation, the state of Minnesota [36] attempts to provide agencies with a simple and objective way to measure their progress in CI and outline steps to follow in the future. They

consider each of five categories to include leadership, organizational knowledge and awareness, organizational infrastructure and deployment, results, and sustainment.

In reviewing leadership, they award points for the demonstrated understanding of CI and its level of requirement and use within an agency. Once scores are assigned, specific directions are given based on the scores. For example, if a score is 2–4, senior leadership must consider creating a leadership team to create and monitor a plan of action, identifying and allocating time and resources to create a CI program/effort, and consistently communicating to staff regarding intentions to develop and grow CI efforts.

For organizational knowledge and awareness, the level of training in techniques and tools and the ability to implement improvement changes are measured. Consideration is given to levels of participation in training and the amounts of training provided [36]. For organizational infrastructure and deployment, reviews of dedicated internal resources (money and/or staff time) to lead and participate in efforts are performed. Consideration is given to resources devoted to communicating and growing the use of CI tools within the service enterprise. In terms of results, a review of measureable, positive outcomes using CI tools and techniques within the service provider is performed. Criteria include improved customer service, reduced costs, and improved employee engagement and morale. There must be measures in place to demonstrate the effectiveness of improvements being implemented. The final consideration is sustainment, whereby the service provider demonstrates a clear commitment to CI to enable training and other resource investments, process improvement efforts, and results to be sustained beyond the current year. A measurement system is in place that directly correlates with efforts to improve over time. At each and every level, scores are assigned and specific, prescribed actions are considered based on those scores.

3.5 COMPONENT 4: SP

The fourth major component of an SMS is promotion to encourage a positive safety culture and environment conducive to the accomplishment of safety objectives [1]. It is characterized by the safety values, attitudes, and behaviors exhibited within the organization. Current safety information and training appropriate for staff, regardless of their level within the service provider, are indicative of management commitment to an effective SMS [1]. Personnel must be trained so that they are capable of performing their jobs safely. At the senior level, management must also obtain familiarity with regulatory and organizational safety requirements. They should also be aware of techniques for establishing safety targets and their own accountability in attempting to meet those targets [1]. This requires an effective communication system, as well as integration of SMS into the overall management system, with clear SPIs identified and monitored. When deviations occur, management must be alerted and must understand the appropriate response measures. Krause [37] suggests that organizations tend to corrupt the methodologies employed by rushing into them without committing appropriate or adequate resources. Thus, the tools do not work and the causal factors remain unknown.

Regardless of scores, Krause reports the use of visual and verbal feedback provides reinforcement for safety-related behaviors and improvement efforts. Historically, causes of accidents have been divided into two major categories—worker-related, for which the employee made an error or caused the problem; or facilities-related, for which maintenance, equipment, or design problems

resulted in an accident. Despite popular thinking, Krause suggests that a problem is rarely caused by the employee. Following an extensive causal analysis of injuries in various organizations over multiple years, Krause reports in most cases, actual causes of injuries are typically due to interactions between the worker and the facility. To reduce these injuries and improve safety, the enterprise must systematically define and improve these critically important interactions between the worker and facility. Engaging the employee in the improvement process will also serve as a catalyst in this process. Krause suggests that employees value safe performance, and this is reinforced as it improves and as feedback regarding behavior is obtained. Feedback is based on behavioral observations used to plan improvements, and the focus is on improving the system and its components rather than on the individual. System components include facilities, equipment, design, maintenance, and other less obvious mechanisms, such as purchasing and decision-making [37].

According to Krause [37], certain behaviors, identified as enabled, are within the employee's control. For example, the employee may or may not use an appropriate safety device. The behavior is non-enabled if the employee has no access to the device. This behavior may be difficult if obtaining the use of the device is time consuming or challenging. This would be the case if the employee must travel a long distance to obtain the device or if it is otherwise not readily available. Krause determined that non-enabled and difficult behaviors often occur more frequently than enabled behaviors. By identifying critical behaviors, Krause suggests employees who work unsafely are not necessarily doing so because they are at fault or to blame but because barriers that interfere with their efforts to work safely are in place. Exposure to technology and other variables having an adverse effect on safe performance may actually be signal indicators to overall problems in the system. Potential problems can be pinpointed by identifying and studying critical safety behaviors within the employee population [37].

Janicak [14] points out the five safety indicators of leadership: two-way communications; employee involvement (i.e., participation in risk identification, assessment, and hazard control); learning culture or applying lessons learned from previous accidents and analysis of unsafe acts; and attitude toward blame or focusing on the cause of accidents rather than placing blame. Cooper [38] defined safety culture as consisting of psychological, behavioral, and situational or corporate aspects. Psychological aspects include employee perceptions of safety
and the SMS in place [14]. Petersen [39] stated there are six elements necessary to achieve a safety culture:

1. A system must be in place to ensure daily proactive supervisory (or team) activities.
2. The system must actively ensure that middle management tasks and activities are conducted in three areas:

    - Ensuring subordinate (supervisory or team) regular performance
    - Ensuring the quality of that performance
    - Engaging in certain well-defined activities to show that safety is so important that even upper-level managers are addressing it

3. Top management must visibly demonstrate that safety has a high value in the organization.

4. Any worker who chooses to do so should be able to be actively engaged in meaningful safety-related activities.
5. The safety system must be flexible, allowing choices of activities at all levels to obtain ownership.
6. The workforce must see the safety effort as positive.

Many view safety as the absence of accidents or incidents or as an acceptable level of risk at which few things go wrong [40]. According to traditional beliefs in safety, termed by this article as Safety I, things go wrong because of failures—technical, human, or organizational. When things go right, it is because the system functions and people work as planned. Things go wrong when something has malfunctioned or failed. The two modes are assumed to be different and the purpose of safety management is to ensure that the system remains in the first mode and never wanders into the second. Humans are often viewed as a liability or hazard. These beliefs were formulated when organizational systems were simpler and could easily be broken into component parts and diagnosed as working or not working. In a more complex world where systems cannot be meaningfully separated and diagnosed individually, this model no longer works. Safety I does not explain why things go right, only why things go wrong. Specifically, it does not account for human performance in relation to things going right. This performance is not necessarily a result of individuals being told what and how to do things, but may be a result of people adjusting their work to the conditions within which they work. As systems develop and change, these adjustments become increasingly important. The challenge is to understand the adjustments and why safety performance goes right [40].

Safety management should move away from attempting to eliminate things that go wrong and toward ensuring that as many things as possible go right [40]. This concept is termed Safety II, and it relates to the organizational ability to operate successfully under various evolving and changing conditions. The challenge in the management of safety is to attempt to anticipate various developments and events and their resulting conditions. Thus, an investigation considers how things usually go right as a basis for understanding how things went wrong. Risk assessment attempts to understand conditions in which performance variability can be difficult or even impossible to monitor and control. Understanding and embracing Safety II does not eliminate the need for practices that have historically been based on Safety I, but it does require the service enterprise to consider the incorporation of additional beliefs and techniques not previously incorporated into the SMS [40].

The whole concept moves toward ensuring that safety management investigates why things went right and then works toward ensuring that those things continue to happen [40]. Failures should not be considered unique, but rather expressions of everyday performance variability. It is likely that something that goes wrong will have likely gone right many times in the past and will likely go right multiple times in the future. When something goes wrong, the emphasis should be on finding how it usually goes right instead of focusing on the anomalies that only explain the cause of one specific incident. Ensuring that things go right cannot be accomplished by simply responding to problems but requires interventions prior to the problems manifesting themselves [40].

Events are usually explained by tracing back from event to cause(s). The causes are then associated with some component, function, or event that typically failed. Although the adverse outcome is,

in fact, real, it may be due to transient conditions particular to that time and space. The observed, final outcome is real, but the conditions leading to that outcome may be gone. It may therefore be impossible to identify, eliminate, or control those conditions [40].

Safety I and II are not considered in opposition to one another and should be considered complementary [40]. Safety I approaches and techniques can therefore be complemented by the Safety II additions. These additions will require consideration of events and conditions that occur regularly. A focus on frequency should be emphasized more than once on severity. This will mean careful consideration of things that go right, analyses of how things work, and management of performance variability rather than just constraining it [40].

3.6 IMPLEMENTATION OF SMS

In the overall process, it is important for management to understand that SMS is accomplished through implementation in a series of phases [1].

According to Yu [16], plans for implementation should always consider that similar approaches encourage a flat organizational structure; further, enterprises should be open to change in culture and shifts in management philosophies. This will require full commitment and participation by all to include significant time commitments in meetings and ongoing follow-up activities. There must also be clarity of roles and expectations. Executives must embrace a more democratic style of management, yet make it clear that although individual ideas will not always be accepted and implemented, they will be considered. Yu suggests the following phases are critical for implementation of a successful SMS:

Phase 1: Review safety policy and safety plan. The safety policy, clearly defined and promulgated to all employees, is an integral part of the business strategic plan. Management also shows the commitment for allocating resources and priority for safety issues in the safety policy and plan.

Phase 2: Examine hazard identification and control plans and involve all workers in the process to enhance their personal ownership of the program. Roles and responsibilities are clearly defined. Training is provided for those lacking knowledge and skills in identifying and controlling risk.

Phase 3: Evaluate safety management practices. Employees are empowered to work safely and have the right to refuse unsafe jobs. Critical safety-related behaviors are observed, measured, and analyzed by statistical techniques with feedback to employees for improving safety. Education and training are ongoing to ensure adequate knowledge and skills to work safely. Management and employees continuously work to reduce unsafe practices.

Phase 4: Incident investigation and emergency plans are clearly described and made known. Teams are involved in incident investigation and emergency-plan implementation with continuous efforts to reduce variation in practices. The costs of both safety and of accidents are calculated and compared.

Phase 5: Analyze safety communication and documentation. SMS is well-planned and documented with hazards recorded and communicated to employees. All safety management practices and standards are documented and made available to employees for reference. Safety committees and

safety teams are established, and safety roles and responsibilities are written into job descriptions and work instructions. Employees know their duties regarding safety.

Phase 6: Review safety program evaluation and audits. Safety programs are constantly reviewed to assure that TQM philosophy and safety management briefs have been incorporated. Audits are structured to serve as useful tools for providing feedback for continuous safety improvement.

As initiation of SMS is considered and service providers move toward complete integration of processes, Edwards [41] sets forth a five-phase implementation by the Cornerstone Consulting Group:

Phase 1: Define the engagement in terms of purpose, audience, and how the findings will be used, as these are critical considerations in building the assessment instrument.

Phase 2: Establish an information base including progress reports, mission statements, program manuals, and formal evaluations. The challenge is to determine what is most important and target those items.

Phase 3: Capture individual perspectives of stakeholders through structured interviews with project leaders and other constituency groups. Interviews should offer anonymity and time for personal reflection. The goal should be to analyze achievements, challenges, and elements considered critical by stakeholders.

Phase 4: Prepare a report providing an accurate and informed view of the service provider's status and direction. The document should be reviewed by participants before being finalized for broader distribution.

Phase 5: Present the report in a formal setting in which participants can reflect and react. This will allow participants to reflect on whether they are following the right course, how others view their efforts and achievements, and necessary changes. This report becomes a critical tool for charting the future course of the service provider.

Companies must realize that this overall approach is not a quick fix but is implemented over a realistic time frame, permitting the organizational culture to adapt and evolve as the new concepts, principles, and techniques are applied [16].

A four-phase implementation of SMS has been outlined to include the following steps and timelines [1]:

Phase 1: During this phase, basic planning and assigning of responsibilities occurs. An implementation team and plan are established and a gap analysis is performed. Key safety personnel will be appointed, training and education planned, and a strong safety communication system put into place. Phase 1 is expected to take approximately 12 months.

Phase 2: This phase consists of implementing essential safety management processes while correcting potential deficiencies in safety management processes. Safety policies will be developed and communicated, accountabilities established, the ERP coordinated, and an SMS

documentation system set up and made operational. Phase 2 is also expected to take approximately 12 months.

Phase 3: The objective of Phase 3 is to establish safety risk-management processes. By the end of this phase, the organization will be ready to collect safety data and perform analyses based on information found. This phase involves managing change and developing processes and documentation for CI. Phase 3 is expected to take approximately 18 months.

Phase 4: This phase involves mature implementation of SRM and SA. All of the above elements, including management commitment and responsibility, hazard identification, safety performance monitoring and measuring, CI, training and education, and safety communication are fully implemented and operating in the CI mode. Phase 4 is expected to take approximately 18 months.

Each of these phases, their respective elements, and component parts are carefully outlined by the ICAO in its 3rd edition of its *Safety Management Manual* (Doc 9859 AN/474, 2013). They could be very useful in delineating levels of maturity among service providers implementing an SMS. Throughout all phases, safety documentation, training and education, and safety communication are progressively implemented. Table 4 outlines the steps and timetables expected by the ICAO in the implementation of an SMS program.

Table 4. Four phases of SMS implementation [1]

Phase 1 (12 months*)	Phase 2 (12 months)	Phase 3 (18 months)	Phase 4 (18 months)
1. SMS Element 1.1 (I): a) Identify the SMS accountable executive; b) Establish an SMS implementation team; c) Define the scope of the SMS; d) Perform an SMS gap analysis. 2. SMS Element 1.3: a) Develop an SMS gap analysis. 3. SMS Element 1.3: a) Establish a key person/office responsible for the administration and maintenance of the SMS. 4. SMS Element 4.1 (I): a) Establish an SMS training programme for personnel, with priority for the SMS implementation team. 5. SMS Element 4.2 (I): a) Initiate SMS/safety communication channels.	1. SMS Element 1.1 (II): a) Establish the safety policy and objectives, 2. SMS Element 1.2: a) Define safety management responsibilities and accountabilities across relevant departments of the organization; b) Establish an SMS/safety coordination mechanism/committee; c) Establish departmental/divisional SAGs where applicable. 3. SMS Element 1.4: a) Establish an emergency response plan. 4. SMS Element 1.5 (II) a) Initiate progressive development of an SMS document/manual and other supporting documentation.	1. SMS Element 2.1 (I): a) Establish a voluntary hazard reporting procedure. 2. SMS element 2.2: a) Establish safety risk management procedures. 3. SMS Element 3.1 (I): a) Establish occurrence reporting and investigation procedures; b) Establish a safety data collection and processing system for high-consequence outcomes; c) Develop high-consequence SPIs and associated targets and alert settings. 4. SMS Element 3.2: a) Establish a management of change procedure that includes safety risk assessment. 5. SMS Element 3.3 (I): a) Establish an internal quality audit programme; b) Establish an external quality audit programme.	1. SMS Element 1.1 (III): a) Enhance the existing disciplinary procedure/policy with due consideration of unintentional errors or mistakes from deliberate or gross violations. 2. SMS Element 2.1 (II): a) Integrate hazards identified from occurrence investigation reports with the voluntary hazard reporting system; b) Integrate hazard identification and risk management procedures with the subcontractor's or customer's SMS where applicable. 3. SMS Element 3.1 (II): a) Enhance the safety data collection and processing system to include lower-consequence events; b) Develop lower-consequence SPIs and associated targets/alert settings. 4. SMS Element 3.3 (II): a) Establish SMS audit programmers or integrate them into existing internal and external audit programmes; b) Establish other operational SMS review/survey programmes where appropriate. 5. SMS Element 4.1 (II): a) Ensure that the SMS training programme for all relevant personnel has been completed. 6. SMS Element 4.2 (II): a) Promote safety information sharing and exchange internally and externally.
SMS Element 1.5: SMS documentation (Phases 1 to 4)			
SMS Elements 4.1 and 4.2: SMS training, education and communication (Phases 1 and thereafter)			
Note 1. — The implementation period indicated is an approximation. The actual implementation period is dependent on the scope of actions required for each element allocated and the size/complexity of the organization. Note 2. — The SMS element numbers indicated correspond to the ICAO SMS element numbers. Suffixes such as a), b) and c) indicate that the element has been subdivided to facilitate the phased implementation approach.			

3.7 REVIEW SYNOPSIS

The overall goal of SMS is to ensure safe operation of aircraft through effective management of safety risk [1]. The system should continuously improve safety by identifying hazards, collecting and analyzing data, and continuously assessing risks. In spite of best efforts, there are some potential problems or pitfalls. Arendt and Adamski [2] propose that there must first be a thorough understanding of the system, its components, and the operating environment. This implies the establishment of performance expectations, setting goals related to that performance, identifying activities to reach those goals, and continuously measuring and improving performance to ensure goals are, in fact, being met.

Under Component 1, SPO, the service providers will establish goals by seeking input from key stakeholders [1], and their input will be reviewed throughout the SMS development process and, periodically, once implementation has occurred. Consideration will not only be given to safety standards, but to accountabilities and how safety performance will be reviewed by senior safety management. There will be zero tolerance for unsafe acts [15]. Senior management must ensure a teamwork culture exists throughout the organization with an ongoing and active demonstration of commitment to the program and a continuous effort to reduce errors, simplify processes, and reduce variations in routine operations [16].

Within the second component, SRM, the service provider must implement a formal process to continuously identify hazards in both reactive and proactive, or predictive, data-collection modes. This process must be able to identify, document, and eliminate or mitigate hazards. It requires a clear allocation of necessary resources and insurance that safety directives and controls are embedded in all SOPs. Accountabilities and responsibilities must be defined, communicated, measured, and controlled throughout the organization. Safety performance is then measured by how well the system and its components manage risk [1].

Empathy, team play, and recognition-sharing are all vital to the system [17]. Leaders must also be willing to recognize and admit their own mistakes. The authority and ability to adjust individual parts of the system at lower levels must be maintained and communicated throughout the enterprise [20]. Risk factors must be identified, characterized as to hazardousness and potential severity, and mitigated or eliminated before problems occur [22]. A critical consideration is that any approach taken cannot be merely compliance-oriented but must also rely on CI [16]. This will be evidenced by appropriate infrastructure, implementation, and performance, as measured by perception surveys; quizzes to employees; discrete observations of performance as indicators of knowledge, abilities, and attitudes; and economic analysis to determine gains or losses due to investments in safety [14]. Safety is culture driven and only the board of directors and senior management are in positions to establish, integrate, and maintain an effective SMS [18].

The third component of SMS, SA, requires safety performance to be compared to appropriate metrics and targets [1]. A mandatory or voluntary incident-reporting system must be in place along with other controls, such as safety studies, reviews, audits, and investigations. All employees must be engaged in the SMS, and system effectiveness must be monitored and assessed through internal evaluations to enable improvements. Six critical areas, including the safety management plan, documentation, safety oversight, training, QA, and emergency preparedness must all be measured to determine conformance to expectations, whether criteria are met, and what corrective actions,

if any, must be taken [3]. Mathis [28] also suggests evaluation of leading indicators to predict and prevent future problems. These include leadership, supervision, conditional control of safety issues, onboarding practices, and knowledge/skill-building activities. Cambon et al. [29] identified 10 basic risk factors and discussed how a validated survey can be used to identify areas of weakness and indicate whether management is truly committed to SMS. Petersen [32] indicated the only categories showing strong, positive relationships with safety performance were monetary resources committed and hazard controls in place. He proposed using surveys to measure strengths and weaknesses of the SMS and suggested indicators of effectiveness may include behavior sampling, percentage to goal on system improvements, and return on safety investments. The AIM [35] proposes satisfaction rates, competency completion rates, outcomes of complaints and appeals processes, outcomes of management processes, and opportunities for improvement by staff and stakeholders as useful indicators that can be evidenced through surveys. Numerous others have also provided direction and instruction on critical components and methods of measurement to guide evaluators of SMS programs in gauging their effectiveness.

The fourth major component of SMS, promotion, encourages a positive safety culture and environment conducive to the accomplishment of safety objectives [1]. It implies dissemination of current safety information and the use of effective and ongoing safety training programs. This component requires senior management to be familiar with regulatory and organizational safety requirements and integrate SMS into the overall management system. Clear SPIs are identified and monitored. Krause [37] suggests that problems occur when management fails to commit adequate resources. He also emphasizes the need for feedback to reinforce safety-related behaviors and improvement efforts. Additionally, Krause stresses the need to engage employees in the improvement process. He emphasizes improving the system and its components rather than the individual employee, but he states that critical behaviors must be identified and studied.

Janicak [14] states that the safety indicators of leadership include two-way communications, employee involvement, learning culture, and attitude toward causation rather than blame. Cooper [38] states that safety culture consists of psychological, behavioral, and situational or corporate aspects. Petersen [39] outlines elements needed to achieve a safety culture: a system to ensure proactive supervisory or team activities with middle management appropriately engaged, high-visibility top-management participation, encouragement of workers to engage in meaningful safety activities, flexibility, and positive perception of the safety effort.

The challenge in the management of safety is attempting to anticipate developments and their resulting conditions [40]. This may require companies to consider not only why things went wrong, but also why they went right, and to intervene prior to problems manifesting themselves. Management must embrace a participatory culture and maintain clarity of roles and expectations [16].

Management must also understand that SMS does not occur in one step but develops through phased implementation [1]. Phase 1 involves performing a gap analysis, planning, and assigning responsibilities in key safety positions while a strong communication system is put into place. In Phase 2, safety-management processes are implemented and deficiencies in them are corrected. Also, policies regarding safety are developed and communicated, and accountabilities are established. The SMS documentation system is set up and made operational. In Phase 3, SRM processes are established, safety data are collected, and analysis is performed. Phase 4 is the mature

implementation of SRM and assurance. At this point, management commitment and responsibility, hazard identification, safety performance monitoring and measuring, training and education, and safety communication are fully implemented and operating in the CI mode.

SMS is both a philosophy and a methodology. It requires a full commitment to safety from the very top of the organization to every employee on the front line. The commitment involves both financial and human resources and must be recognized throughout the organization. SMS will not happen overnight but will typically take place over a period of five years. Each phase is critical and success is fully dependent on both compliance to SMS procedures and commitment to performance objectives. Ultimately, a safety-based culture is embedded in a safety-oriented management system developed and continuously improved through the efforts of members in every level of the organization.

Although the specific components of SMS are clearly defined and phases outlined, there is no clear path toward evaluating its effectiveness. Some efforts have been made toward building evaluation tools, but close examination of those tools always reveals shortcomings. Clear indicators of success also appear to be lacking. For example, with the assessment tool by
TC [3], it simply evaluates an enterprise on whether it has a policy in place and a few other criteria that really do little to help evaluate its effectiveness. There are few performance criteria in any of evaluation tools; therefore, much is left to the judgment of the person performing the assessment. By integrating information found in the literature and continuing to explore new contributions to the literature, the basis for a strong evaluation tool can be explored. The goal is to make the tool as objective as possible to provide a high level of reliability. This can only occur with input from industry representatives. The next phase involved personal interviews with experts in the field who provided input pertaining to their history and experience with SMS. This was done by structured telephone and onsite interviews with safety professionals in charge of, and responsible for, the implementation and operation of SMS in various aviation organizations.

4. INTERVIEWS

4.1 TELEPHONE AND PERSONAL INTERVIEW RESULTS

A total of 22 structured interviews were completed between September 2014 and April 2015 for the purpose of (a) providing increased understanding of SMS implementation and (b) revising the draft survey tool that will be used for collecting data for the DEA model-building process. Most of the interviewees were from major air carriers, but some were from airports, airport authorities, fixed-base operators, manufacturers, international air carriers, and others. Also included were a few from Canada. The 12 guiding questions used are shown in appendix A.

A qualitative analysis of these interviews was done using NVivo—a qualitative research tool that allowed the researchers to collect, organize, and analyze content from interview discussions and then perform pattern matching to uncover even subtle trends—and other analyses. Figure 1 shows interviews by type of organization, and figure 2 shows interviews by country; predominately international U.S. air carriers were interviewed.

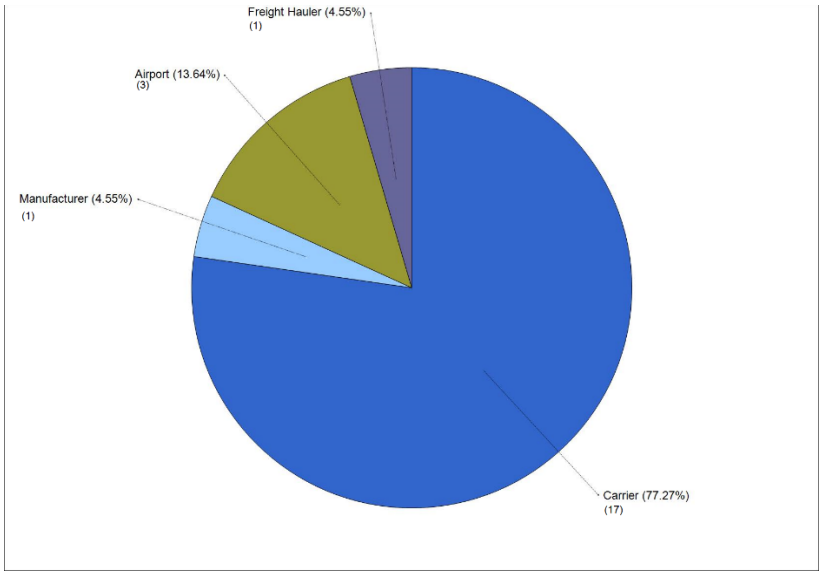

Figure 1. Interviews by type of organization

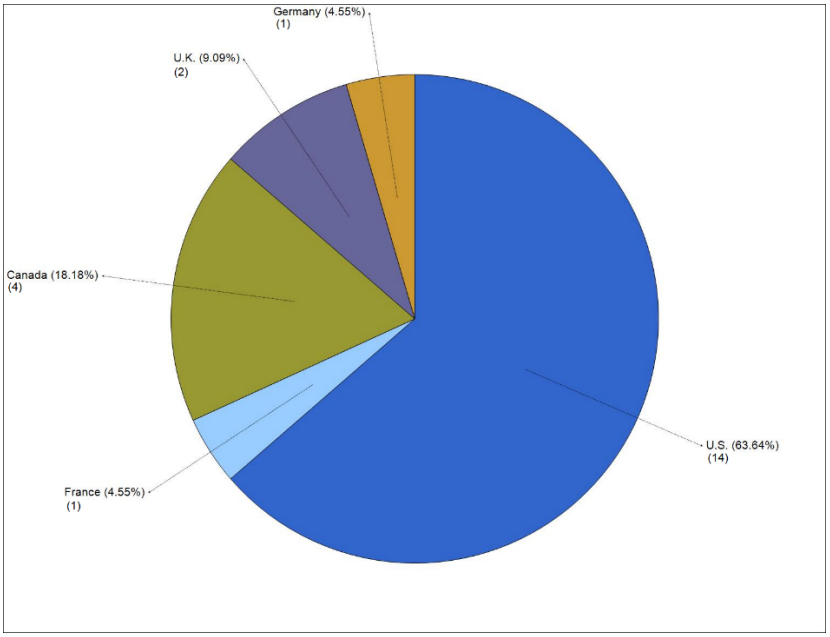

Figure 2. Interviews by country

Interviews use structured questions administered mostly by phone and, in a few cases, in person. Open-ended responses were summarized by interviewers and then categorically coded. First-pass coding is shown in appendix B, with consolidated coding shown in appendix C. The coding was not unique (i.e., for a given question, the response may have resulted in more than one category).

The consolidated coding in appendix C was intersected with interviewee attributes of organizational type, country, and route structure to create the detailed results in appendices D–N. Question 12 asked what other organizations should be interviewed and was used to identify additional respondents; as such, it is not included in these results.

In addition to categorical coding by questions, themes were also coded. Themes are discussed after the presentation of categorical results.

Q01: On a scale of 1-10, how would you personally rate the effectiveness of SMS in your organization?

Most U.S.-based organizations rated themselves between 7 and 9, whereas Canadian-based organizations rated themselves between 5 and 7. Four organizations did not use the numbering system provided ("SMS_Eff_00_NotRanked" in the appendices), instead suggesting they were in compliance with regulatory authorities or would rather not answer because they were not yet fully implemented.

Q02: How did you go about tying SMS to the overall mission of the organization?

Integration of SMS into the business model, corporate values, and operations were the most common answers along with adapting existing safety policies to SMS. Many respondents noted their approach as a top-down implementation method. One airport and one carrier cited an FAA pilot program as part of their implementation process.

Q03: How did you determine allocation of resources toward SMS? Is there guidance you can provide for other organizations?

Personnel was emphasized as a resource by many respondents, including having dedicated SMS personnel for six respondents. Making SMS part of the business model and integration into the entire system were also popular themes. Notably, only one respondent mentioned a gap analysis.

Q04: How do you evaluate the effectiveness of SMS within your organization? What are the metrics and measures you use for evaluating effectiveness? Do you weight the variables you consider based on importance? If so, how? May I have a copy of the tool(s) used? Who performs these assessments and how are the results reported?

Audits were mentioned most frequently as a way to evaluate SMS effectiveness, followed closely by no formal method. Figure 3 shows a word tree of how audits were captured by interviewers. Some organizations used dashboards and SPIs/KPIs. Some made mention of an internal evaluation program (IEP) to measure SMS effectiveness and monitoring trends. Only one respondent mentioned the use of variable weighting.

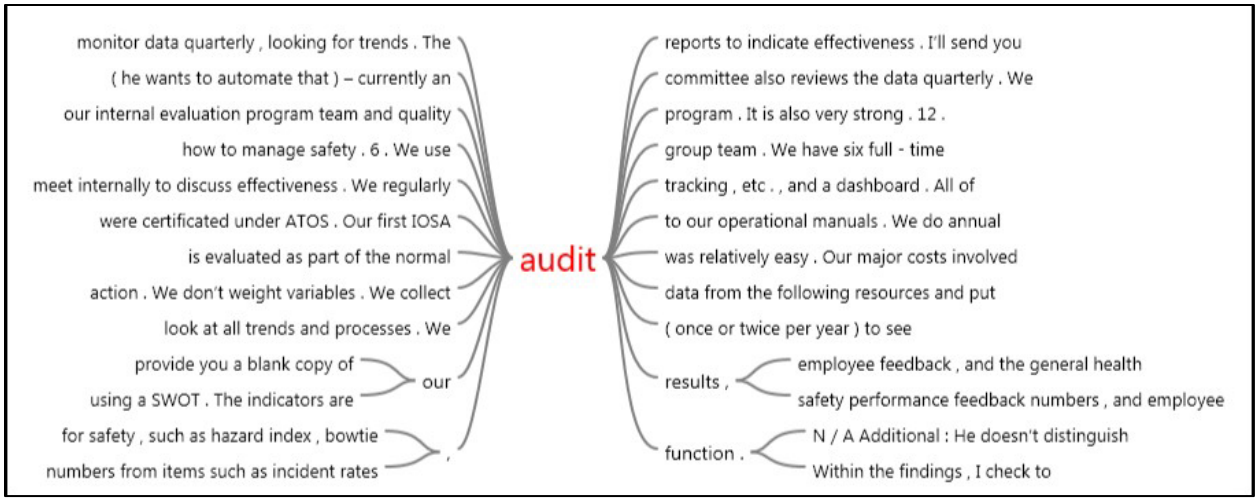

Figure 3. "Audit" word tree

Q05: How do you ensure that the system is continuously improving?

Trending was reported by six respondents, followed closely by four respondents who had no method to gauge CI. Similar to question 4, audits, trends, and SPIs/KPIs were used by some respondents to gauge CI.

Q06: Do you generate reports that indicate effectiveness of the SMS? Can we see these?

Most organizations reported no specific SMS reports. For those who did have reports, there was no standout theme; rather, methods included baselines and goals, SPIs/KPIs, audit reports/safety standards reports, trend charts, and score cards. Some interviewees were unwilling to share details.

Q07. How is SMS built into performance appraisals?

By far, the most common answer was that SMS was not specifically included in performance appraisals, although safety generally was included. Of the 22 organizations interviewed, only three clearly indicated that SMS was included in performance appraisals.

Q08. What is the job title of the person responsible for the overall operation of SMS in your organization? What is the relationship of this person on the organizational chart within the overall management of the organization? What are the job titles of his or her direct reports?

The CEO, chief operating (COO), or president was most commonly responsible for SMS in organizations. Other SMS responsible parties were at the vice presidential level or assigned to the SMS manager. No airport assigned the SMS role to the CEO, COO, or president.

Q09. On average, how much time is spent annually per person in training on SMS at each of the following levels (top, middle, line management, non-management)?

Most organizations invested less than 6 hours per year on annual SMS training, with many investing less than 2 hours per year. There were some indications that management may receive more training than non-management employees.

Q10. Can you show me examples of SMS implementation within your organization? Can you tell me how the results are evaluated?

Many organizations did not share examples of their SMS implementation. For those that did share, trends were a weak theme.

Q11. Are there features of your SMS that may be unique and could provide assistance to others?

Answers to this question presented no emergent theme, but a range of ideas. Refer to the tables in appendix N for the complete list.

Observed Themes:

Software solutions for SMS was the most commonly observed theme, mentioned approximately 12 times. Respondents emphasized the importance of their current software. Three out of the four Canadian respondents found regulatory guidance inconsistent and two mentioned the use of IOSAs. Figures 4 and 5 show U.S. and Canadian operators, respectively, with their self-ratings of SMS effectiveness and select themes.

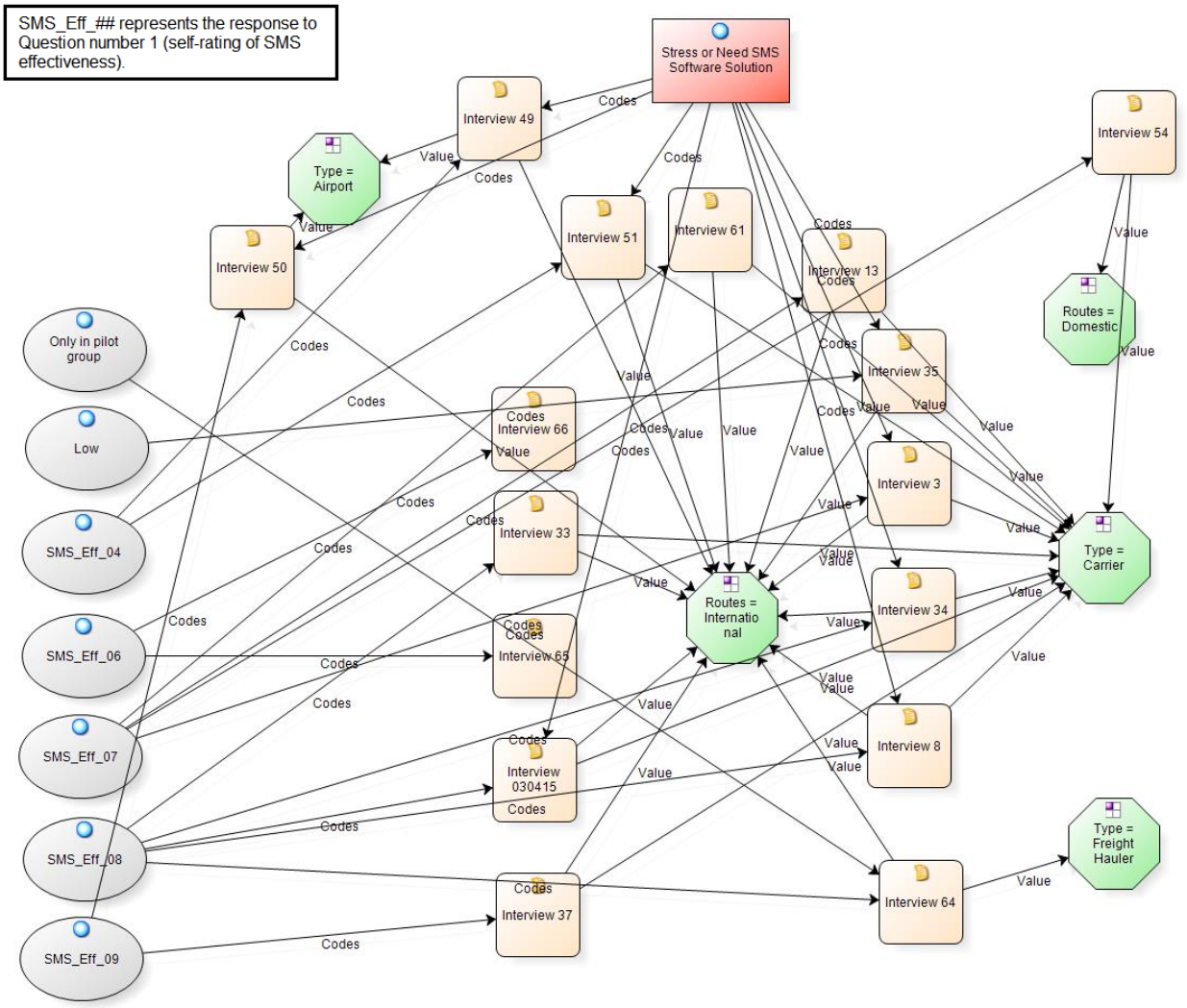

Figure 4. U.S. organizations with select categories and themes

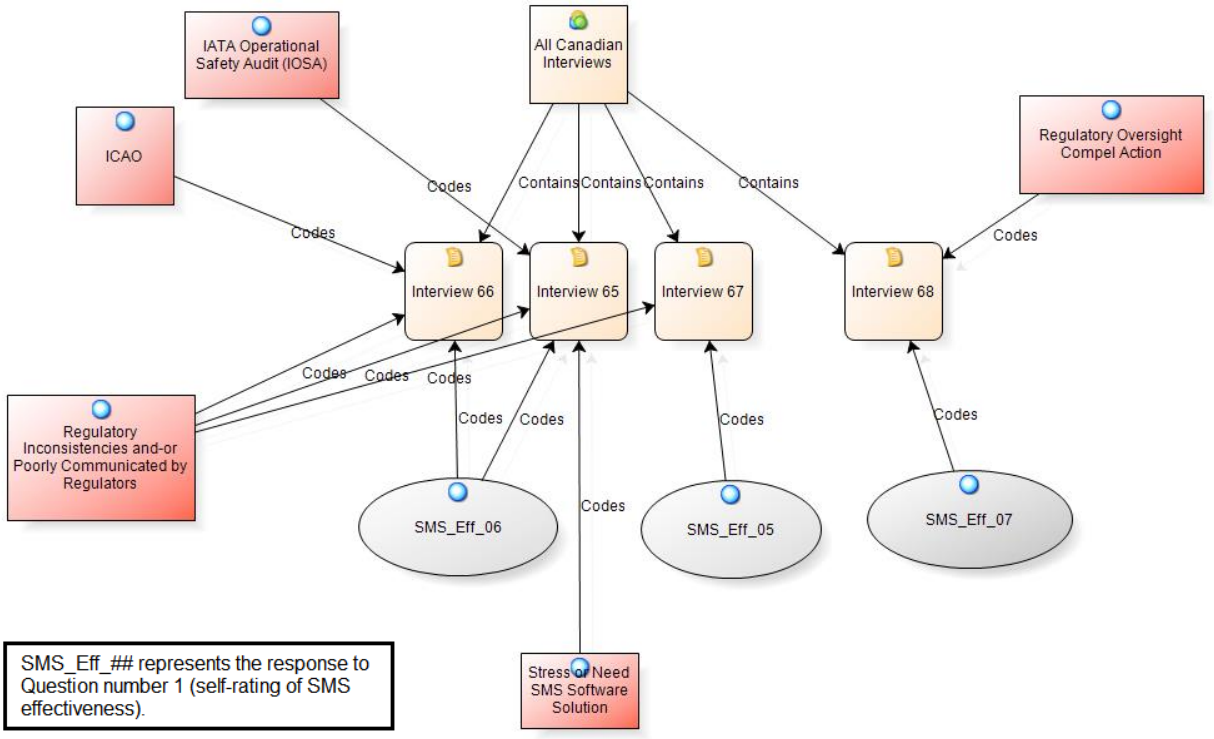

Figure 5. Canadian operators with select categories and themes

4.1.1 SMS Interview Results Summary

4.1.1.1 Where Do They Stand?

When asked about the effectiveness of SMS within their respective organizations, most organizations expressed the opinion that they were in the 7–9 range on a scale of 1–10. The lowest scores were two 4s and 5s. Interestingly, the Canadian organizations typically responded they were operating in the 5–6 range. U.S. companies responded with higher numbers.

4.1.1.2 How Does SMS Fit?

More progressive companies met with stakeholders to buy-in on SMS before it was ever implemented. They attempted to integrate SMS by aligning it with corporate objectives and realigning current safety objectives with SMS principles. The idea was to link it to the corporate strategic vision and get the attention of the whole organization. At the same time, they attempted to integrate SMS with work at every level throughout the company. Ideally, SMS began with a commitment from the CEO, as noted in written correspondence, and was then endorsed level-by-level throughout the company. It was driven down to individual operational groups and embraced as part of the work rather than as a separate task. Individuals were given specific SMS responsibilities within appropriate departments that they typically assumed in addition to their regular work. Attempts are made to solve problems by mitigating hazards and making corrections at the working levels before the problems make their way to upper-management levels. When there is a new product design or change made, one company attempts to play out every possible scenario

and spends time interacting with customers before the product is released. SMS is integrated into every aspect of the system from buying materials to supplying products to end users.

In some cases, full-time SMS personnel were selected and placed in key positions throughout the company. The SMS personnel report to the corporate safety director, who then reports to the accountable executive. The goal was to integrate SMS by providing support within key individual departments. Resources were also allocated to departments to help them manage their SMS. Any time significant changes in corporate policies are made, the changes are reviewed under SMS protocols.

At least one company said that SMS has not been as successful because it resides as a separate activity. Employees do not understand that it is part of operations. Employees see SMS as a stand-alone activity run by the safety department. The emphasis is on compliance rather than cultural changes. Comments made include the following:

> #37. As a 121 carrier, safety is integral to our mission and part of everything we do. SMS gives us a formalization of the safety process, but it is a process we already used throughout the organization. It fit perfectly into our overall mission.
>
> #50. SMS is linked to our strategic vision. We link it to the employee, customer, and financial environments within the organization. We let representatives from each group be a part of our plan. Our policy statement addresses partnerships with all our stakeholders in an attempt to get their participation in SMS.
>
> #65. (Canadian Air Carrier) We did a poor job of tying SMS to the mission. Our former corporate safety department went to flight operations, and when we first implemented SMS we had no overseer of SMS for the whole company. Our training and oversight were poor in the beginning. In 2009, we revised this and came up with an overall safety program that went throughout the company. We tied it to the mission by locating representatives throughout the company and having them report to the accountable executive who reports to the CEO. We also developed programs for education to assure SMS awareness is raised throughout the company.
>
> #66. It is a very comprehensive regulation, but it isn't clearly communicated. The SMS may be stand alone because compliance doesn't necessarily move us toward integration with the organizational mission. It resides here as a separate activity (from our mission). Many just don't understand that SMS is part of operations. They believe it is part of the safety mission.

4.1.1.3 Allocation of Resources

The reporting and integration of information has been a problem. A few companies stated that information and data varied widely, and they have worked to integrate the various pieces of safety information. Information gathered from different sources and in different formats was difficult to use. Some organizations felt they did not have enough data to see and analyze trends, so budget allocations to get the greatest return have been problematic.

In stronger operations, SMS is part of the daily routine of every job. Each department may set aside a portion of its budget for handling problems. If departments require resources beyond their own budgets to handle mitigation problems, then requests are sent upward. When new products are introduced or new needs discovered, additional budget requests are made. Gap analysis or other tools are used for risk assessment and to determine resources necessary to perform SMS effectively. Budget allocations are then based on needs discovered, history of problems, and feasibility. Companies attempt to prioritize risk factors and address the more important ones first. Executive management reviews requests and typically makes decisions based on the business case made for each. Budget allocations are justified as they are in any other operation in terms of how the proposal will add value to the organization.

One of the biggest problems is not having a full awareness of the needs or the budgets related to those needs. Reporting and integration of information into the system has been an issue. Organizations are using reports they believe can be fairly effective but are having trouble fitting those reports into an overall database to provide them with the information needed to make appropriate corrections and related budget requests. Locating appropriate software to handle this problem has been a concern.

Another question that arose is whether SMS functions could be performed by existing personnel through added workload or if additional personnel were needed. Some determined a dedicated SMS team is better, whereas others attempted to integrate SMS into the workload. Comments made include the following:

> #5. Our major costs involved developing a strong data base for recording, reporting, trending, etc. Since SMS is built into each position and isn't handled separately, we didn't have the requirement for large numbers of additional resources.
>
> #49. My operational department oversees SMS as it relates to Part 139 (Airport) compliance. When I have a need I go up through channels. If the need requires large amounts of money, I can go directly to executive management with my request.
>
> #50. I'm the only person with full-time SMS responsibilities. My position was created for SMS. We also have departments of fire safety and aviation safety and other departments handle aspects of safety, as well.
>
> #66. In order to fulfill the requirements of our SMS, we provide a business case to justify our need for resources. Everything is based on cost-benefit.

4.1.1.4 Evaluation of SMS Effectiveness

In some cases, companies have no formal method of assessment. Early in the process, companies evaluate the effectiveness of their SMS by reviewing data and considering trends. The results of recurring inspections—such as lighting, taxiways, and contractor problems—are sometimes included in the trend analyses. A dashboard was established by one company, whereby they gather data on items such as employee injuries, aircraft damage, unstable approaches, incursions, flight deviations, and go-arounds. Special items, such as results from accident investigations, are added to the mix, but many companies have no formal method of evaluation of SMS or even the trends.

In one case, the organization established acceptable levels of accidents and incidents, and they intervene only when problems in a given area exceed those levels. As long as they are not observing excessive numbers, they operate under the assumption that the SMS is performing effectively. The more sophisticated groups have sought evaluation tools to help determine their effectiveness and, in some cases, have turned the evaluation over to the auditors. Mention was made of tools provided by the FAA, DOD, and IOSA. Some companies also hire outside auditors or evaluators to help them determine effectiveness. The evaluators check the overall performance of the SMS and at different levels within the system. Companies are audited as often as semi-annually or as infrequently as every 2–4 years. The time between checks may vary depending on the division within the company and its perceived criticality.

In most cases, trends and data are reviewed at regular intervals by safety departments, mid-level management, and, less frequently, members of top management. The traditional model appeared to be monthly by mid-management and quarterly by top management. Responses regarding this issue include the following:

> #3. The reporting and integration of information has been a problem. We realized our data was all over the place and we have worked to integrate the various pieces of safety information. ASAP, Flight Operational Quality Assurance, pilot reporting, etc. were all in different data bases. We are still trying to find appropriate risk management software. We evaluate SMS by looking at how well we are modifying our actions to correct problems. The problems are prioritized and handled accordingly. We are transitioning toward using controls to look at contributing factors that may lead to errors. Instead of waiting for the contributing factors to combine with others to lead to an accident, we are working to identify and correct them. For example, instead of looking at runway incursions, we look at factors leading to runway incursions and try to correct before the incursion occurs. We do look at problem areas that have more contributing factors than others. For example, if nine components contribute to an approach problem, our computer system tracks how many occur and will tell us how many are there at once. We address these accordingly.
>
> #34. We share risk assessment and trends regularly, and all information regarding high risk assessments moves to the top. We watch trends and communicate what we see to senior management.
>
> #37. We don't have a formal process for assessing SMS. We review previous corrective actions but not on a systematic basis. Our intent is to be sure that changes haven't resulted in new hazard creation.
>
> #49. (airport) No. We don't have the data to generate reports on SMS effectiveness.
>
> #50. We are not yet evaluating the effectiveness of the SMS program. We are still in the early stages—not yet fully implemented.

4.1.1.5 Assurance of CI

Trend analysis is the most popular method of assuring CI. Goals are reviewed and, when they are met, the process is reviewed. Both positive and negative results are considered. One company

measures effectiveness with scorecards, another variation of trend monitoring. Results of audits are also considered. In nearly every case, results of SMS actions are monitored periodically at higher levels and negative results are pushed back for improvement. Evaluations of injuries, damages, and claims are common indices of SMS effectiveness. Essentially, companies are looking for what they consider key indicators of safety performance. If the indicators are moving in the right direction, they consider their SMS as doing the same. Comments made include the following:

> #5. We look at trend analysis and reported problems. As we identify trends-both positive and negative-and associated risks, we try to go deeply into them. Until a problem is solved, it is continually addressed at meeting after meeting.
>
> #13. We lack health monitoring of our SMS. Robust support for SMS is needed. If the organization is built around SMS, the budget needs will be minimal—mostly for training, but there must be representation from throughout the organization. We don't need dedicated personnel at the operations level, but someone needs to be monitoring what is happening and assuring that personnel don't lose sight of SMS.
>
> #4. We're not yet doing formal assessment, but we are assessing. We use design and performance instruments as part of Job Aid. These are performed by our IEP team and quality audit group team.
>
> #35. We are looking at both departmental and overall data. At this point we're considering trends, but we have no specific metrics. Triggers for intervention include changes in operations or preventive measures, new systems, and results from reactive measures such as incident/accident investigations.
>
> #54. Our process looks at the system and the trends. We try to assure that repeats are going down and that any follow ups are effective. When we make a correction we go back to assure it is working.
>
> #61. We perform SMS checks at different hierarchical levels within our system, and we also use both inside (QA department within each of four separate divisions-every 2-4 years) and outside evaluators (DoD and IOSA annually) to look at it. Our safety group also looks at it regularly now using FAA tools. This year we are also hiring another external auditor to give us a fresh look at our SMS. Currently though, we review monthly, quarterly, and annually. Our evaluations are all standardized. We are particularly concerned that we address the areas with highest risk: maintenance and maintaining air worthiness, quality of production, flight operations, and ramp operations. The accuracy of data is under constant scrutiny, and we are always working to improve that.
>
> #65. Our effectiveness reporting is a work in progress. We aren't doing a great job with this yet.

4.1.1.6 SMS and Performance Appraisals

A number of companies look at overall safety performance in terms of numbers within areas of responsibility under a given manager. If accident or loss numbers are up, performance is considered down, and vice versa. One company stated they simply look to see if goals are being met. For example, they have established a target of 15% reduction in damages. As long as that and similar goals are achieved, safety performance is considered positive. No organization interviewed had any SMS built into overall management appraisals. In a few instances, the SMS managers themselves were appraised on how well they fulfilled their roles as SMS managers. Comments made include the following:

> #7. The line personnel are expected to do their jobs, and that includes various aspects of SMS, depending on what the job is. SMS is embedded in the jobs and, therefore, into the appraisals.
>
> #13. It isn't built into performance appraisals.
>
> #51. SMS is not yet built into performance appraisals. It is built into goals of managers in terms of quantitative metrics sought.
>
> #64. End result is built into performance appraisals. We're not looking at how a 15% reduction in damage occurred, but simply that it did. If that was the goal, and it didn't happen, we review what steps were taken and what adjustments need to be made. Emphasis is on meeting the goals.

4.1.1.7 The Accountable Executive and the SMS Manager

In most cases, the accountable executive is either the CEO or the COO reporting directly to the CEO. The safety director typically reports to the CEO or the COO, and the director either handles SMS or has an immediate report do so. In almost every case, the SMS person has dotted-line access to the CEO or COO, either through a safety manager or directly. Comments made include the following:

> #35. The COO is responsible for overall operations of SMS. Reporting to him are the operating VPs and the Director of Safety
>
> #54. The CEO is the accountable executive. Reporting to him are the COO, the CFO, the CIO, and other VPs. The VP of safety reports to the COO and has a dotted line to the CEO. I report to the VP of safety.
>
> #64. The Manager of SMS is the person responsible. He reports to the VP of Air Ops and has specialists in lean (black belts) reporting to him.

4.1.1.8 Training on SMS

Companies reported that most training on SMS takes place as SMS is introduced. In some instances, no direct SMS training takes place, but concepts are introduced in regular, safety-training meetings. The training tends to be heaviest at the mid-management levels and less at the

top management and non-management levels. Those directly responsible for SMS are most likely to receive SMS training. Training times vary from nominal training of 30 minutes or less to up to two or three days per year. Most employees at any level, once they have been through the initial SMS orientation, receive very little follow-up training. Comments made include the following:

> #5. No annual training at any level. All new hires are given a briefing on safety responsibilities and managers meet monthly to discuss safety issues.
>
> #8. We are working on an annual training now. It will be completely online and will be about 1-2 hours for management and 45 minutes for non-managers. We do have an initial SMS training of 4 hours for top management and 2 hours for the other levels of management and non-management personnel.
>
> #34. Managing Director of Safety Assurance is the key person responsible for SMS—reports to VP of safety who reports to COO. Sr. Mgr of IEPs, SMS mgr., and Environmental person also report to MDSA.
>
> #37. We review safety stuff at the beginning of each monthly meeting for about 15 minutes per meeting. This time is not exclusively devoted to SMS, but everything we review is related to SMS. If you call this training, our managers get about three hours per year each. Non-management personnel receive a 45-minute overview of SMS initially with no subsequent training on the topic.
> #51. We train ten hours per year on SMS specifically plus another 20 or so hours on safety
>
> #61. All employees go through 30 minutes of training every other year. There is also 4 hours of classroom training for all VPs of operational groups, the CEO, and the managing directors. We are extending that to vendors and our MRO stations, so approximately 600 personnel will receive the 4-hour SMS training.

4.1.1.9 Other Points

The Canadian companies pointed out that their biggest problems were inconsistencies on the part of TC. When questions are asked of TC, they receive different responses, depending on the person asked. These inconsistencies make it very difficult to effectively implement SMS according to the standards.

A second major problem related to the above is a lack of training. In the United States, companies are requesting detailed training regarding effective implementation of SMS with widespread availability. Comments made include the following:

> #67. (Canadian Air Carrier) We were struggling with SMS early on, but then had an epiphany during a 4 day ISO 9001 course. We saw the huge overlap with SMS and then this all made sense. We believe SMS and QMS are inseparable.

5. SURVEYS

Once the interviews were complete, information obtained was integrated with literature review findings to develop a preliminary survey designed to measure the effectiveness of each of the four SMS components.

5.1 SURVEY DEMOGRAPHIC DESCRIPTIVE STATISTICS

The electronic survey was open for a two-week period during June/July 2015, with 269 respondents. Of the 269 responders, 83 answered questions on the demographic first page and 33 completed the survey. The 50 respondents who failed to complete the survey were compared to the 33 who completed the survey as a measure of non-response bias. Across seven different demographic questions, chi-square results showed no significant difference between the 50 respondents who failed to complete the survey and the 33 who did complete the survey, indicating no evidence for non-response bias. The results that follow consider only the 33 respondents who completed the survey.

Respondents took an average of 30 minutes to complete the survey (median 19 minutes, standard deviation 39 minutes). A total of 22 respondents (66.7%) answered survey questions based on their whole organization; the remaining 11 respondents (33.3%) answered survey questions for specific departments within their organization. FTE employees varied between 0 and 50,000 (mean 4192, median 140, standard deviation 11,428). Figure 6 shows a histogram of the distribution.

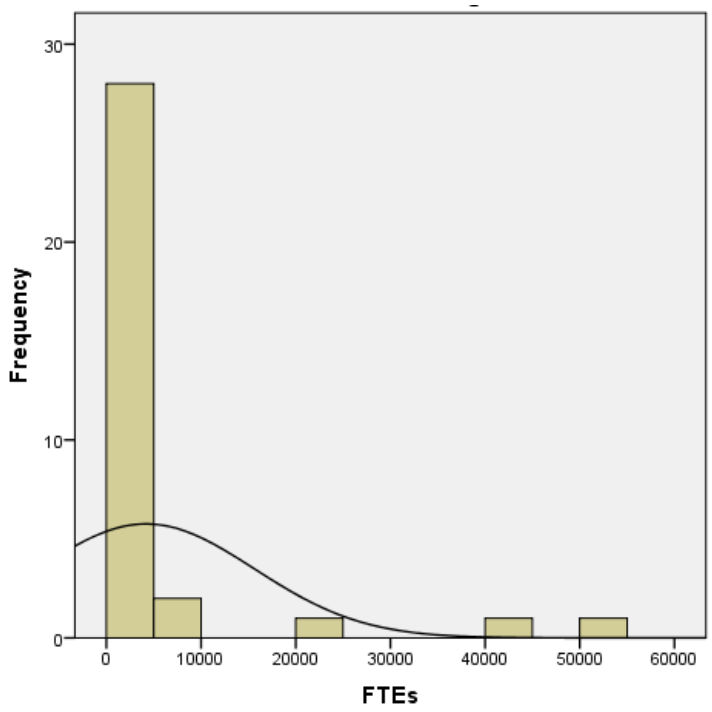

Figure 6. FTE histogram

Table 5 shows the type of organizations that responded, the largest number reporting "Other." Varied "Other" responses were qualitatively coded to develop the nine categories shown in table 6, the largest group representing corporate flight departments.

Table 5. Organization type

Organization Type	Count	Percent
Airport	1	3.0
Cargo Airline	1	3.0
Manufacturer	1	3.0
Other	16	48.5
Passenger Airline	14	42.4

Table 6. "Other" organization type

Organization Type	Count
Blank	1
Air Traffic Organization Flight Training	1
Fixed-Base Operator	1
Maintenance Organization	1
Medical Flight	1
University	1
Part 91 Commercial	2
Government (direct or contract)	3
Corporate Flight Department	4

Distribution of years in business and annual revenue are shown in figure 7. Mean years in business was 44.6 (median 30, standard deviation 32.3). Mean annual revenue was $1.1 billion (median $1 million, standard deviation $2.6 billion).

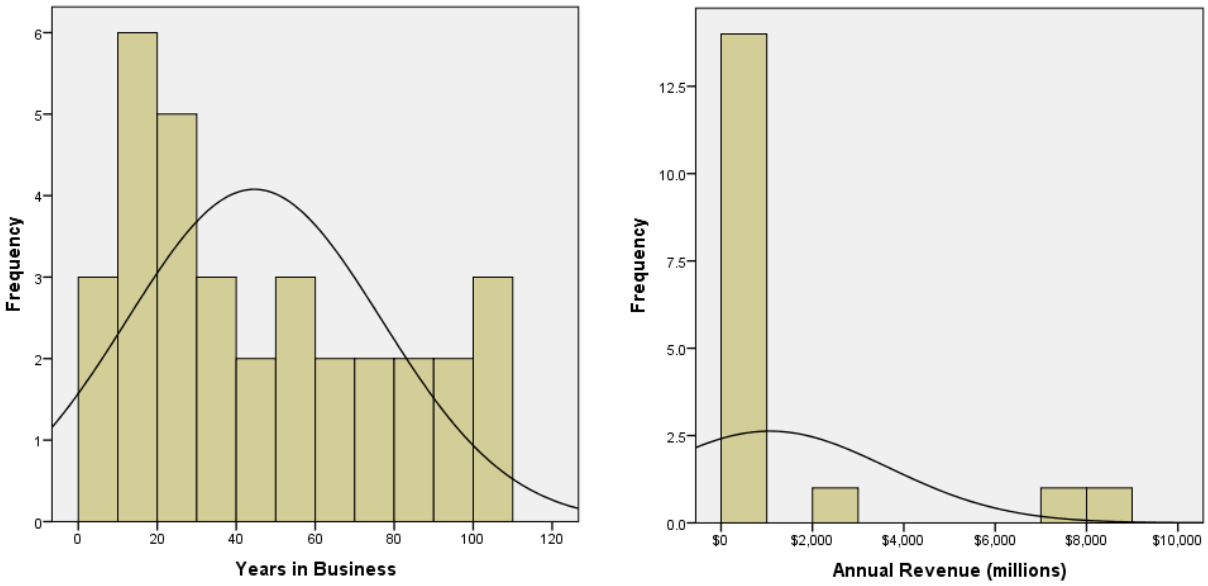

Figure 7. Annual revenue and years in business

Table 7 shows the respondents' self-report of the SMS stage. Figure 8 shows SMS stage cross tabulated by respondents reporting for the whole organization or specific departments. The most common response was "Using SMS and monitored by regulatory authorities," followed by "Using SMS without any regulatory requirements."

Table 7. SMS stage

SMS Stage	Count	Percent
Exploring SMS	1	3.0
Not using SMS	3	9.1
Using SMS and have submitted to regulatory authorities	4	12.1
Using SMS and monitored by regulatory authorities	13	39.4
Using SMS and preparing to submit to regulatory authorities	4	12.1
Using SMS without any regulatory requirements	8	24.2

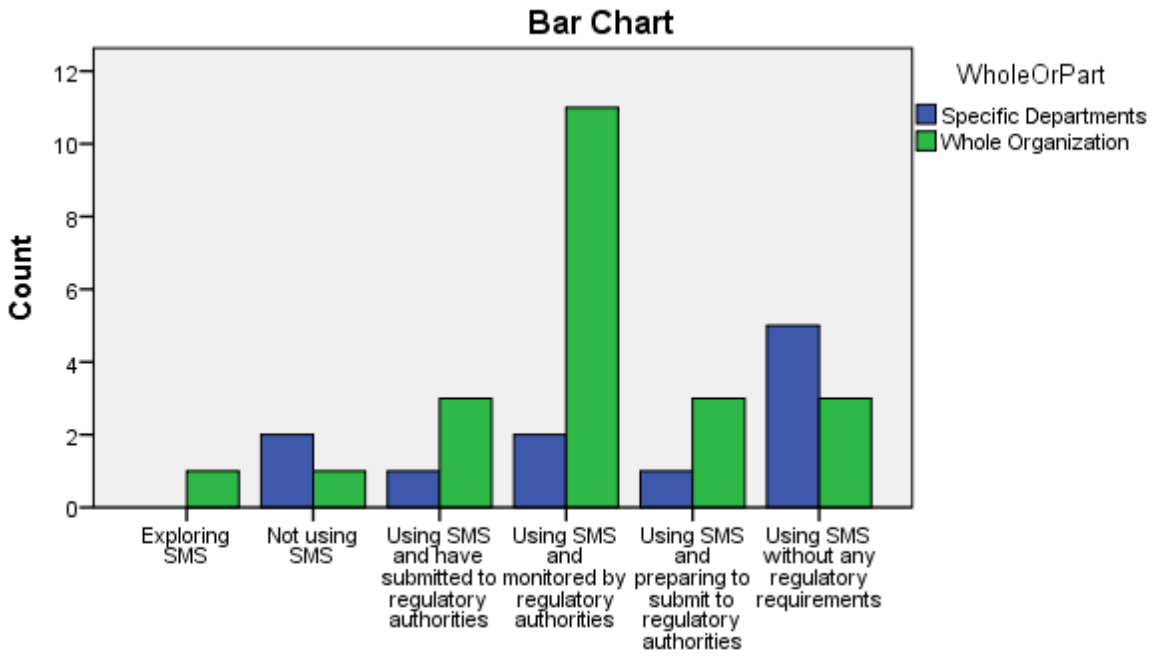

Figure 8. SMS stage by respondent "whole" or "specific" organizational reporting

Mean years using an SMS were 5.2 (median 5.0, standard deviation 3.7). Figure 9 shows the frequency distribution of responses.

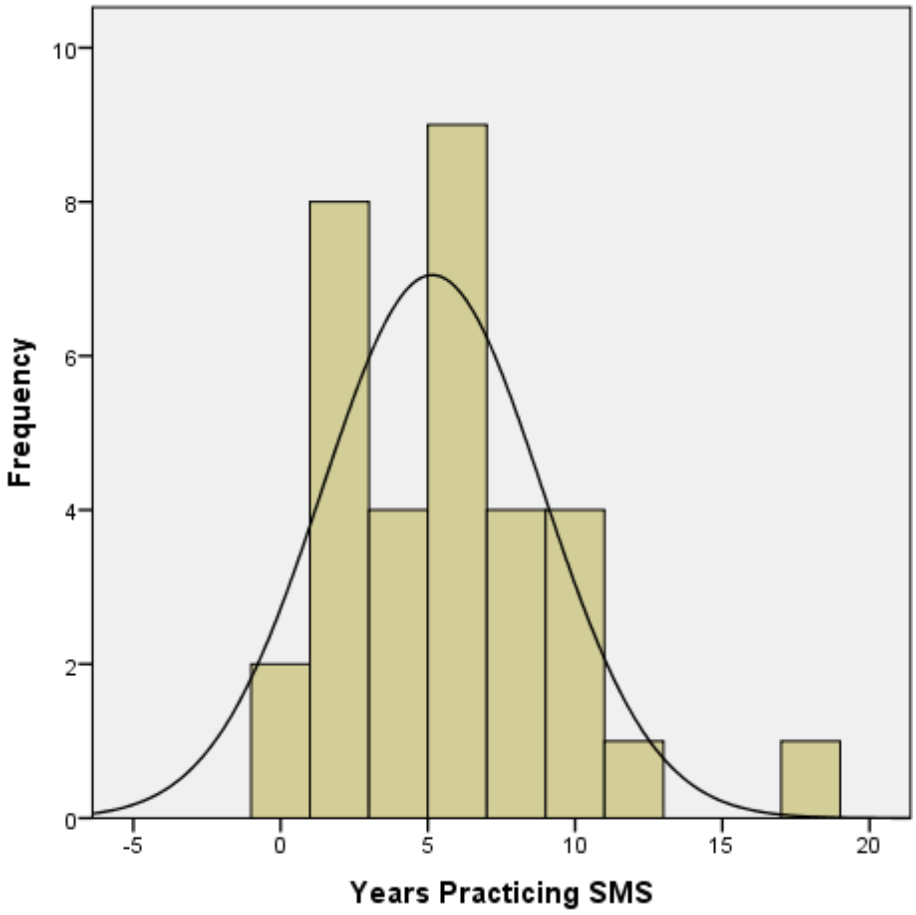

Figure 9. Years practicing SMS (with normal distribution curve also shown)

Persons responding to the survey were asked to provide their years with the company and years of total SMS experience. Mean years with the company were reported as 10.1 (median 6.0, standard deviation 10.2), whereas mean years of total SMS experience were reported as 7.3 (median 6.0, standard deviation 6.2).

5.2 SURVEY QUALITATIVE RESPONSES

Persons responding to the survey were asked to provide their job titles and job responsibilities in free-form—resulting in 31 and 32 unique responses, respectively. Job titles were qualitatively grouped and consolidated to 17 unique responses, the most common being safety officer/manager (7; 21.2%), followed by director of safety (5; 15.2%) and
SMS manager (4; 12.1%). See appendix Q for all groupings.

Job responsibility responses were generally longer, resulting in multiple groupings per response; accordingly, coding resulted in 33 groupings. The most common job responsibility was SMS implementer (8; 24.2%), followed by safety management (7; 21.2%), SMS management (5; 15.2%), and SMS regulatory compliance (4; 12.1%). See appendix Q for all groupings.

Respondents were asked to provide overall comments on the survey, and 11 out of 33 respondents provided substantive responses. Approximately five respondents felt the survey was too complex and too long. Two respondents were concerned that personnel turnover related to SMS oversight adversely impacted SMS effectiveness. Two respondents provided elaboration on some of the numerical responses provided. Other one-off responses included concerns for proprietary information, inability to answer the question because of lack of ready-access to necessary data, concern about lack of government buy-in, and a positive comment that SMS is valuable.

5.3 SURVEY LIKERT AND NUMERICAL DESCRIPTIVE STATISTICS

Appendix R provides aggregate descriptive statistics for questions 10–64. Tables R1–R8 are organized by SMS component (SPO, SRM, SA, and SP), Likert, and numerical responses.

5.4 ASSESSMENT OF NORMALITY AND OUTLIERS

The CFA requires that the skewness and outliers of data must be assessed. The kurtosis values were used to evaluate the normality, and Mahalanobis D-squared values were used to evaluate the outliers. Table O1 shows the skew and kurtosis values for each measured item derived from AMOS. The results indicated that the kurtosis values were within the acceptable ranges [9]. Table O2 presents Mahalanobis D-squared values for observation. The results did not show any significant D-squared values, indicating outliers were not a concern [9].

5.5 CONFIRMATORY FACTOR ANALYSIS MODEL

The CFA model was constructed using AMOS Graphic, with four SMS constructs and 31 corresponding observed variables (see appendix O, figure O-1). The four SMS constructs are SPO, measured by 11 items; SRM, measured by six items; SA, measured by eight items; and SP, measured by six items. Table O3 presents the complete list of codes and questions.

5.6 RELIABILITY AND VALIDITY ASSESSMENT

The CFA model was tested by AMOS Graphic and the model fit assessed. Because of the small sample size, the model presented relatively high variances and error covariance, which affected the model fit. CMIN/df and CFI were chosen as the major fit indices because they were less sensitive to the sample size. A CFI of 0.9 or higher and CMIN/df of 0.3 or less indicate good model fit [9]. For a large-scale survey, the use of additional indices—such as NFI, GFI, and RMSEA—are recommended. The original CFA model resulted in poor-fit indices and, therefore, a post hoc analysis was performed. The model respecification process resulted in removing items with high error covariance. The final model showed an acceptable fit with a CFI of 0.9 and CMIN/df of 1.705. The results from this CFA model were used to assess the reliability, convergent validity, and discriminant validity. Table 8 shows the measured items in the final CFA model, standardized factor loadings, Cronbach's alpha, CR, and AVE.

Table 8. Standardized factor loadings, reliability, and convergent validity

Constructs/Factors	Items	Standardized Factor Loadings	Cronbach's alpha	CR	AVE
SPO	SPO2	0.803	0.91	0.9	0.72
	SPO3	0.93			
	SPO4	0.903			
	SPO5	0.787			
	SPO8	0.809			
	SPO9	0.865			
SRM	SRM1	0.855	0.88	0.88	0.72
	SRM3	0.847			
	SRM4	0.952			
	SRM5	0.752			
	SRM6	0.812			
SA	SA2	0.947	0.93	0.92	0.83
	SA3	0.925			
	SA4	0.941			
	SA8	0.821			
SP	SP1	0.795	0.92	0.91	0.82
	SP2	0.889			
	SP3	0.97			
	SP4	0.954			

Both Cronbach's alpha and the CR values for all constructs were greater than 0.7, indicating good CR [7, 6]. In addition, AVE was used to test the convergent validity. All AVEs were greater than 0.5, providing evidence of convergent validity [7].

Table 9 presents the results of the discriminant validity test. The square root of AVE for each construct is bolded in red and can be found on the diagonal. Other numbers present the correlation coefficients among constructs. Evidence of discriminant validity exists if the square root of AVE of each construct is greater than the correlations in its corresponding row and column [10, 11, 7]. The results in table 5 indicate that there was insufficient evidence of discriminant validity. This issue can be explained by the high correlations among constructs and among question items of different constructs. The high correlations among question items could be caused by similar wording of the questions. Accordingly, it was important to revise the wording of the questions carefully to avoid confusion. The reworded questions were included in the final survey instrument (appendix S). In this pilot study, because DEA models were developed and tested for each SMS component separately, the lack of discriminant validity would not have substantial effects on DEA results, but this issue would need to be noted in the process of interpreting the results.

Table 9. Discriminant validity assessment

	SPO	SRM	SA	SP
SPO	**0.85**			
SRM	0.95	**0.85**		
SA	0.937	0.96	**0.91**	
SP	0.9	0.92	0.77	**0.9**

6. DEA MODELS

The reliability and validity of measured items had been assessed in the previous step. The items derived from this assessment were used as inputs for DEA models. In this analysis, each organization represents a DMU. The survey resulted in 33 completed responses. Each unit was assigned a sequential number from 1–33 and, thereafter would be used in the report. As mentioned previously, the non-response bias test indicated no significant differences between respondents and non-respondents; therefore, the sample was considered acceptable for the DEA modeling purpose. Further data examination for each unit was conducted with more emphasis on output variables to ensure the usability and validity of the data before entering them in DEA models. In examining the data in each unit, it was observed that some units included unusable data for DEA purposes for several reasons, as follows:

- The output data were invalid.
- The respondents were unverified.
- The respondents were not SMS experts working for an aviation organization.
- The organizations were not using SMS at the time of the survey.

Table P1 shows the details of deleted cases along with specific reasons. This resulted in 24 cases corresponding to 24 units. These units were used in DEA models for SMS effectiveness.
The next step in data preparation was to perform necessary conversion for the purpose of developing DEA models. Because all input questions were in Likert scales, no conversion was required. Conversely, the output questions reflected actual SMS performance in different areas and the performance varied depending on the organization size; therefore, conversion was needed to ensure that data were comparable across organizations. Table P-2 shows necessary conversions for output variables (by dividing by number of FTEs or other output values). Note that some output variables did not require conversion because they were independent of the organizational size. Variable SRM_O1 was inverted to meet the DEA assumption that outputs are measured on scales in which larger numerical values correspond to greater safety performance. Finally, zero values were substituted with relatively small values compared to known values in other units to ensure comparability. Once all data preparation was done, DEA models for each SMS component were developed and tested using Frontier Analyst software.

6.1 DEA MODEL FOR SPO COMPONENT

The DEA model for the SPO component was constructed using Frontier Analyst with three outputs and six inputs. The outputs were derived from the survey with conversions discussed previously.

The inputs were derived from the result of the CFA test. Figure 10 shows the process diagram of this model.

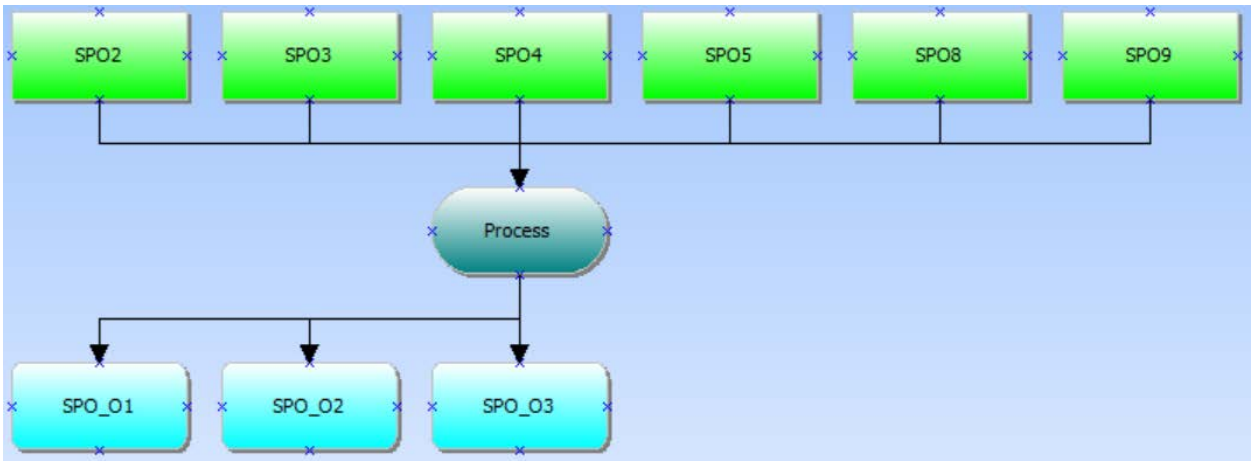

Figure 10. DEA model for SPO component

The DEA model was tested and the efficiency scores were calculated for individual units.
Table P3 shows the efficiency score for each unit, whether the unit is efficient, and the condition. Green indicates that the unit is truly efficient with no further improvements needed. Amber indicates that the unit has a high efficiency score, but there are still potential improvements that can be made. Red indicates that the unit is not efficient and, to become efficient, the unit needs to improve either inputs, outputs, or both. The results indicated six efficient units (1, 4, 8, 22, 28, and 32). The remaining units were considered inefficient. Figure 11 shows the score distribution that provides more insight into these inefficient units. It may be noted that there were 10 units with efficiency scores of 10% or less, 4 units with scores between 11% and 30%, 1 unit with a score of 46%, 2 units with scores between 70% and 80%, and only one unit with a score near 90%. Overall, 25% of the investigated organizations were considered efficient in SPO; nearly 60% of these were considered very inefficient.

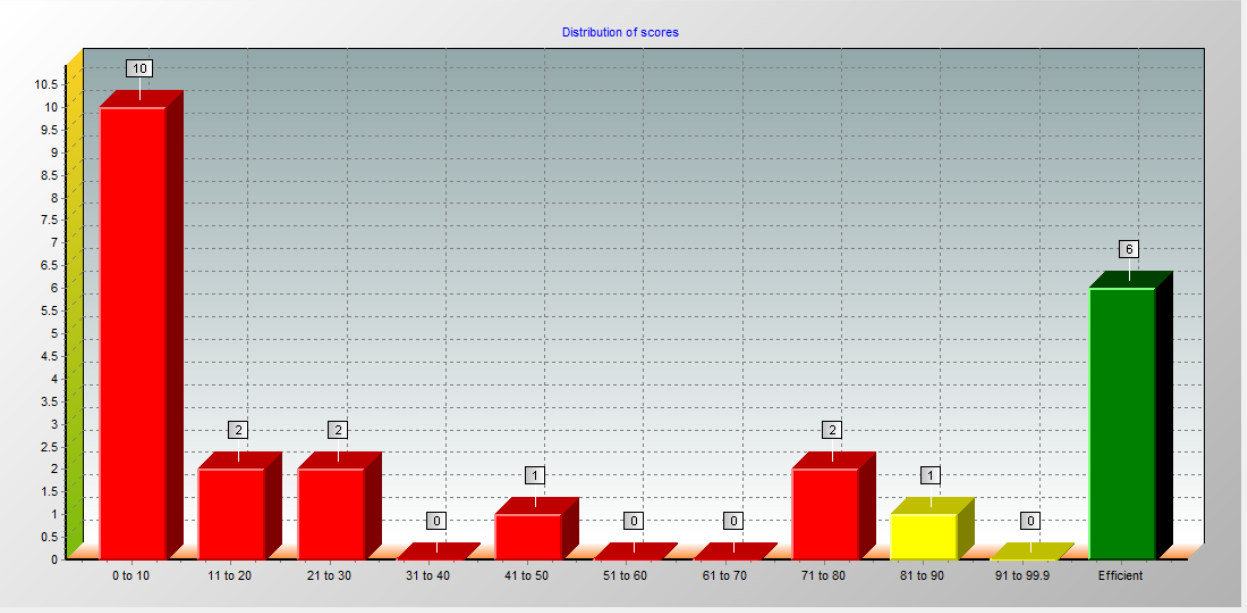

Figure 11. Distribution of scores for SPO component

Figure 12 shows the total potential improvements for inputs and outputs in this model. The results indicate that the overall output by SPO_O3 (overall budget allocated toward system safety) required the most improvement, followed by SPO_O2 (number of employees with system safety in their job descriptions) and SPO_O1 (number of employees with safety in their job titles). The improvements in inputs were nonsubstantial.

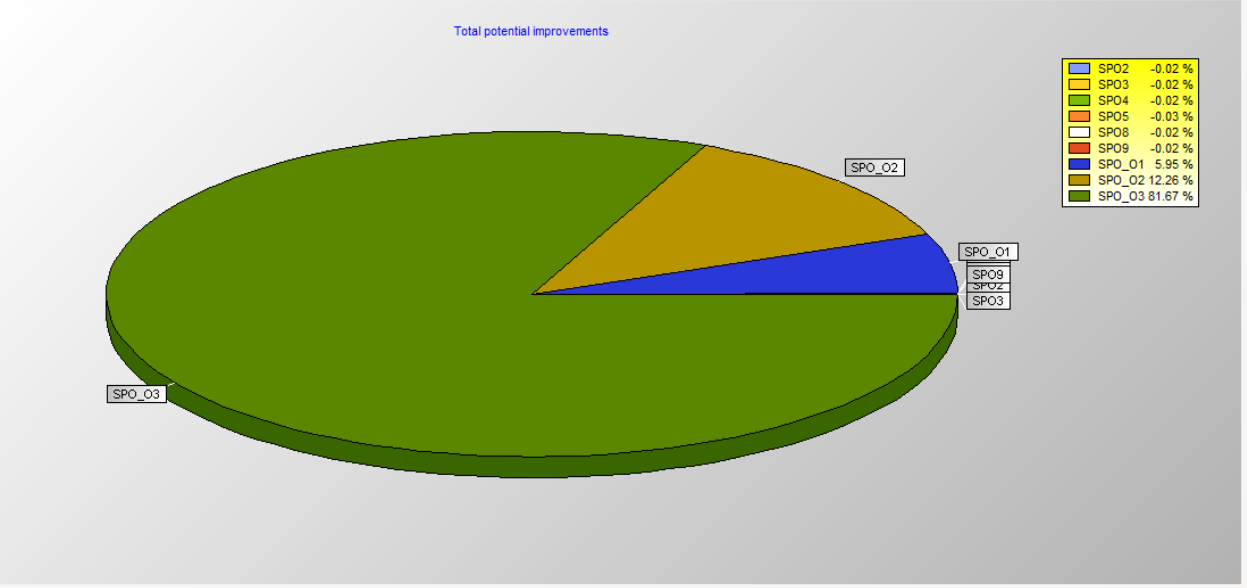

Figure 12. Total potential improvements for SPO component

Table P4 shows individual potential improvements for specific inputs and outputs that each unit needed to become more efficient. The results indicated that six efficient units do not need any

further improvement because they were already efficient in SPO components. Units 20, 30, and 31 could potentially get closer to becoming efficient with necessary improvements in inputs and outputs. It would be more challenging for unit 33 because of the improvement effort to put in three outputs. Similarly, units 5, 21, 19, and 10 would need to triple or quadruple their outputs to be able to reach the efficiency level. More effort and resources are required to achieve this objective. Finally, the last 10 units were very inefficient, and it seems that it would be even more challenging for them to become efficient. A closer review of the raw data for the two most inefficient units (3 and 18) showed that they had almost no employees with safety in their job titles and descriptions, and no budget allocated to system safety. To improve their SMS efficiency, these units would need major changes in the organizational safety strategy.

6.2 DEA MODEL FOR SRM COMPONENT

The process diagram of the DEA model for the SRM component is shown in figure 13 with five inputs and one output. Table P5 presents the efficiency results of this DEA model. The results indicate that only unit 32 was considered truly efficient. Although units 3, 5, and 18 received a high efficiency score, their SRM practices still needed some improvements. Figure 14 depicts a score distribution among these units. In addition to one true efficient unit and three near-efficient units, it is worthy to note that unit 14 received a score of less than 10% (most of them received 0%), 5 units received a score of 50%, and 1 unit received a score of 66.7%. This indicated very left-skewed distribution of efficiency scores, or poor performance, in the SRM component. Further investigation into potential improvements would provide more details pertaining to which units should receive more attention and what could be done to make them more efficient.

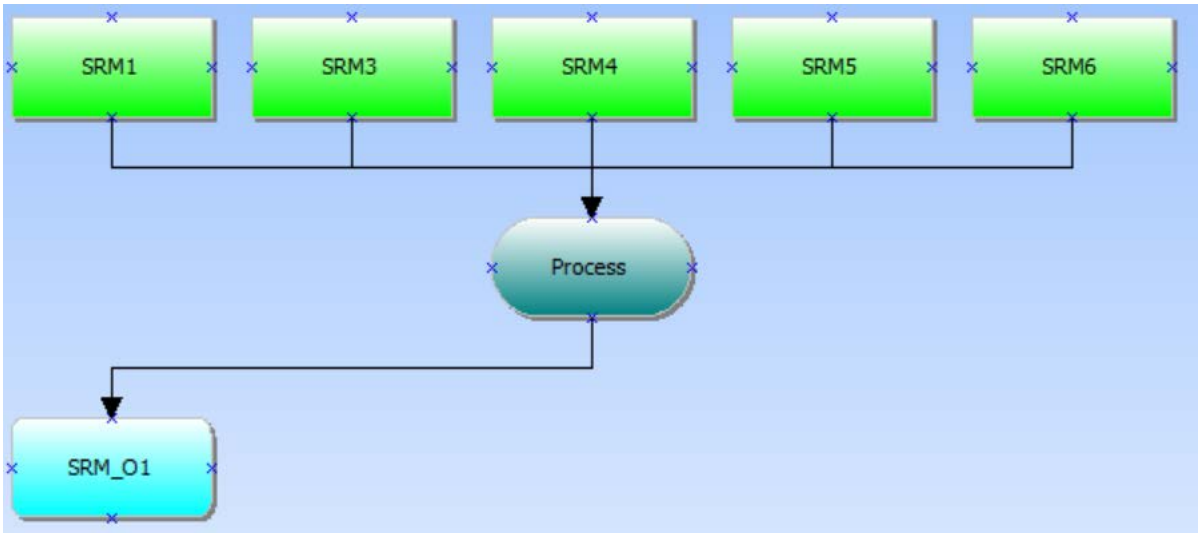

Figure 13. DEA model for SRM component

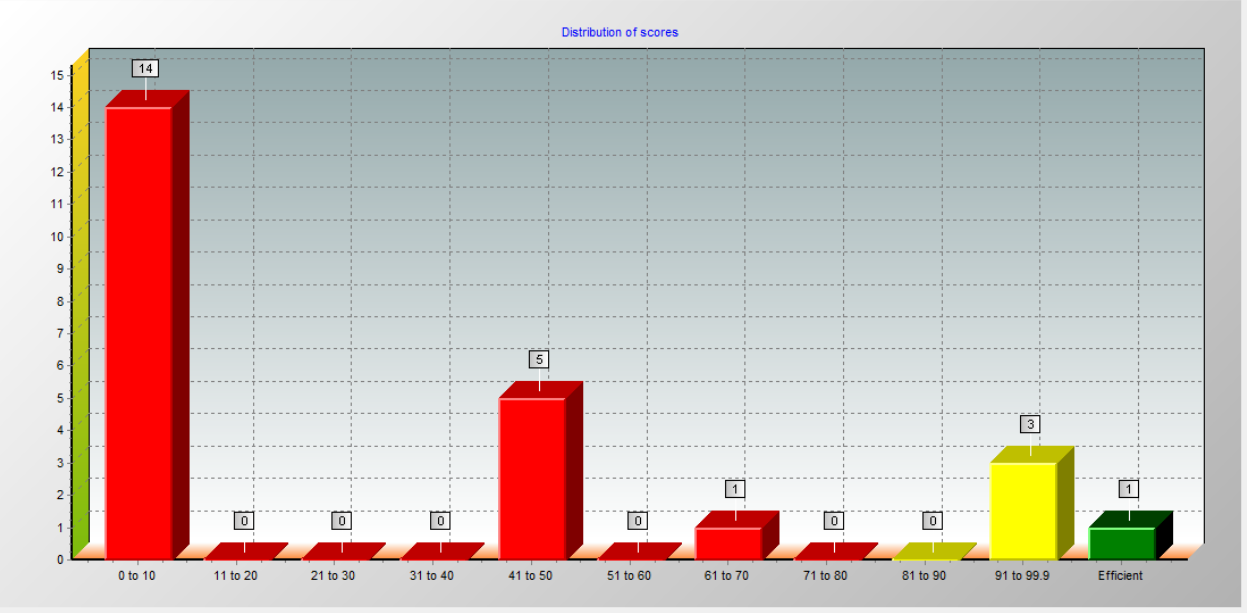

Figure 14. Distribution of scores for SRM component

As shown in figure 15, overall, the output SRM_O1 (spending on direct property damage losses) requires the most improvement, followed by the input SRM5 (a closed-loop system for the reporting of safety issues) and the input SRM6 (anonymity). Table P6 shows more details of individual potential improvements for each unit. Unit 32 was truly efficient, so no improvement was needed. Units 3, 5, and 18 could still advance by improving the inputs SRM5 and SRM6. The next six units could get closer to becoming efficient by improving the output SRM_O1 (note that we inverted SRM_O1). The last 14 units need considerable improvement in the output to improve their efficiency scores. Reviewing the raw data of these units showed large spending on property damage losses, indicating poor performance in SRM. Considerably more effort is needed to improve risk management and control for the units to become more efficient.

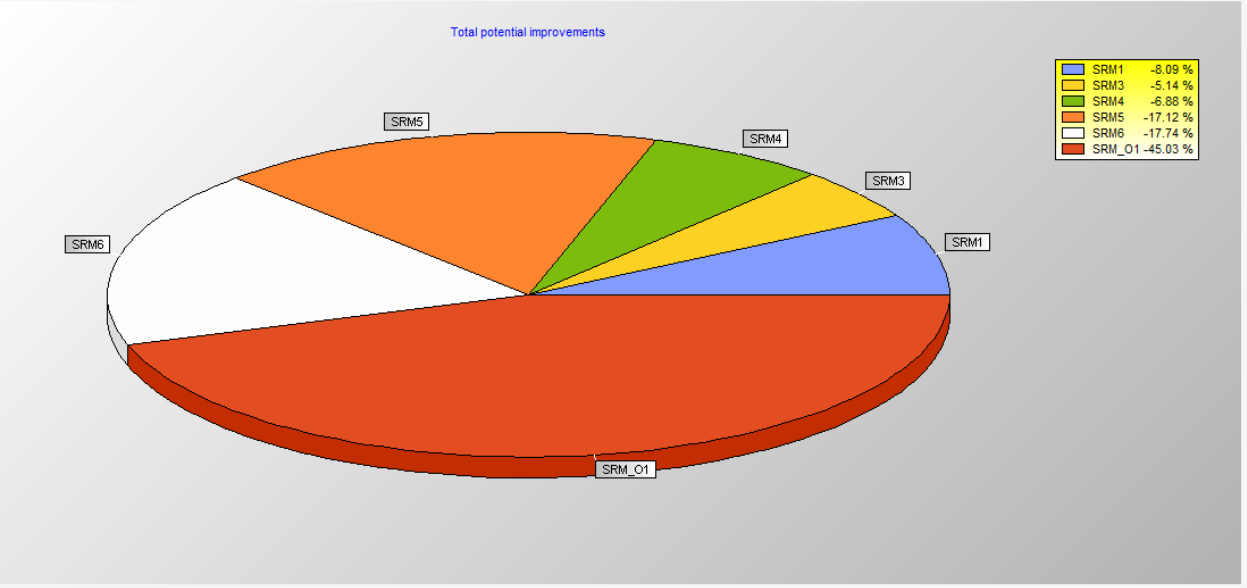

Figure 15. Total improvements for SRM component

6.3 DEA MODEL FOR SA COMPONENT

The DEA model for the SA component includes four inputs and seven outputs (figure 16). As shown in table P7, 15 units were considered efficient, with a score of 100%. The score distribution in figure 17 showed that among inefficient units, three units received scores between 81% and 91%, three units received scores between 51% and 80%, and three units received scores of less than 10%. Overall, the efficiency performance for the SP component was better than other components, though the score distribution was skewed to the right.

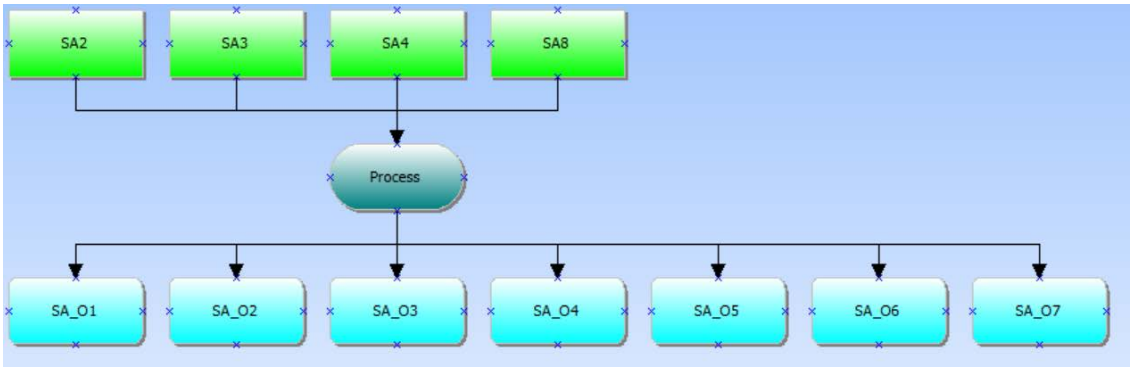

Figure 16. DEA model for SA component

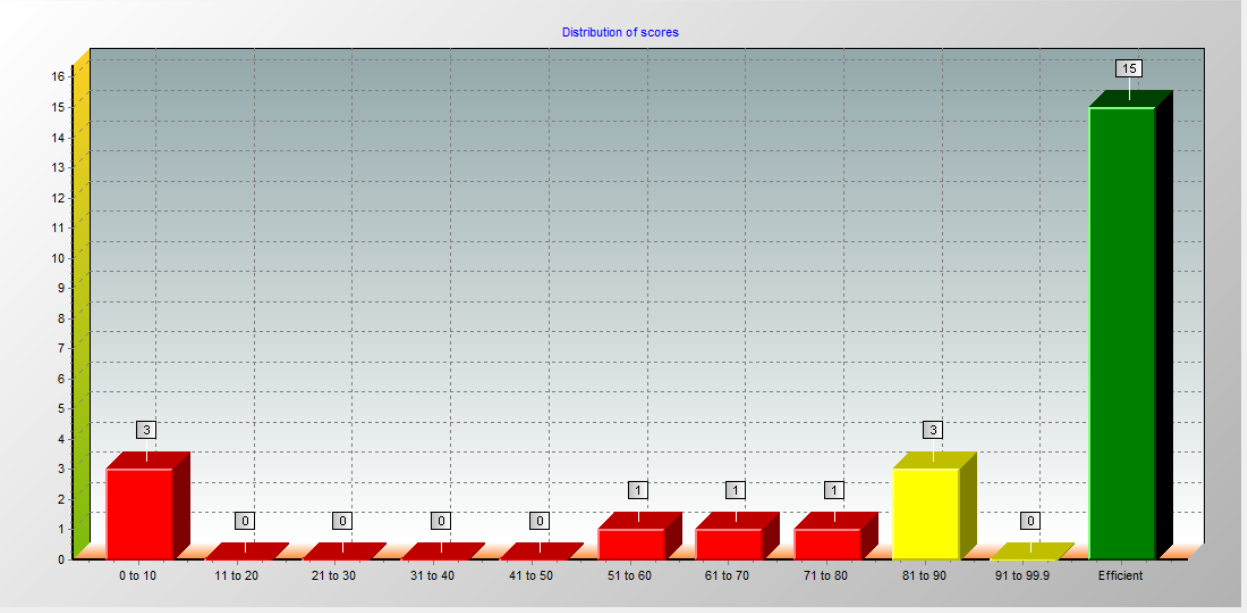

Figure 17. Distribution of scores for SA component

The total potential improvements (figure 18) for this model indicated that the output SA_O1 (number of reviews of safety outputs completed by accountable executive) needed the most improvement, followed by the outputs SA_O5 (number of external safety audits accomplished) and SA_O6 (number of deviations from policies/procedures found and corrected). A closer examination of individual potential improvements for each unit (table P8) indicated that the first 15 units were efficient and no improvement was needed. The next six units could still increase their efficiency scores by improving the corresponding inputs and outputs, as indicated. It is noted that units 10 and 28 (although they had higher efficiency scores) needed substantial improvement in the output SA_O1. The last three units (1, 13, and 32) needed considerable improvement to increase their efficiency scores. Reviewing the raw data for these units indicated that they had answered 0 for almost all outputs in SA performance. More substantial changes in their safety strategies are needed for them to increase their system safety efficiency in the future.

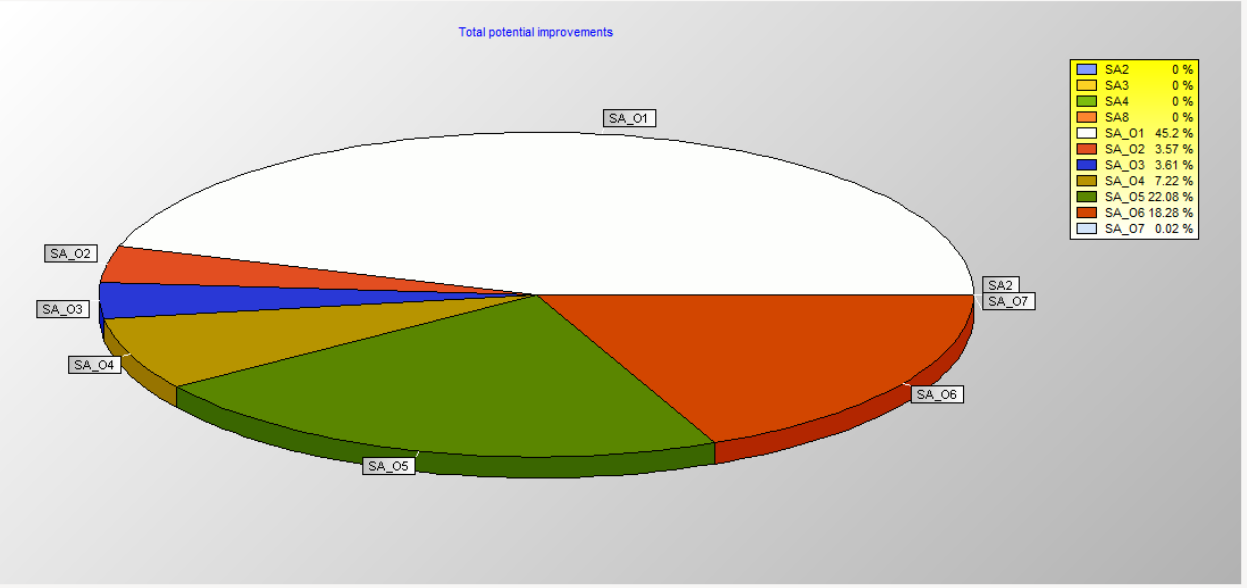

Figure 18. Total potential improvements for SA component

6.4 DEA MODEL FOR THE SP COMPONENT

The DEA model for the SP component includes four inputs and seven outputs (figure 19). Table P9 shows the efficiency scores of all units. The results showed seven units with a 100% efficiency score. The score distribution (figure 20) indicated more scattered results in this component: Two units with scores between 81% and 99%, two units with scores between 51% and 70%, and 13 units with scores scattered from 0%–40%.

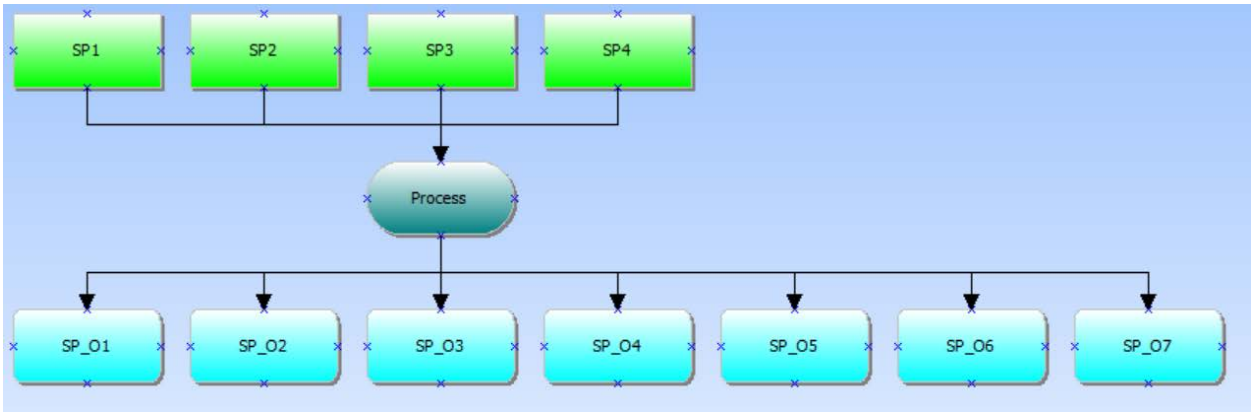

Figure 19. DEA model for SP component

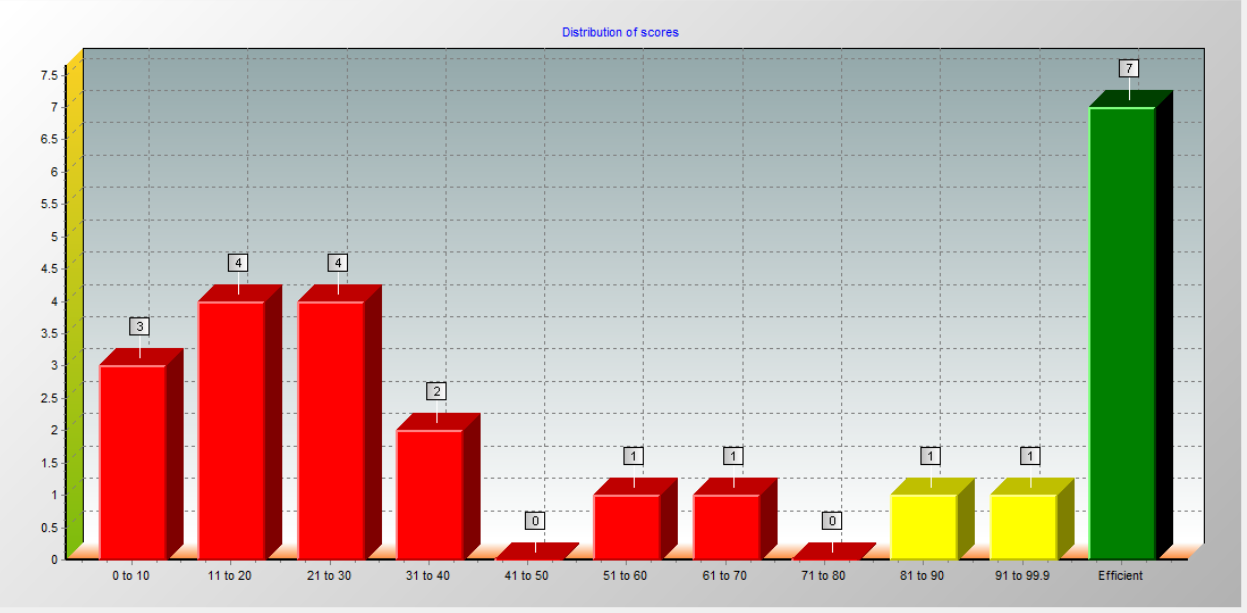

Figure 20. Distribution of scores for SP component

The total potential improvements (figure 21) indicated that the output SP_O3 (hours spent in training for each transferred employee) needed the most improvement, followed by the output SP_O2 (hours spent in training for each newly hired employee). The individual potential improvements (table 19) showed that the first seven units were efficient and did not need any improvement. It is important to note that although units 16 and 8 had relatively higher efficiency scores, they still need improvements for the outputs SP_O2 and SP_O3. Similar issues could be observed for the next several units in the table. This indicated the poor investment in safety training for newly hired and transferred employees. A closer review of raw data in the most inefficient units (units 1, 2, 13, and 32) showed that they had answered 0 for almost all outputs in the SP component. Accordingly, these units would also need major changes in their safety strategies to be able to improve their system safety efficiency.

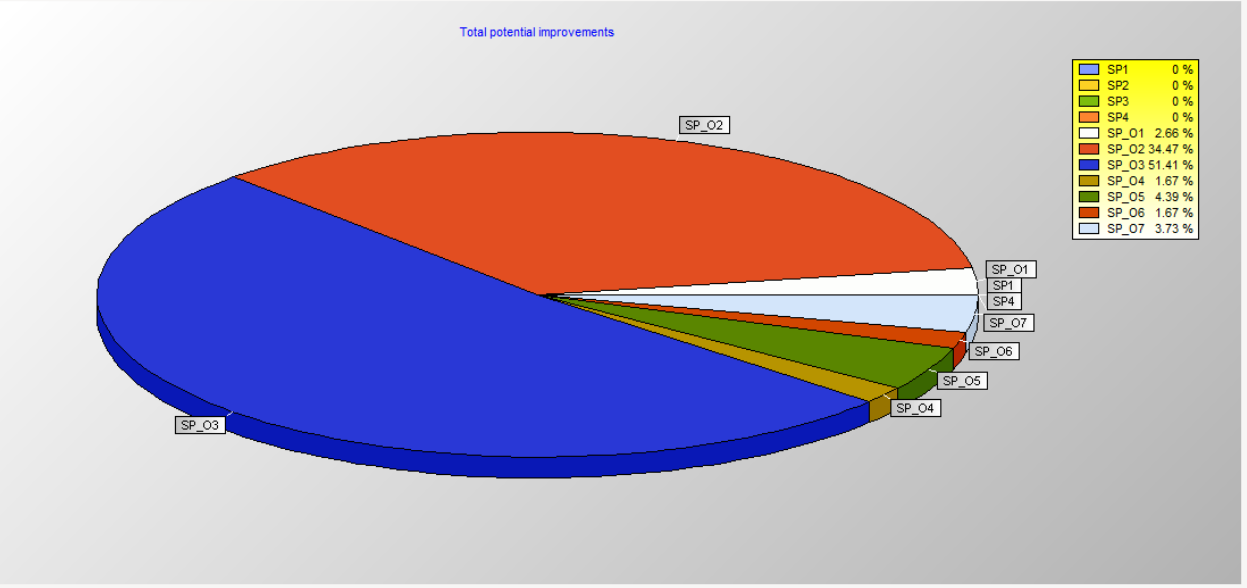

Figure 21. Total potential improvements for the SP component

Overall, four DEA models were developed for four SMS components. The models calculated efficiency scores for participating organizations, identified inefficient organizations, and identified potential improvements required for them to become more efficient. The method provided important results pertaining to an organization's SMS effectiveness, how it performs in comparison to other organizations, and how far it is from the benchmark. Organizations' executives can use these results to determine their position in the industry, identify potential issues with SMS inputs and outputs, and develop corrective actions to improve their SMS effectiveness. Overall, the DEA method appears to be an appropriate method for determining SMS effectiveness, but, in this study, the small sample size limited the findings to these specific aviation organizations. A larger sample size—including more organizations with a variety of types and sizes—is recommended for future research.

7. CONCLUSIONS AND RECOMMENDATIONS

The general objective for this research study was to develop a model to measure and test safety management system (SMS) effectiveness. Through a review of a broad array of literature and an examination of existing surveys, a series of interview questions was developed to gather information from 22 aviation safety experts from the U.S., Canada, and Europe. Based on the findings and the review and adaptation of existing instruments, an initial survey designed to measure SMS effectiveness was developed and pretested with five expert participants. Through the use of their feedback, the model was modified and sent to a predetermined group of aviation experts and the aviation safety community via a listserv. With 269 surveys begun and 33 completed, results were used to test both reliability and validity of the instrument. The survey instrument was determined to be reliable and have a high level of convergent validity. There was insufficient evidence to confirm discriminate validity. The determination was that participants likely found that questions 21, 43, and 57 overlapped. One other question was deemed to be poorly placed, so it was moved. All issues were addressed and the final instrument appears in appendix S.

Results from the survey were evaluated using data envelopment analysis (DEA). Frontier Analyst® software was used to calculate the relative efficiency score of each participating organization. Based on the responses received, the software also identified inefficient organizations and the improvements required to increase their efficiency scores. The executives and authorities within organizations can use the results to identify the position of each organization in the group and the shortcomings in SMS practices, and to develop necessary strategies and actions to improve the organization's efficiency.

All survey results and conclusions generated from the surveys in this project were based on a relatively limited sample size in airline organizations. As the size of the sample increases, more accurate efficiency scores can be calculated, and shortcomings can be more correctly identified among participants.

This survey instrument and the DEA model administered have been determined to work well and provide useful results to each participant; however, the small sample size in airline organizations limits the findings to this group of organizations. To complete the research and finalize the development of a tool to be used by all aviation entities subject to current and future FAA regulations, a more extensive and systematic administration of the instrument must be performed. The reliability and validity of the survey instrument have clearly been established. Future research will possibly lead to minor survey modifications and ensure that the baseline established for effective SMS administration provides accurate and complete guidance for all participants.

It is recommended that this research be continued. Next steps should include:

- Refining and improving questions to provide more and better inputs and outputs for the DEA model.
- Exploring other datasets that may exist within the FAA or elsewhere that can inform the model, focusing on certain segments of the industry (such as air carrier maintenance, business aviation, etc.).
- Obtaining a much higher response rate for the selected segment(s).
- Rerunning the DEA models and validating the new ones against the present study.
- Building tools for which organizations could input their own data at their discretion to benchmark their progress with respect to SMS.

8. REFERENCES

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APPENDIX A—INTERVIEW INSTRUMENT

We are attempting to develop an appropriate system for evaluation of a Safety Management System (SMS). We have been informed that your organization has an effective SMS, and as a result, I'd like to ask you some questions about your system.

Q01. On a scale of 1-10, how would you personally rate the effectiveness of SMS in your organization?

Q02. How did you go about tying SMS to the overall mission of the organization?

Q03. How did you determine allocation of resources toward SMS? Is there guidance you can provide for other organizations?

Q04. How do you evaluate the effectiveness of SMS within your organization? What are the metrics and measures you use for evaluating effectiveness? Do you weight the variables you consider based on importance? If so, how? May I have a copy of the tool(s) used? Who performs these assessments, and how are the results reported?

Q05. How do you ensure that the system is continuously improving?

Q06. Do you generate reports that indicate effectiveness of the SMS? Can we see these?

Q07. How is SMS built into performance appraisals?

Q08. What is the job title of the person responsible for the overall operation of SMS in your organization? What is the relationship of this person on the organizational chart within the overall management of the organization? What are the job titles of his or her direct reports?

Q09. On average how much time is spent annually per person in training on SMS at each of the following levels?

a. Top management

b. Middle management

c. Line management

d. Non-management employees

Q10. Can you show me examples of SMS implementation within your organization? Can you tell me how the results are evaluated?

Q11. Are there features of your SMS program that may be unique and could provide assistance to others?

Q12. What other organizations should I interview to learn more about the critical components of SMS? Can you supply names and contact information?

APPENDIX B—ALL CATEGORIZED INTERVIEW DATA (INITIAL CODING)

Q01	N
Low	1
Meet Rule	2
Only in pilot group	1
SMS_Eff_04	2
SMS_Eff_05	1
SMS_Eff_06	2
SMS_Eff_07	5
SMS_Eff_08	6
SMS_Eff_09	3
Q02	
Adapted Existing Safety Policy to SMS	3
Corporate Values	1
Corporate Visibility and Related to Risks	1
Departmental Implementation Teams or Reps	2
Education and Training	1
Federal Aviation Administration (FAA) Pilot Program	2
Management System	1
Not Sure	1
Operationally Integrated	2
Part of QMS	2
Regulatory Mandate	1
SMS Department (or Departmental Levels)	1
Tied to Goals and Work Processes	3
Top Level Commitment	2
Top-Down, Integrated	2
Weak Connection	1
Q03	
Ad Hoc Request Process	1
Business Model or Case	4
Companywide Data Collection and Departmental Data Analysis	1
Dedicated SMS Personnel	1
Departmental SMS Representatives	6
Different Question Answered	2
Gap Analysis	1
Integrated Into Entire System	5
Needs, Experience, Feasibility	2
No Budget	1
Work in Progress, Future-Dedicated SMS Personnel	1

Q04	N
Audits	6
By Element	1
Current-No, Future-Planned	1
Dashboard	1
Documentation, Tracking, Visibility	1
Eval Corrections Made Outcome	2
Eval_Eff_No Formal Method	1
Eval_Eff_Regular Meetings	1
Feedback-Review Loop	1
Internal Evaluation Program	3
Metrics_Threats_Issues	3
No Formal Process	2
Operational Monitoring	1
Regulatory Inspection	1
Risk Assessment	1
SPIs or KPIs	3
SWOT Analysis	1
Trends and Meetings	4
Variable Weighting	1
Q05	
200-250 People In Management Review SMS Results Monthly	1
Analyze KPIs or SPIs, etc.	2
Answered in Q04	1
Audits	3
Color Coding	2
Continuous	1
Continuous Training of SMS Personnel	1
Current-No, Future-Trying	2
Current-Trends, Future-Software Targeted at CI	1
Do Not Ensure	1
Emphasis Area and Dedicated SMS Staff	1
Enterprise Risk Management	1
Future, More Data Analytics	1
Goal Focus	2
IEP	1
Job Aids from SMS Voluntary Program	1
Not Sure	1
Safety Culture	1
Surveys	1
Taxonomy	1
Trending	4
Watch Dog Organizational Unit	1

Q06	N
Answered in Q5	2
Audit Reports	1
Baselining and Goals	2
Dashboard	1
How Risk Controls Impacting Numbers	1
KPI	1
Monthly to Quarterly Management Reporting	1
No SMS-Specific Reports	6
Not Sure	1
Process Needs Improvement	1
Safety Standards Report	1
Score Cards	1
Share-Reluctant or No Share	2
Trend Charts	1
Well Developed	1
Yes (context unclear)	1
Yes, Generate Reports	1
Q07	
Currently-No	10
End Results, Goals in Performance Appraisals	1
Future-Likely	4
Informal	2
Limited Extent	1
Part of Manager Goals; For Others, Just Safety	2
Safety Is, But Not Specifically SMS	5
SMS Component Incorporated in Performance Appraisals	1
SMS Embedded in Jobs	1
Q08	
(Aviation) SMS Manager	3
Airline President	1
Chief Executive Officer	5
Chief Operating Officer (COO)	4
Detailed Hierarchy Provided	17
Director of Safety (Assurance)	2
One Level Below COO	1
Operations Safety Administrator	1
Vice President of (Flight) Operations	4
Vice President of Safety	1

Q09	N
15-20 Briefings Per Year	1
Annual-10 to 15 Hours	2
Annual-20 to 30 Hours	1
Annual-2 to 5 Days	1
Annual-2 to 6 Hours	11
Annual-8 to12 Hours	4
Annual-Less Than 2 Hours	18
Based on Job Function	1
Minimal	6
No Recurrent, Only Initial	5
None (per se)	3
Not Sure	1
Q10	
Air Group Risk Matrix	1
At Part 5 Level	1
Audits	1
Cannot Share Examples	1
Exists-Will (Might) Be Sent	7
No (context uncertain)	4
Risk Assessment Matrix	1
Safety Risk Profile	1
SMS Assessments	1
SMS Data Flows to the Top	1
Submitting Level 4 SMS to FAA in March 2015	1
Trends	3
Vague Answer	1

Q11	N
Audit Program	1
Collaborate With Other Orgs	2
Consistent Process	1
Cookie-Cutter Format	1
Direct Reports to SMS Manager	1
Dirty Dozen Concept	1
Eval-Audit	1
Event Risk Classification	1
Features-Controls	1
Integrated Review Board	1
Just Culture	1
Merger Improved SMS	1
No (context uncertain)	1
Nothing Unique	2
Operating Groups Own Their Processes	1
Overall Organizational Risk Index of Safety	1
Physically Locate Safety Managers Next to One Another	1
Revised QA Program	1
Risk Management Focus	2
Risk Reduction Trumps Compliance	1
Security and Environmental Areas	1
SMS Integrated Into System	3
SPIs and Alert Levels	1
Strong Internal Communication	1
System and Task Analysis	1

APPENDIX C—ALL CATEGORIZED INTERVIEW DATA (CONSOLIDATED CODING)

Q01	N
SMS_Eff_00_NotRanked	4
SMS_Eff_04	2
SMS_Eff_05	1
SMS_Eff_06	2
SMS_Eff_07	5
SMS_Eff_08	6
SMS_Eff_09	3
Q02	
Adapted Existing Safety Policy or QMS to SMS	5
Departmental Implementation, Including SMS Department	3
Education and Training	1
FAA Pilot Program	2
Information Not Available	1
Integrated into Business Model, Corporate Values, Operations	8
Regulatory Mandate	1
Top-Down, Integrated	4
Weak Relation to Organizational Mission	1
Q03	
Ad Hoc Request Process	1
Business Model or Case	4
Companywide Data Collection and Departmental Data Analysis	1
Dedicated SMS Personnel	6
Different Question Answered	2
Gap Analysis	1
Integrated Into Entire System	5
Needs, Experience, Feasibility	2
No Budget	1
Work in Progress, Future-dedicated SMS Personnel	1
Q04	
Audits	6
Dashboard	1
Documentation, Tracking, Visibility	1
Eval_Eff_Regular Meetings	1
Feedback-Review Loop	3
Internal Evaluation Program	3
Measure by Element	1
Metrics_Threats_Issues	4
No Formal Method	4
Operational Monitoring	1
Regulatory Inspection	1
SPIs or KPIs	3
SWOT Analysis	1
Trends and Meetings	4
Variable Weighting	1

Q05	
Analyze KPIs or SPIs, etc.	3
Audits	3
Continuous	1
Emphasis Area, and Dedicated SMS Staff	1
Enterprise Risk Management	1
Goal Focus	2
Job Aids from SMS Voluntary Program	1
Monthly Management Review	1
No Current Method	4
Not Sure	1
Safety Culture	1
Surveys	1
Trending	6
Q06	
Audit Reports	1
Baselining and Goals	2
Dashboard	1
How Risk Controls Impacting Numbers	1
KPI	1
Monthly to Quarterly Management Reporting	1
No SMS-specific Reports	7
Not Sure	1
Safety Standards Report	1
Score Cards	1
Trend Charts	1
Unwilling to Share Details	2
Well Developed	1
Yes (details not provided)	2
Q07	
Currently-No	10
End Results, Goals in Performance Appraisals	1
Future-Likely	4
Informal	2
Limited Extent	1
Part of Manager Goals; For Others, Just Safety	2
Safety Is, But Not Specifically SMS	6
SMS Component Incorporated in Performance Appraisals	1
Q08	
CEO or President	6
COO	4
Director of Safety (Assurance)	3
One Level Below COO	1
SMS Manager	3
Vice President of Operations	4
Vice President of Safety	1

Q09	
Annual-10 to 15 hours	2
Annual-15 to 20 Briefings	1
Annual-20 to 30 hours	1
Annual-2 to 5 days	1
Annual-2 to 6 hours	11
Annual-8 to 12 hours	4
Annual-Less Than 2hours	18
Based on Job Function	1
Minimal	6
No Recurrent, Only Initial	5
None (per se)	3
Not Sure	1
Q10	
Air Group Risk Matrix	1
As Per SMS Level 4 Submission to FAA	1
At Part 5 Level	1
Audits	1
No (context uncertain)	4
Not Provided	7
Risk Assessment Matrix	1
Safety Risk Profile	1
SMS Assessments	1
SMS Data Flows to the Top	1
Trends	3
Vague Answer	1
Will Not Share	1

Q11	
Audit Program	1
Collaborate With Other Orgs	2
Consistent Process	1
Cookie-Cutter Format	1
Direct Reports to SMS Manager	1
Dirty Dozen Concept	1
Eval-Audit	1
Event Risk Classification	1
Features-Controls	1
Integrated Review Board	1
Just Culture	1
Merger Improved SMS	1
No (context uncertain)	1
Nothing Unique	2
Operating Groups Own Their Processes	1
Overall Organizational Risk Index of Safety	1
Physically Locate Safety Managers Next to One Another	1
Revised QA Program	1
Risk Management Focus	2
Risk Reduction Trumps Compliance	1
Security and Environmental Areas	1
SMS Integrated Into System	3
SPIs and Alert Levels	1
Strong Internal Communication	1
System and Task Analysis	1

SWOT= Strengths, Weaknesses, Opportunities, Threats

APPENDIX D—CONSOLIDATED QUESTION Q01 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q01													
SMS_Eff_00_NotRanked	4	3			1	2			1	1		4	
SMS_Eff_04	2	1		1		2						2	
SMS_Eff_05	1			1				1				1	
SMS_Eff_06	2	2						2				2	
SMS_Eff_07	5	5				4		1				4	1
SMS_Eff_08	6	5			1	5			1			6	
SMS_Eff_09	3	1	1	1		2	1				1	2	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q01									
SMS_Eff_00_NotRanked	1	1	1				1		
SMS_Eff_04	1				1				
SMS_Eff_05									1
SMS_Eff_06								2	
SMS_Eff_07	3					1		1	
SMS_Eff_08	4	1					1		
SMS_Eff_09	1			1	1				

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q01													
SMS_Eff_00_NotRanked	1	1	1			1			3				1
SMS_Eff_04	1				1				1		1		
SMS_Eff_05								1			1		
SMS_Eff_06							2		2				
SMS_Eff_07	4						1		4			1	
SMS_Eff_08	4	1				1			5				1
SMS_Eff_09	1			1	1				1	1	1		

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q01						
SMS_Eff_00_NotRanked	2	1	1			
SMS_Eff_04	2					
SMS_Eff_05						1
SMS_Eff_06						2
SMS_Eff_07	3				1	1
SMS_Eff_08	5	1				
SMS_Eff_09	2			1		

APPENDIX E—CONSOLIDATED QUESTION Q02 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q02													
Adapted Existing Safety Policy or QMS to SMS	5	5				5						4	1
Departmental Implementation, Including SMS Department	3	3				2		1				2	1
Education and Training	1	1						1				1	
FAA Pilot Program	2	1		1		2						2	
Information Not Available	1		1				1				1		
Integrated Into Business Model, Corporate Values, Operations	8	7			1	5		1	1	1		8	
Regulatory Mandate	1	1						1				1	
Top-Down, Integrated	4	3		1		3			1			4	
Weak Relation to Organizational Mission	1			1				1				1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q02									
Adapted Existing Safety Policy or QMS to SMS	4					1			
Departmental Implementation, Including SMS Department	1					1		1	
Education and Training								1	
FAA Pilot Program	1				1				
Information Not Available				1					
Integrated Into Business Model, Corporate Values, Operations	4	1	1				1	1	
Regulatory Mandate								1	
Top-Down, Integrated	2	1			1				
Weak Relation to Organizational Mission									1

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q02													
Adapted Existing Safety Policy or QMS to SMS	5								4			1	
Departmental Implementation, Including SMS Department	2						1		2			1	
Education and Training							1		1				
FAA Pilot Program	1				1				1		1		
Information Not Available				1						1			
Integrated Into Business Model, Corporate Values, Operations	4	1	1			1	1		7				1
Regulatory Mandate							1		1				
Top-Down, Integrated	2	1			1				3		1		
Weak Relation to Organizational Mission								1			1		

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q02						
Adapted Existing Safety Policy or QMS to SMS	4				1	
Departmental Implementation, Including SMS Department	1				1	1
Education and Training						1
FAA Pilot Program	2					
Information Not Available				1		
Integrated Into Business Model, Corporate Values, Operations	5	1	1			1
Regulatory Mandate						1
Top-Down, Integrated	3	1				
Weak Relation to Organizational Mission						1

APPENDIX F—CONSOLIDATED QUESTION Q03 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q03													
Ad Hoc Request Process	1			1		1						1	
Business Model or Case	4	4				1		1	1	1		4	
Company-wide Data Collection and Departmental Data Analysis	1	1				1						1	
Dedicated SMS Personnel	6	5		1		4		2				6	
Different Question Answered	2	2				2						2	
Gap Analysis	1	1				1						1	
Integrated Into Entire System	5	3	1	1		2	1	1	1		1	4	
Needs, Experience, Feasibility	2	2				1		1				1	1
No Budget	1	1				1						1	
Work in Progress, Future-dedicated SMS Personnel	1				1	1						1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q03									
Ad Hoc Request Process					1				
Business Model or Case	1	1	1					1	
Companywide Data Collection and Departmental Data Analysis	1								
Dedicated SMS Personnel	4							1	1
Different Question Answered	2								
Gap Analysis	1								
Integrated Into Entire System	1	1		1	1			1	
Needs, Experience, Feasibility						1		1	
No Budget	1								
Work in Progress, Future-dedicated SMS Personnel							1		

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q03													
Ad Hoc Request Process					1						1		
Business Model or Case	1	1	1				1		4				
Companywide Data Collection and Departmental Data Analysis	1								1				
Dedicated SMS Personnel	4						1	1	5		1		
Different Question Answered	2								2				
Gap Analysis	1								1				
Integrated Into Entire System	1	1		1	1		1		3	1	1		
Needs, Experience, Feasibility	1						1		1			1	
No Budget	1								1				
Work in Progress, Future-dedicated SMS Personnel						1							1

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q03						
Ad Hoc Request Process	1					
Business Model or Case	1	1	1			1
Companywide Data Collection and Departmental Data Analysis	1					
Dedicated SMS Personnel	4					2
Different Question Answered	2					
Gap Analysis	1					
Integrated Into Entire System	2	1		1		1
Needs, Experience, Feasibility					1	1
No Budget	1					
Work in Progress, Future-dedicated SMS Personnel	1					

APPENDIX G—CONSOLIDATED QUESTION Q04 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q04													
Audits	6	6				2		3	1			6	
Dashboard	1	1				1						1	
Documentation, Tracking, Visibility	1	1				1						1	
Eval_Eff_Regular Meetings	1	1				1						1	
Feedback-Review Loop	3	1	1		1	2	1				1	2	
IEP	3	3				3						3	
Measure by Element	1	1							1			1	
Metrics_Threats_Issues	4	4				3			1			4	
No Formal Method	4	3		1		4						3	1
Operational Monitoring	1			1		1						1	
Regulatory Inspection	1	1						1				1	
SPI or KPIs	3	2		1		1		1		1		3	
SWOT Analysis	1	1						1				1	
Trends and Meetings	4	3			1	2		1		1		4	
Variable Weighting	1				1	1						1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q04									
Audits	2	1						3	
Dashboard	1								
Documentation, Tracking, Visibility	1								
Eval_Eff_Regular Meetings	1								
Feedback-Review Loop	1			1			1		
IEP	3								
Measure by Element		1							
Metrics_Threats_Issues	3	1							
No Formal Method	2				1	1			
Operational Monitoring					1				
Regulatory Inspection								1	
SPI or KPIs	1		1						1
SWOT Analysis								1	
Trends and Meetings	1		1				1	1	
Variable Weighting							1		

	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q04																	
Audits			3		2	1					3		6				
Dashboard					1								1				
Documentation, Tracking, Visibility					1								1				
Eval_Eff_Regular Meetings					1								1				
Feedback-Review Loop		1			1			1		1			1	1			1
IEP					3								3				
Measure by Element						1							1				
Metrics_Threats_ Issues					3	1							4				
No Formal Method	1				3				1				2		1	1	
Operational Monitoring									1						1		
Regulatory Inspection			1								1		1				
SPI or KPIs				1	1		1					1	2		1		
SWOT Analysis			1								1		1				
Trends and Meetings		1	1		1		1			1	1		3				1
Variable Weighting		1								1							1

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q04						
Audits	2	1				3
Dashboard	1					
Documentation, Tracking, Visibility	1					
Eval_Eff_Regular Meetings	1					
Feedback-Review Loop	2			1		
IEP	3					
Measure by Element		1				
Metrics_Threats_Issues	3	1				
No Formal Method	3				1	
Operational Monitoring	1					
Regulatory Inspection						1
SPI or KPIs	1		1			1
SWOT Analysis						1
Trends and Meetings	2		1			1
Variable Weighting	1					

APPENDIX H—CONSOLIDATED QUESTION Q05 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q05													
Analyze KPIs or SPIs, etc.	3	2		1		1		1		1		3	
Audits	3	2		1		3						3	
Continuous	1	1				1						1	
Emphasis Area, and Dedicated SMS Staff	1				1	1						1	
Enterprise Risk Management	1			1		1						1	
Goal Focus	2	2				1		1				2	
Job Aids From SMS Voluntary Program	1	1				1						1	
Monthly Management Review	1	1				1						1	
No Current Method	4	4				3		1				4	
Not Sure	1		1				1				1		
Safety Culture	1	1				1						1	
Surveys	1	1				1						1	
Trending	6	6				3		1	2			5	1

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q05									
Analyze KPIs or SPIs, etc.	1		1						1
Audits	2				1				
Continuous	1								
Emphasis Area, and Dedicated SMS Staff							1		
Enterprise Risk Management					1				
Goal Focus	1							1	
Job Aids From SMS Voluntary Program	1								
Monthly Management Review	1								
No Current Method	3							1	
Not Sure				1					
Safety Culture	1								
Surveys	1								
Trending	2	2				1		1	

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q05													
Analyze KPIs or SPIs, etc.	1		1					1	2		1		
Audits	2				1				2		1		
Continuous	1								1				
Emphasis Area, and Dedicated SMS Staff						1							1
Enterprise Risk Management					1						1		
Goal Focus	1						1		2				
Job Aids From SMS Voluntary Program	1								1				
Monthly Management Review	1								1				
No Current Method	3						1		4				
Not Sure				1						1			
Safety Culture	1								1				
Surveys	1								1				
Trending	3	2					1		5			1	

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q05						
Analyze KPIs or SPIs, etc.	1		1			1
Audits	3					
Continuous	1					
Emphasis Area, and Dedicated SMS Staff	1					
Enterprise Risk Management	1					
Goal Focus	1					1
Job Aids From SMS Voluntary Program	1					
Monthly Management Review	1					
No Current Method	3					1
Not Sure				1		
Safety Culture	1					
Surveys	1					
Trending	2	2			1	1

APPENDIX 1—CONSOLIDATED QUESTION Q06 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q06													
Audit Reports	1	1						1				1	
Baselining and Goals	2	1		1		1		1				2	
Dashboard	1	1				1						1	
How Risk Controls Impacting Numbers	1	1				1							1
KPI	1	1				1						1	
Monthly to Quarterly Management Reporting	1	1				1						1	
No SMS-Specific Reports	7	6		1		5		1	1			7	
Not Sure	1		1				1				1		
Safety Standards Report	1	1						1				1	
Score Cards	1			1		1						1	
Trend Charts	1	1				1						1	
Unwilling to Share Details	2	1			1	1			1			2	
Well Developed	1	1							1			1	
Yes (details not provided)	2	1			1	2						2	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q06									
Audit Reports								1	
Baselining and Goals	1								1
Dashboard	1								
How Risk Controls Impacting Numbers						1			
KPI	1								
Monthly to Quarterly Management Reporting	1								
No SMS-Specific Reports	4	1			1			1	
Not Sure				1					
Safety Standards Report								1	
Score Cards					1				
Trend Charts	1								
Unwilling to Share Details		1					1		
Well Developed		1							
Yes (details not provided)	1						1		

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q06													
Audit Reports							1		1				
Baselining and Goals	1							1	1		1		
Dashboard	1								1				
How Risk Controls Impacting Numbers	1											1	
KPI	1								1				
Monthly to Quarterly Management Reporting	1								1				
No SMS-Specific Reports	4	1			1		1		6		1		
Not Sure				1						1			
Safety Standards Report							1		1				
Score Cards					1						1		
Trend Charts	1								1				
Unwilling to Share Details		1				1			1				1
Well Developed		1							1				
Yes (details not provided)	1					1			1				1

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q06						
Audit Reports						1
Baselining and Goals	1					1
Dashboard	1					
How Risk Controls Impacting Numbers					1	
KPI	1					
Monthly to Quarterly Management Reporting	1					
No SMS-Specific Reports	5	1				1
Not Sure				1		
Safety Standards Report						1
Score Cards	1					
Trend Charts	1					
Unwilling to Share Details	1	1				
Well Developed		1				
Yes (details not provided)	2					

APPENDIX J—CONSOLIDATED QUESTION Q07 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q07													
Currently-No	10	10				7		1	1	1		10	
End Results, Goals in Performance Appraisals	1				1	1						1	
Future-Likely	4	4				2		1	1			4	
Informal	2	2				1		1				2	
Limited Extent	1			1				1				1	
Part of Manager Goals; For Others, Just Safety	2	2				2						1	1
Safety Is, But Not Specifically SMS	6	3	1	2		4	1		1		1	5	
SMS Component Incorporated in Performance Appraisals	1	1						1				1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q07									
Currently-No	7	1	1					1	
End Results, Goals in Performance Appraisals							1		
Future-Likely	2	1						1	
Informal	1							1	
Limited Extent									1
Part of Manager Goals; For Others, Just Safety	1					1			
Safety Is, But Not Specifically SMS	2	1		1	2				
SMS Component Incorporated in Performance Appraisals								1	

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q07													
Currently-No	7	1	1				1		10				
End Results, Goals in Performance Appraisals						1							1
Future-Likely	2	1					1		4				
Informal	1						1		2				
Limited Extent								1			1		
Part of Manager Goals; For Others, Just Safety	2								1			1	
Safety Is, But Not Specifically SMS	2	1		1	2				3	1	2		
SMS Component Incorporated in Performance Appraisals							1		1				

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q07						
Currently-No	7	1	1			1
End Results, Goals in Performance Appraisals	1					
Future-Likely	2	1				1
Informal	1					1
Limited Extent						1
Part of Manager Goals; For Others, Just Safety	1				1	
Safety Is, But Not Specifically SMS	4	1		1		
SMS Component Incorporated in Performance Appraisals						1

APPENDIX K—CONSOLIDATED QUESTION Q08 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q08													
CEO or President	6	5	1			3	1	2			1	4	1
COO	4	4				3			1			4	
Director of Safety (Assurance)	3	2		1		2			1			3	
One Level Below COO	1	1								1		1	
SMS Manager	3	1		1	1	3						3	
Vice President of Operations	4	4				3		1				4	
Vice President of Safety	1			1				1				1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q08									
CEO or President	2			1		1		2	
COO	3	1							
Director of Safety (Assurance)	1	1			1				
One Level Below COO			1						
SMS Manager	1				1		1		
Vice President of Operations	3							1	
Vice President of Safety									1

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q08													
CEO or President	3			1			2		4	1		1	
COO	3	1							4				
Director of Safety (Assurance)	1	1			1				2		1		
One Level Below COO			1						1				
SMS Manager	1				1	1			1		1		1
Vice President of Operations	3						1		4				
Vice President of Safety								1			1		

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q08						
CEO or President	2			1	1	2
COO	3	1				
Director of Safety (Assurance)	2	1				
One Level Below COO			1			
SMS Manager	3					
Vice President of Operations	3					1
Vice President of Safety						1

APPENDIX L—CONSOLIDATED QUESTION Q09 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q09													
Annual-10 to 15 hours	2	1		1		2						2	
Annual-15 to 20 Briefings	1	1				1						1	
Annual-20 to 30 Hours	1			1		1						1	
Annual-2 to 5 days	1				1	1						1	
Annual-2 to 6 Hours	11	10		1		10		1				11	
Annual-8 to 12 Hours	4	2		2		3		1				4	
Annual-Less Than 2 Hours	18	13		5		16		2				18	
Based on Job Function	1	1							1			1	
Minimal	6	5			1	3		1	1	1		5	1
No Recurrent, Only Initial	5	1		4		4			1			5	
None (per se)	3	3				3						3	
Not Sure	1		1				1				1		

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q09									
Annual-10 to 15 Hours	1				1				
Annual-15 to 20 Briefings	1								
Annual-20 to 30 Hours					1				
Annual-2 to 5 Days							1		
Annual-2 to 6 Hours	10								1
Annual-8 to 12 Hours	1				2			1	
Annual-Less Than 2 Hours	12				4			1	1
Based on Job Function		1							
Minimal	1	1	1			1	1	1	
No Recurrent, Only Initial		1			4				
None (per se)	3								
Not Sure				1					

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q09													
Annual-10 to 15 Hours	1				1				1		1		
Annual-15 to 20 Briefings	1								1				
Annual-20 to 30 Hours					1						1		
Annual-2 to 5 Days						1							1
Annual-2 to 6 Hours	10							1	10		1		
Annual-8 to 12 Hours	1				2		1		2		2		
Annual-Less Than 2 Hours	12				4		1	1	13		5		
Based on Job Function		1							1				
Minimal	2	1	1			1	1		4			1	1
No Recurrent, Only Initial		1			4				1		4		
None (per se)	3								3				
Not Sure				1						1			

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q09						
Annual-10 to 15 Hours	2					
Annual-15 to 20 Briefings	1					
Annual-20 to 30 Hours	1					
Annual-2 to 5 Days	1					
Annual-2 to 6 Hours	10					1
Annual-8 to 12 Hours	3					1
Annual-Less Than 2 Hours	16					2
Based on Job Function		1				
Minimal	2	1	1		1	1
No Recurrent, Only Initial	4	1				
None (per se)	3					
Not Sure				1		

	Top management	Middle management	Line management	Non-management employees
Annual-10 to 15 Hours	1	0	1	0
Annual-15 to 20 Briefings	0	1	0	0
Annual-20 to 30 Hours	0	0	0	1
Annual-2 to 5 Days	1	1	1	0
Annual-2 to 6 Hours	6	6	4	3
Annual-8 to 12 Hours	1	1	1	1
Annual-Less Than 2 Hours	5	4	6	10
Minimal	4	5	4	3
No Recurrent, Only Initial	1	1	1	1
None (per se)	0	1	2	1
Not Sure	0	0	0	0

APPENDIX M—CONSOLIDATED QUESTION Q10 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q10													
Air Group Risk Matrix	1	1				1						1	
As Per SMS Level 4 Submission to FAA	1	1				1						1	
At Part 5 Level	1	1				1						1	
Audits	1	1							1			1	
No (context uncertain)	4	2	1	1		2	1	1			1	3	
Not Provided	7	6		1		7						6	1
Risk Assessment Matrix	1	1						1				1	
Safety Risk Profile	1	1						1				1	
SMS Assessments	1	1				1						1	
SMS Data Flows to the Top	1	1				1						1	
Trends	3	3				1			1	1		3	
Vague Answer	1			1				1				1	
Will Not Share	1				1	1						1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q10									
Air Group Risk Matrix	1								
As Per SMS Level 4 Submission to FAA	1								
At Part 5 Level	1								
Audits		1							
No (context uncertain)	1			1	1			1	
Not Provided	5				1	1			
Risk Assessment Matrix								1	
Safety Risk Profile								1	
SMS Assessments	1								
SMS Data Flows to the Top	1								
Trends	1	1	1						
Vague Answer									1
Will Not Share							1		

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q10													
Air Group Risk Matrix	1								1				
As Per SMS Level 4 Submission to FAA	1								1				
At Part 5 Level	1								1				
Audits		1							1				
No (context uncertain)	1			1	1		1		2	1	1		
Not Provided	6				1				5		1	1	
Risk Assessment Matrix							1		1				
Safety Risk Profile							1		1				
SMS Assessments	1								1				
SMS Data Flows to the Top	1								1				
Trends	1	1	1						3				
Vague Answer								1			1		
Will Not Share						1							1

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q10						
Air Group Risk Matrix	1					
As Per SMS Level 4 Submission to FAA	1					
At Part 5 Level	1					
Audits		1				
No (context uncertain)	2			1		1
Not Provided	6				1	
Risk Assessment Matrix						1
Safety Risk Profile						1
SMS Assessments	1					
SMS Data Flows to the Top	1					
Trends	1	1	1			
Vague Answer						1
Will Not Share	1					

APPENDIX N—CONSOLIDATED QUESTION Q11 WITH DEMOGRAPHICS

	All Interviews	Type = Carrier	Type = Manufacturer	Type = Airport	Type = Freight Hauler	Base = U.S.	Base = France	Base = Canada	Base = U.K.	Base = Germany	Routes = Not Applicable	Routes = International	Routes = Domestic
Q11													
Audit Program	1	1						1				1	
Collaborate With Other Orgs	2	2				2						2	
Consistent Process	1	1				1						1	
Cookie-Cutter Format	1				1	1						1	
Direct Reports to SMS Manager	1	1				1							1
Dirty Dozen Concept	1	1				1						1	
Eval-Audit	1	1							1			1	
Event Risk Classification	1	1				1						1	
Features-Controls	1	1							1			1	
Integrated Review Board	1	1				1						1	
Just Culture	1	1				1						1	
Merger Improved SMS	1	1				1						1	
No (context uncertain)	1	1				1						1	
Nothing Unique	2			2		2						2	
Operating Groups Own Their Processes	1	1				1						1	
Overall Organizational Risk Index of Safety	1	1								1		1	
Physically Locate Safety Managers Next to One Another	1	1						1				1	
Revised QA Program	1			1				1				1	
Risk Management Focus	2	2				2						2	
Risk Reduction Trumps Compliance	1	1				1						1	
Security and Environmental Areas	1	1				1						1	
SMS Integrated Into System	3	2	1				1	1	1		1	2	
SPIs and Alert Levels	1			1				1				1	
Strong Internal Communication	1	1						1				1	
System and Task Analysis	1	1				1						1	

	Type-Base-Route = Carrier-U.S.-International	Type-Base-Route = Carrier-U.K.-International	Type-Base-Route = Carrier-Germany-International	Type-Base-Route = Manufacturer-France-Not Applicable	Type-Base-Route = Airport-U.S.-International	Type-Base-Route = Carrier-U.S.-Domestic	Type-Base-Route = Freight Hauler-U.S.-International	Type-Base-Route = Carrier-Canada-International	Type-Base-Route = Airport-Canada-International
Q11									
Audit Program								1	
Collaborate With Other Orgs	2								
Consistent Process	1								
Cookie-Cutter Format							1		
Direct reports to SMS Manager						1			
Dirty Dozen Concept	1								
Eval-Audit		1							
Event Risk Classification	1								
Features-Controls		1							
Integrated Review Board	1								
Just Culture	1								
Merger Improved SMS	1								
No (context uncertain)	1								
Nothing Unique					2				
Operating Groups Own Their Processes	1								
Overall Organizational Risk Index of Safety			1						
Physically Locate Safety Managers Next to One Another								1	
Revised QA Program									1
Risk Management Focus	2								
Risk Reduction Trumps Compliance	1								
Security and Environmental Areas	1								
SMS Integrated Into System		1		1				1	
SPIs and Alert Levels									1
Strong Internal Communication								1	
System and Task Analysis	1								

	Type-Base = Carrier-U.S.	Type-Base = Carrier-U.K.	Type-Base = Carrier-Germany	Type-Base = Manufacturer-France	Type-Base = Airport-U.S.	Type-Base = Freight Hauler-U.S.	Type-Base = Carrier-Canada	Type-Base = Airport-Canada	Type-Routes = Carrier-International	Type-Routes = Manufacturer-Not Applicable	Type-Routes = Airport-International	Type-Routes = Carrier-Domestic	Type-Routes = Freight Hauler-International
Q11													
Audit Program							1		1				
Collaborate With Other Orgs	2								2				
Consistent Process	1								1				
Cookie-Cutter Format						1							1
Direct Reports to SMS Manager	1											1	
Dirty Dozen Concept	1								1				
Eval-Audit		1							1				
Event Risk Classification	1								1				
Features-Controls		1							1				
Integrated Review Board	1								1				
Just Culture	1								1				
Merger Improved SMS	1								1				
No (context uncertain)	1								1				
Nothing Unique					2						2		
Operating Groups Own Their Processes	1								1				
Overall Organizational Risk Index of Safety			1						1				
Physically Locate Safety Managers Next to One Another							1		1				
Revised QA Program								1			1		
Risk Management Focus	2								2				
Risk Reduction Trumps Compliance	1								1				
Security and Environmental Areas	1								1				
SMS Integrated Into System		1		1			1		2	1			
SPIs and Alert Levels								1			1		
Strong Internal Communication							1		1				
System and Task Analysis	1								1				

	Base-Routes = U.S.-International	Base-Routes = U.K.-International	Base-Routes = Germany-International	Base-Routes = France-Not Applicable	Base-Routes = U.S.-Domestic	Base-Routes = Canada-International
Q11						
Audit Program						1
Collaborate With Other Orgs	2					
Consistent Process	1					
Cookie-Cutter Format	1					
Direct Reports to SMS Manager					1	
Dirty Dozen Concept	1					
Eval-Audit		1				
Event Risk Classification	1					
Features-Controls		1				
Integrated Review Board	1					
Just Culture	1					
Merger Improved SMS	1					
No (context uncertain)	1					
Nothing Unique	2					
Operating Groups Own Their Processes	1					
Overall Organizational Risk Index of Safety			1			
Physically Locate Safety Managers Next to One Another						1
Revised QA Program						1
Risk Management Focus	2					
Risk Reduction Trumps Compliance	1					
Security and Environmental Areas	1					
SMS Integrated Into System		1		1		1
SPIs and Alert Levels						1
Strong Internal Communication						1
System and Task Analysis	1					

APPENDIX O—RESULTS OF VALIDITY AND RELIABILITY TESTING

Table O-1. Normality examination

Variable	Min	Max	Skew	Kurtosis
SP1	1.000	5.000	-.510	-.901
SP2	1.000	5.000	-.413	-.982
SP3	1.000	5.000	-.493	-.886
SP4	1.000	5.000	-.346	-1.015
SA2	1.000	5.000	-.276	-1.047
SA3	1.000	5.000	-.382	-1.135
SA4	1.000	5.000	-.146	-1.096
SA8	1.000	5.000	-.720	-.590
SRM1	1.000	5.000	-.556	-.823
SRM3	1.000	5.000	-.507	-.978
SRM4	1.000	5.000	-.392	-1.021
SRM5	1.000	5.000	-.704	-.646
SRM6	1.000	5.000	-.712	-.870
SPO2	1.000	5.000	-.431	-1.029
SPO3	1.000	5.000	-.364	-1.150
SPO4	1.000	5.000	-.020	-1.331
SPO5	1.000	5.000	-.471	-1.086
SPO8	1.000	5.000	-.284	-1.165
SPO9	1.000	5.000	-.552	-1.034

Table O-2. Outlier examination

Observation number	Mahalanobis D-squared
5	30.704
22	29.591
1	28.965
13	27.198
3	27.178
18	26.892
31	26.716
26	26.356
30	26.002
17	25.788
12	25.579
25	25.130
10	25.119
9	24.588
21	23.368
2	23.235
28	22.879
19	21.940
15	20.403
23	19.580
24	17.950
7	15.611
20	14.878
16	14.641
29	12.396
11	11.993
6	7.762
27	7.588
4	6.082
32	3.509
8	2.743
33	2.743
14	1.894

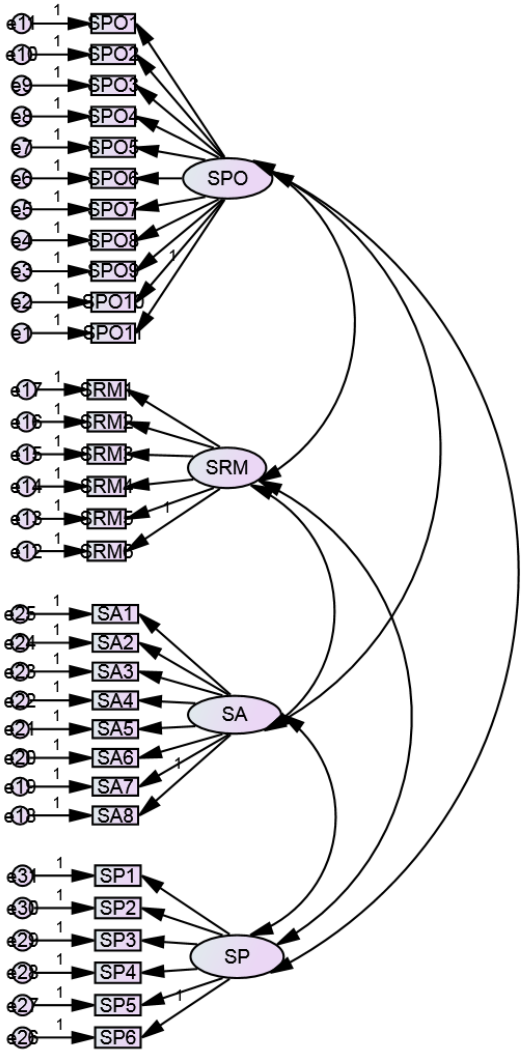

Figure O-1. Confirmatory factor analysis

Table O-3. Question items and codes

Items	Questions
SPO1	Either the chief executive officer, the chief operating officer, or the equivalent fulfills the role of accountable executive.
SPO2	A professional manager, qualified in terms of education and experience and directly reporting to the accountable executive, manages, monitors, and coordinates the system safety process.
SPO3	The organization has developed, documented, and fully implemented a comprehensive system safety plan, accessible to all employees.
SPO4	Safety policies, procedures, and processes based on the safety management plan, are clearly defined, documented, communicated, and implemented throughout the organization.
SPO5	Procedures have been clearly developed and implemented for response to accidents, incidents, and operational emergencies.
SPO6	The safety plan is clearly tied to the organizational mission, aligned with corporate objectives, and integrated throughout the organization.
SPO7	Expectations, accountabilities, responsibilities, and authorities for safety-related policies, processes, and procedures are clearly defined, documented, and communicated throughout the organization.
SPO8	Safety competencies for all applicable positions are identified, and documentation provides evidence that all competency requirements are met for all positions.
SPO9	There are clear standards for acceptable operational behavior as it relates to system safety for all employees.
SPO10	Appropriate responsibilities and authorities can be clearly traced from any level or position to the accountable executive in the organization.
SPO11	Resources in terms of personnel and budgets are appropriate for implementation and maintenance of system safety throughout the organization.
SPO_O1	What is the number of full-time personnel with safety in their job titles? Enter -99 for all.
SPO_O2	What is the number of other full-time personnel with system safety in their job descriptions? Enter -99 for all.
SPO_O3	What percentage of overall budget within the organization is allocated toward system safety?
SRM1	Processes are clearly defined, communicated, and implemented to ensure that all hazards likely to cause death, physical harm, or equipment or property damage are identified and documented at all stages of the system/process/product life cycles.
SRM2	Safety risk analysis processes for all identified hazards are clearly defined, communicated, and implemented throughout the organization.

Table O-3. Question items and codes (continued)

SRM3	During a GAP analysis or other systematic procedure, safety risk assessment processes for all identified hazards were clearly defined, documented, communicated, and implemented throughout the organization.
SRM4	Risk control and mitigation processes, above an appropriate, acceptable, and clearly defined level of risk, are implemented and applied to all hazards.
SRM5	Within corporate guidelines, a closed-loop system for the reporting of safety issues by any and all employees and relevant constituents without fear of reprisal is strongly encouraged and clearly communicated. Anonymity or confidentiality is available when preferred.
SRM6	Anonymity is always available to all personnel when preferred.
SRM_O1	How much was spent on direct property damage losses?
	What was the average number of personnel performing each safety audit?
SA1	Clear documentation and evidence exists showing the organization has a clear and effective system in place to monitor, measure, evaluate, and document the performance and effectiveness of all risk controls.
SA2	Clear documentation and evidence exists showing the organization continuously monitors operational data, including products and services received from contractors, safety reports, and employee safety feedback to determine and document conformity to established risk controls and evaluate system safety performance.
SA3	Clear documentation and evidence exists showing clear and relevant system safety outputs are generated regularly, thoroughly reviewed, and incorporated into policies, procedures, and processes by top management.
SA4	Clear documentation and evidence exists showing there are timely and appropriate periodic reviews of all safety policies, procedures, and processes to ensure relevance and appropriateness.
SA5	Clear documentation and evidence exists showing comprehensive audits of system safety are performed at least annually on all safety-related operational processes, including those performed by contractors, to verify safety performance and evaluate the effectiveness of safety risk controls.
SA6	Clear documentation and evidence exists showing audit(s) demonstrating that all system safety functions are in conformance with the safety management plan and are used for CI of system safety processes and performance.
SA7	Clear documentation and evidence exists showing that auditors possess appropriate professional qualifications and are independent of any processes or work evaluated.
SA8	Clear documentation and evidence exists showing that procedures are clearly defined, documented, communicated, and implemented to collect data and investigate incidents, accidents, and instances of regulatory noncompliance to identify potential new hazards or risk-control failures.
SA_O1	How many reviews of safety outputs were completed by accountable executives?
SA_O2	How many reviews of safety procedures and processes were completed by management personnel?

Table O-3. Question items and codes (continued)

SA_O3	How many written policy/procedure adjustments resulted from safety reviews?
SA_O4	How many internal safety audits were accomplished?
SA_O5	How many external safety audits were accomplished?
SA_O6	How many deviations from policies/ procedures were found during safety audits and corrected?
SA_O7	What was the average number of personnel performing each safety audit?
SP1	Clear documentation and evidence exist of thorough publication and distribution to all employees of senior management's stated commitment to safety whereby top management demonstrates the growth of a positive safety environment throughout the organization.
SP2	Clear documentation and evidence exist of frequent and visible demonstration of management commitment to the safety system through both verbal and written communications.
SP3	Clear documentation and evidence exist demonstrating that the organization ensures all personnel are appropriately trained and competent to perform duties related to the safety system; training scope is commensurate with required competencies and responsibilities in the safety system; and initial and periodic safety system training for all employees is clearly outlined, scheduled, and performed.
SP4	Clear documentation and evidence exist demonstrating that the safety system training requirements are met for all new hires and transfers within the organization.
SP5	Clear documentation and evidence exist demonstrating that appropriate safety system refresher training for all employees is updated and instituted at least annually.
SP6	Clear documentation and evidence exist demonstrating that top management documents communication of safety system outputs throughout the organization, the rationale behind controls, and preventative or corrective actions, and provides its oversight organization access to this information.
SP_O1	How many publications promoting the safety system were distributed to employees?
SP_O2	How many hours were spent in training for each newly hired employee on the safety system?
SP_O3	How many hours were spent in training for each transferred employee on the safety system?
SP_O4	How many hours were spent on safety system refresher training per employee at the top management level?
SP_O5	How many hours were spent on safety system refresher training per employee at the mid-management level?
SP_O6	How many hours were spent on safety system refresher training per employee at the front-line management level?
SP_O7	How many hours were spent on safety system refresher training per employee at the non-management level?

Table O-4. Standardized factor loadings, reliability, and convergent validity

Constructs/Factors	Items	Standardized Factor Loadings	Cronbach's alpha	CR	AVE
SPO	SPO2	0.803	0.91	0.9	0.72
	SPO3	0.93			
	SPO4	0.903			
	SPO5	0.787			
	SPO8	0.809			
	SPO9	0.865			
SRM	SRM1	0.855	0.88	0.88	0.72
	SRM3	0.847			
	SRM4	0.952			
	SRM5	0.752			
	SRM6	0.812			
SA	SA2	0.947	0.93	0.92	0.83
	SA3	0.925			
	SA4	0.941			
	SA8	0.821			
SP	SP1	0.795	0.92	0.91	0.82
	SP2	0.889			
	SP3	0.97			
	SP4	0.954			

APPENDIX P—DATA PREPARATION AND DEA ANALYSIS

Table P-1. Deleted units due to unusable data

Deleted Units	Reasons
6	Organizations are not using SMS.
7	Invalid data regarding number of employees with the "safety system" in the job title/description.
12	Invalid data regarding number of employees with the "safety system" in the job title/description.
14	Unusable data (all answers are 3); unverified respondent.
17	Organizations are not using SMS.
23	Invalid data regarding number of employees with the "safety system" in the job title/description.
24	Irrelevant respondent: college professor.
27	Irrelevant respondent: college professor Organizations are not using SMS.
29	Organizations are not using SMS; all answers to SMS are 1.

Table P-2. Data conversion for output variables

Items	Questions	Conversion
SPO_O1	What is the number of full-time personnel with safety in their job titles?	Divide by FTEs
SPO_O2	What is the number of other full-time personnel with system safety in their job descriptions?	Divide by number of FTEs
SPO_O3	What percentage of overall budget within the organization is allocated toward system safety?	None
SRM_O1	How much was spent on direct property damage losses?	Divide by Number of FTEs Inverted
SA_O1	How many reviews of safety outputs were completed by the accountable executive?	None
SA_O2	How many reviews of safety procedures and processes were completed by management personnel?	Divide by Number of FTEs
SA_O3	How many written policy/procedure adjustments resulted from safety reviews?	Divide by SA_O2
SA_O4	How many internal safety audits were accomplished?	None
SA_O5	How many external safety audits were accomplished?	None
SA_O6	How many deviations from policies/procedures were found during safety audits and corrected?	Divide by (SA_O4+SAO5)
SA_O7	What was the average number of personnel performing each safety audit?	None
SP_O1	How many publications promoting the safety system were distributed to employees?	None
SP_O2	How many hours were spent in training for each newly hired employee on the safety system?	None
SP_O3	How many hours were spent in training for each transferred employee on the safety system?	None
SP_O4	How many hours were spent on safety system refresher training per employee at the top management level?	None
SP_O5	How many hours were spent on safety system refresher training per employee at the mid-management level?	None
SP_O6	How many hours were spent on safety system refresher training per employee at the front-line management level?	None
SP_O7	How many hours were spent on safety system refresher training per employee at the non-management level?	None

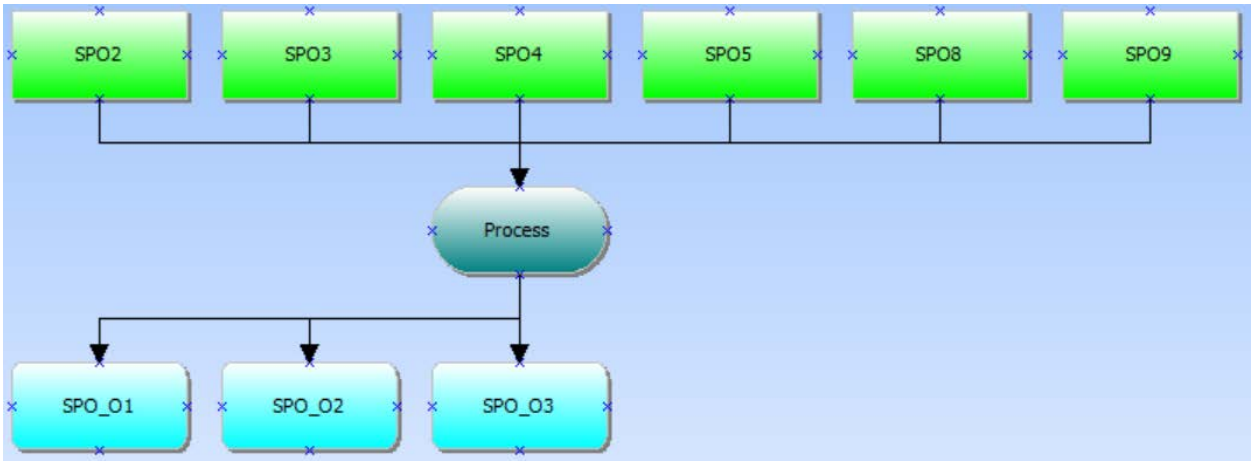

Figure P-1. DEA model for SPO component

Table P-3. Efficiency for SPO component

Unit name	Efficiency Score	Efficient	Condition
8	100.00%	TRUE	Green
1	100.00%	TRUE	Green
28	100.00%	TRUE	Green
4	100.00%	TRUE	Green
22	100.00%	TRUE	Green
32	100.00%	TRUE	Green
20	89.30%	FALSE	Red
30	72.10%	FALSE	Red
31	71.30%	FALSE	Red
33	46.00%	FALSE	Red
5	24.00%	FALSE	Red
21	23.60%	FALSE	Red
19	18.20%	FALSE	Red
10	18.10%	FALSE	Red
2	10.80%	FALSE	Red
9	10.30%	FALSE	Red
15	6.90%	FALSE	Red
13	4.80%	FALSE	Red
26	3.90%	FALSE	Red
11	3.10%	FALSE	Red
16	2.60%	FALSE	Red
25	0.60%	FALSE	Red
3	0.40%	FALSE	Red
18	0.10%	FALSE	Red

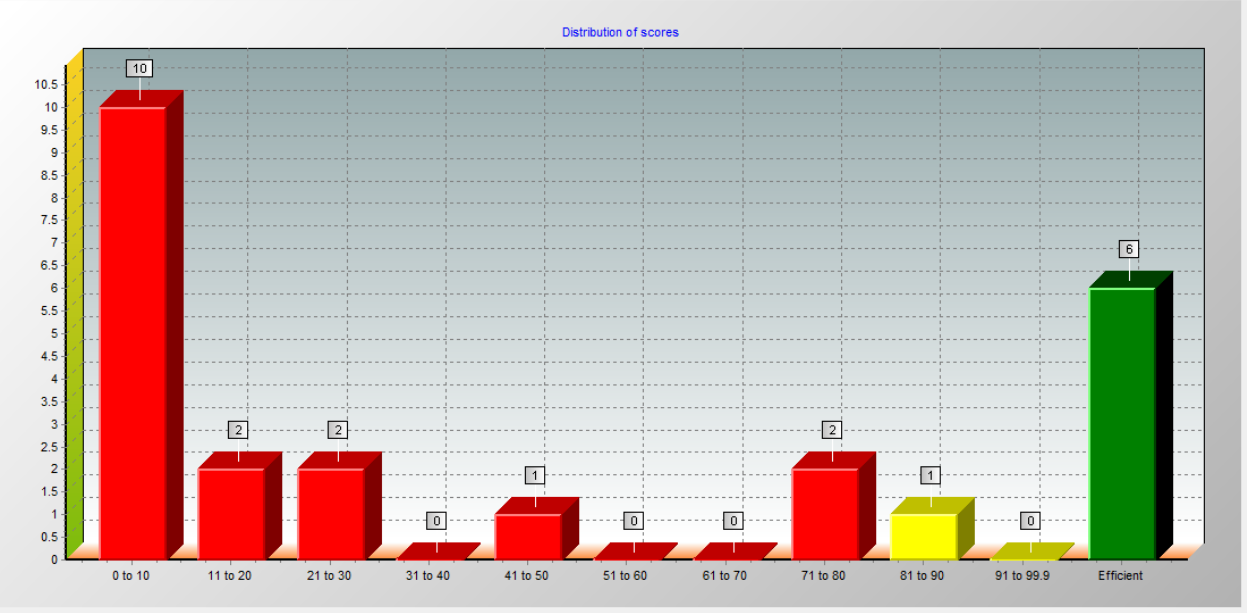

Figure P-2. Distribution of scores for SPO component

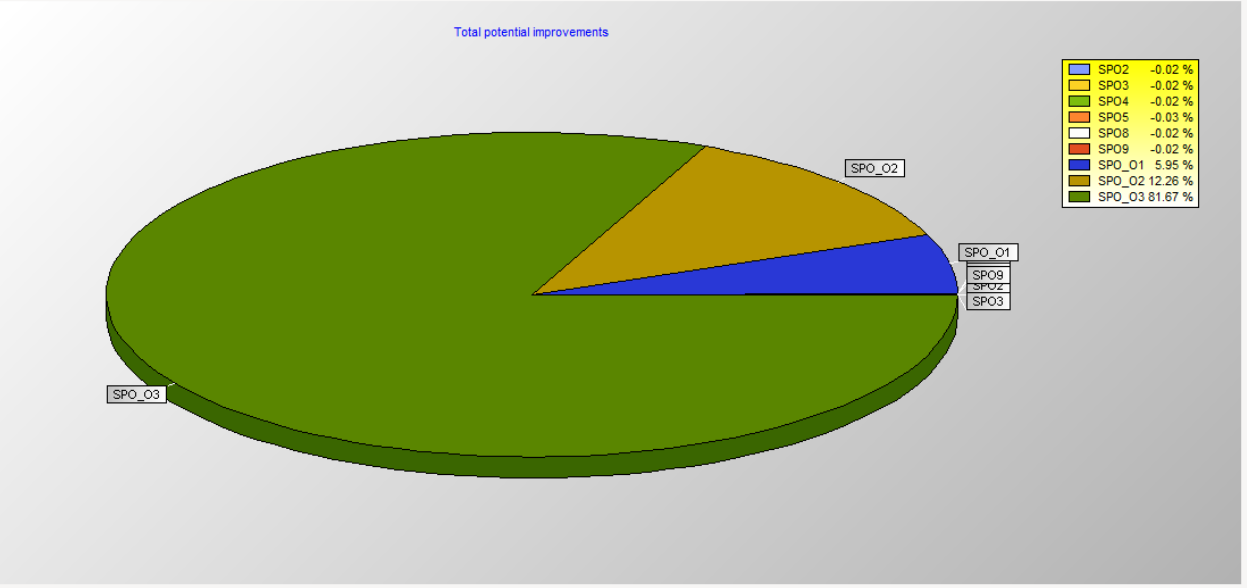

Figure P-3. Total potential improvements for SPO component

Table P-4. Individual potential improvements for SPO component

Unit	Efficiency Score	SPO2	SPO3	SPO4	SPO5	SPO8	SPO9	SPO_O1	SPO_O2	SPO_O3
8	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
28	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
32	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20	89.3%	-50.0%	0.0%	-39.1%	-69.6%	-39.1%	-50.0%	12.0%	12.0%	12.0%
30	72.1%	-20.0%	0.0%	-58.1%	-47.7%	-47.7%	-19.5%	38.7%	38.7%	38.7%
31	71.3%	-21.1%	-21.1%	-60.0%	-60.0%	0.0%	-1.4%	40.2%	40.2%	108.6%
33	46.0%	0.0%	0.0%	-0.2%	-0.2%	-0.2%	0.0%	117.3%	117.3%	117.3%
5	24.0%	-33.3%	-33.3%	-33.3%	0.0%	-33.3%	0.0%	316.9%	316.9%	316.9%
21	23.6%	-55.7%	-44.6%	-33.3%	0.0%	-33.3%	-43.9%	324.0%	324.0%	324.0%
19	18.2%	0.0%	0.0%	-56.2%	-56.2%	-27.0%	0.0%	449.4%	449.4%	449.4%
10	18.1%	0.0%	-20.0%	-20.0%	0.0%	-20.0%	-12.7%	452.4%	36419.0%	452.4%
2	10.8%	-33.3%	0.0%	-53.0%	-64.7%	-29.4%	-47.9%	822.7%	822.7%	822.7%
9	10.3%	-50.0%	0.0%	0.0%	-50.0%	-50.0%	0.0%	871.3%	1488.4%	871.3%
15	6.9%	-40.0%	-25.0%	0.0%	-40.0%	0.0%	-24.4%	1358.3%	12742.0%	1358.3%
13	4.8%	0.0%	-50.0%	-50.0%	-50.0%	0.0%	-75.0%	1983.3%	12400.0%	249900.0%
26	3.9%	-50.0%	-33.3%	0.0%	0.0%	-50.0%	-42.8%	2442.0%	28850.8%	2442.0%
11	3.1%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	3078.5%	3078.5%	3078.5%
16	2.6%	-20.0%	-20.0%	-20.0%	0.0%	0.0%	0.0%	3775.4%	3775.4%	3775.4%
25	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	17256.6%	67342.9%	17256.6%
3	0.4%	0.0%	-50.0%	-50.0%	-75.0%	0.0%	-37.5%	24900.0%	24900.0%	749900.0%
18	0.1%	0.0%	-39.7%	-10.3%	-60.0%	0.0%	-34.9%	69069.0%	69069.0%	715446.0%

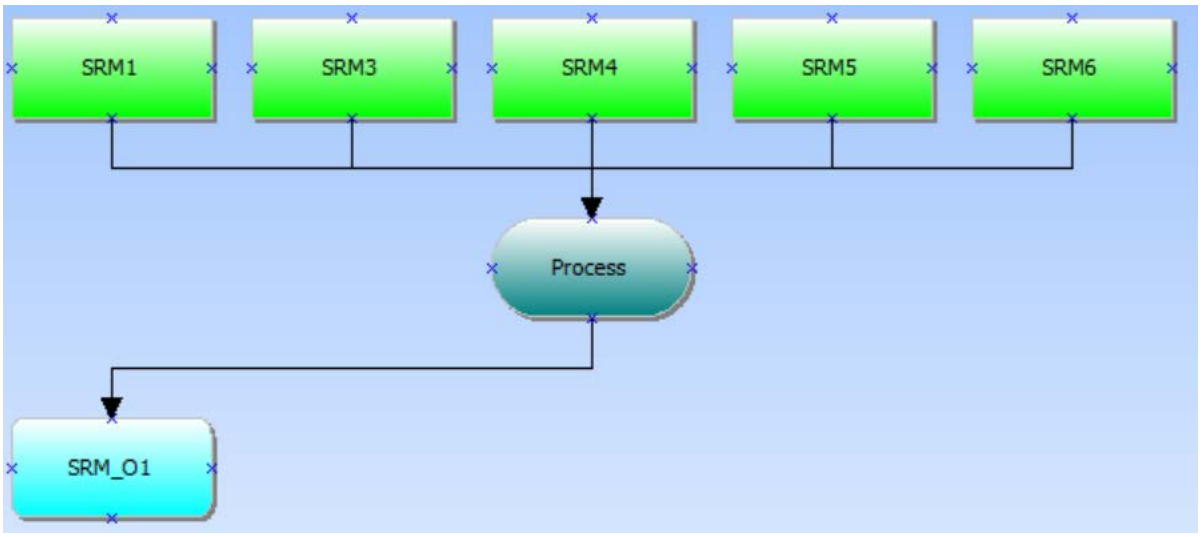

Figure P-4. DEA model for SRM component

Table P-5. Efficiency table for SRM component

Unit name	Score	Efficient	Condition
32	100.00%	TRUE	Green
3	100.00%	FALSE	Amber
5	100.00%	FALSE	Amber
18	100.00%	FALSE	Amber
13	66.70%	FALSE	Red
4	50.00%	FALSE	Red
30	50.00%	FALSE	Red
10	50.00%	FALSE	Red
16	50.00%	FALSE	Red
11	50.00%	FALSE	Red
33	2.50%	FALSE	Red
26	1.40%	FALSE	Red
25	0.10%	FALSE	Red
8	0.00%	FALSE	Red
15	0.00%	FALSE	Red
9	0.00%	FALSE	Red
28	0.00%	FALSE	Red
31	0.00%	FALSE	Red
2	0.00%	FALSE	Red
22	0.00%	FALSE	Red
1	0.00%	FALSE	Red
19	0.00%	FALSE	Red
21	0.00%	FALSE	Red
20	0.00%	FALSE	Red

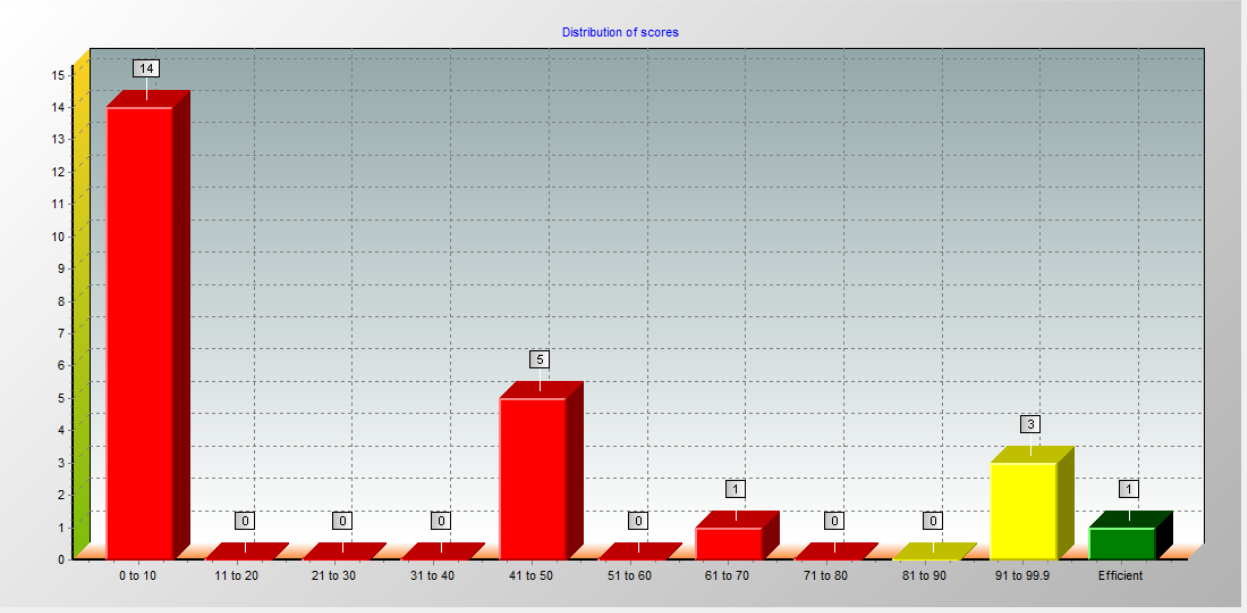

Figure P-5. Distribution of scores for SRM component

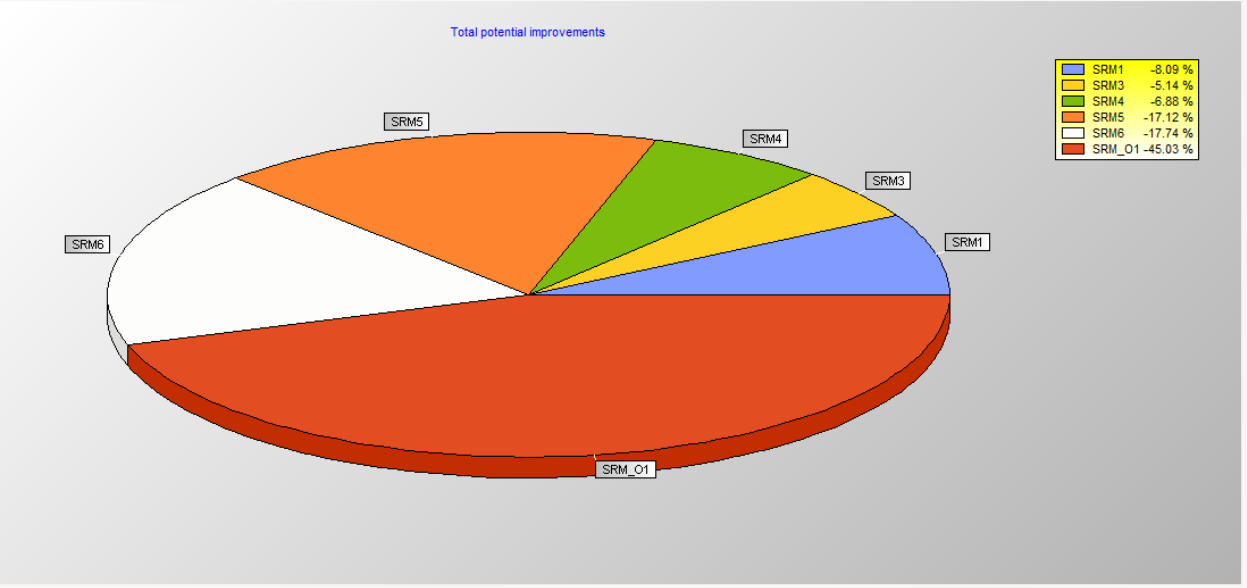

Figure P-6. Total improvements for SRM component

Table P-6. Individual potential improvements for SRM component

Unit	Efficiency Score	SRM1	SRM3	SRM4	SRM5	SRM6	SRM_O1
32	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	100.0%	-33.3%	0.0%	0.0%	-50.0%	-50.0%	0.0%
5	100.0%	0.0%	0.0%	-33.3%	-50.0%	-60.0%	0.0%
18	100.0%	0.0%	-33.3%	0.0%	-60.0%	-60.0%	0.0%
13	66.7%	-25.0%	0.0%	0.0%	-25.0%	-25.0%	-33.3%
4	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-50.0%
30	50.0%	0.0%	0.0%	0.0%	0.0%	-20.0%	-50.0%
10	50.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	-50.0%
16	50.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	-50.0%
11	50.0%	-20.0%	0.0%	-20.0%	-20.0%	-20.0%	-50.0%
33	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	-97.5%
26	1.4%	-33.3%	0.0%	-33.3%	-33.3%	-50.0%	-98.6%
25	0.1%	-25.0%	-25.0%	0.0%	0.0%	0.0%	-99.9%
8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-100.0%
15	0.0%	0.0%	0.0%	-25.0%	-25.0%	-40.0%	-100.0%
9	0.0%	-50.0%	0.0%	0.0%	-50.0%	-50.0%	-100.0%
28	0.0%	0.0%	-25.0%	0.0%	0.0%	-25.0%	-100.0%
31	0.0%	0.0%	0.0%	-20.0%	-20.0%	-20.0%	-100.0%
2	0.0%	-50.0%	-33.3%	-50.0%	-50.0%	0.0%	-100.0%
22	0.0%	-25.0%	0.0%	-25.0%	-25.0%	-25.0%	-100.0%
1	0.0%	0.0%	-75.0%	0.0%	-80.0%	-66.7%	-100.0%
19	0.0%	-40.0%	0.0%	0.0%	-40.0%	-40.0%	-100.0%
21	0.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	-100.0%
20	0.0%	0.0%	0.0%	-50.0%	-50.0%	-50.0%	-100.0%

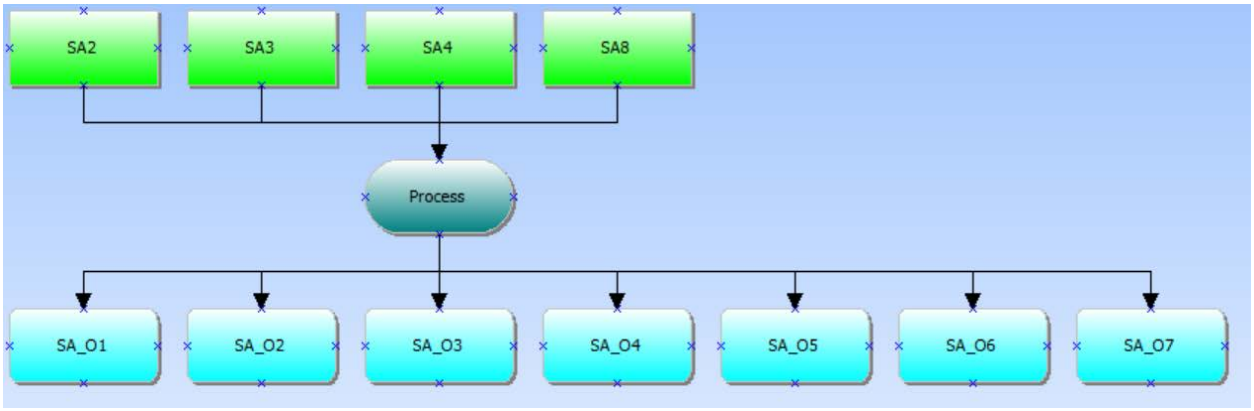

Figure P-7. DEA model for SA component

Table P-7. Efficiency table for SA component

Unit name	Score	Efficient	Condition
11	100.00%	TRUE	Green
15	100.00%	TRUE	Green
16	100.00%	TRUE	Green
18	100.00%	TRUE	Green
19	100.00%	TRUE	Green
20	100.00%	TRUE	Green
25	100.00%	TRUE	Green
26	100.00%	TRUE	Green
3	100.00%	TRUE	Green
30	100.00%	TRUE	Green
31	100.00%	TRUE	Green
5	100.00%	TRUE	Green
8	100.00%	TRUE	Green
9	100.00%	TRUE	Green
22	100.00%	TRUE	Green
10	89.20%	FALSE	Red
2	87.30%	FALSE	Red
33	84.10%	FALSE	Red
28	80.10%	FALSE	Red
21	65.50%	FALSE	Red
4	52.10%	FALSE	Red
13	6.70%	FALSE	Red
1	6.40%	FALSE	Red
32	4.00%	FALSE	Red

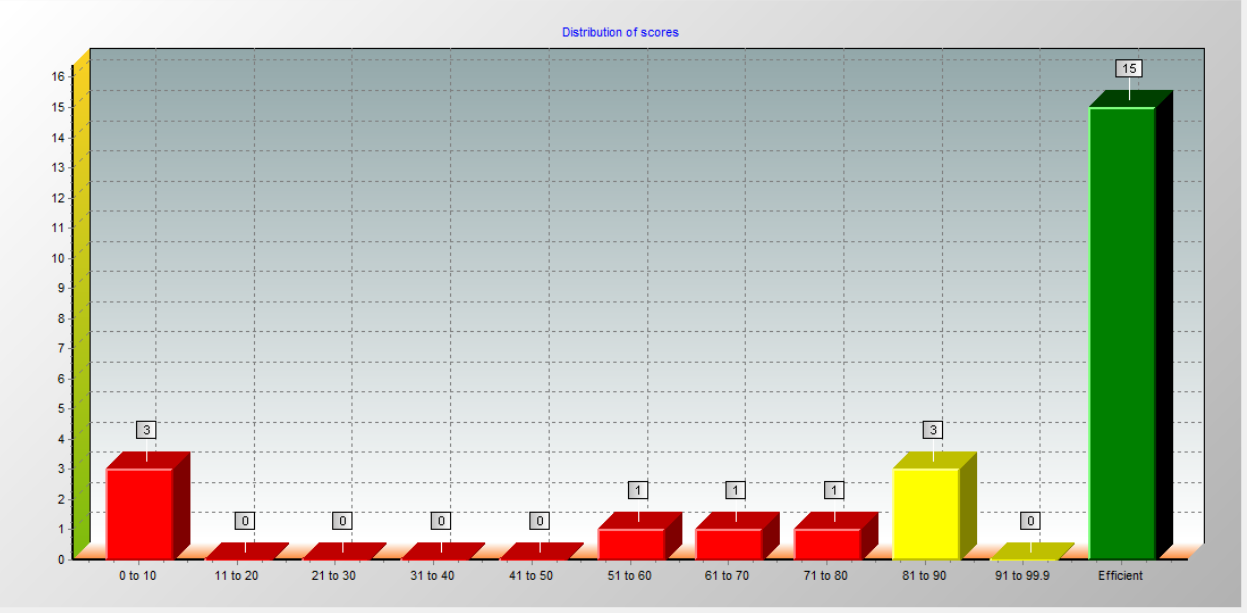

Figure P-8. Distribution of scores for SA component

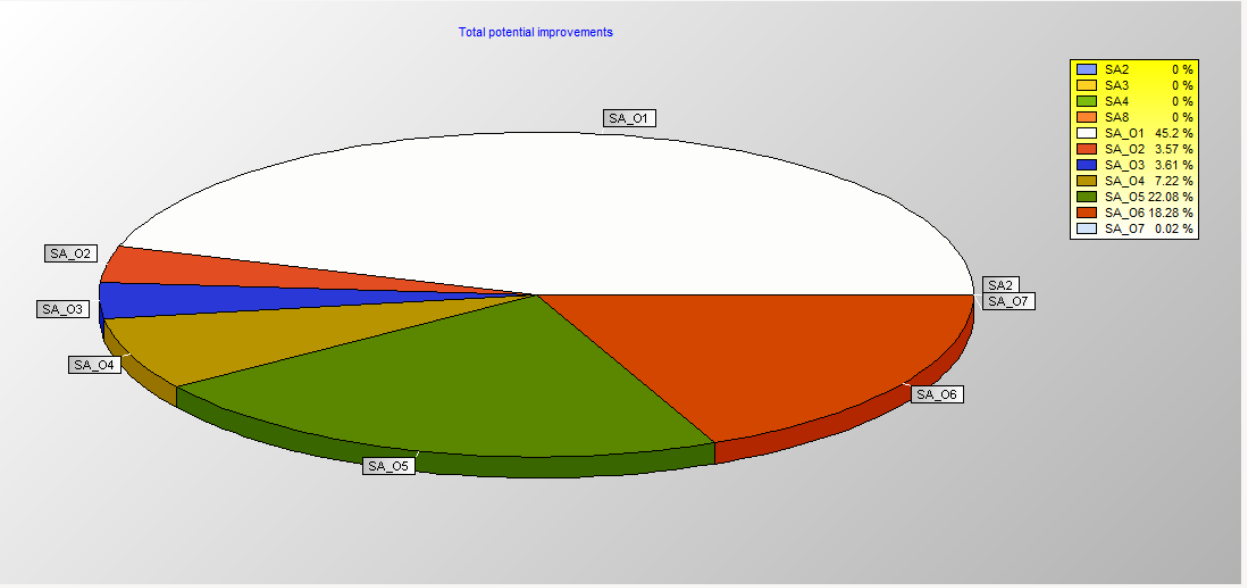

Figure P-9. Total potential improvements for SA component

Table P-8. Individual potential improvements for SA component

Unit name	Score	SA2	SA3	SA4	SA8	SA_O1	SA_O2	SA_O3	SA_O4	SA_O5	SA_O6	SA_O7
11	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
18	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
19	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
25	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
26	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
30	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
31	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	89.2%	89.2%	-28.6%	-36.0%	-43.3%	0.0%	2372148.0%	12.1%	12.1%	12.1%	268.4%	1254453.2%
2	87.3%	87.3%	-25.0%	0.0%	-19.5%	0.0%	14.5%	391.0%	14.5%	14.5%	15.5%	26.0%
33	84.1%	84.1%	-6.7%	-6.8%	-6.8%	0.0%	102.4%	18.9%	18.9%	18.9%	125.2%	169.1%
28	80.1%	80.1%	-20.5%	0.0%	-11.5%	0.0%	1170730.8%	178.3%	24.8%	50.0%	24.8%	3872056.5%
21	65.5%	65.5%	-5.8%	-5.8%	-5.8%	0.0%	52.6%	1750.4%	52.6%	52.6%	5795220.3%	1299911.4%
4	52.1%	52.1%	-14.7%	-0.2%	-14.7%	0.0%	92.1%	92.1%	92.1%	92.1%	92.1%	768.8%
13	6.7%	6.7%	0.0%	-25.0%	0.0%	-40.0%	7499900.0%	833233.3%	749900.0%	1499900.0%	1499900.0%	374900.0%
1	6.4%	6.4%	-9.1%	-18.2%	-27.3%	0.0%	1589747.0%	1473.9%	158892.9%	317876.7%	317876.7%	79401.0%
32	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	4999900.0%	555455.6%	499900.0%	999900.0%	999900.0%	249900.0%

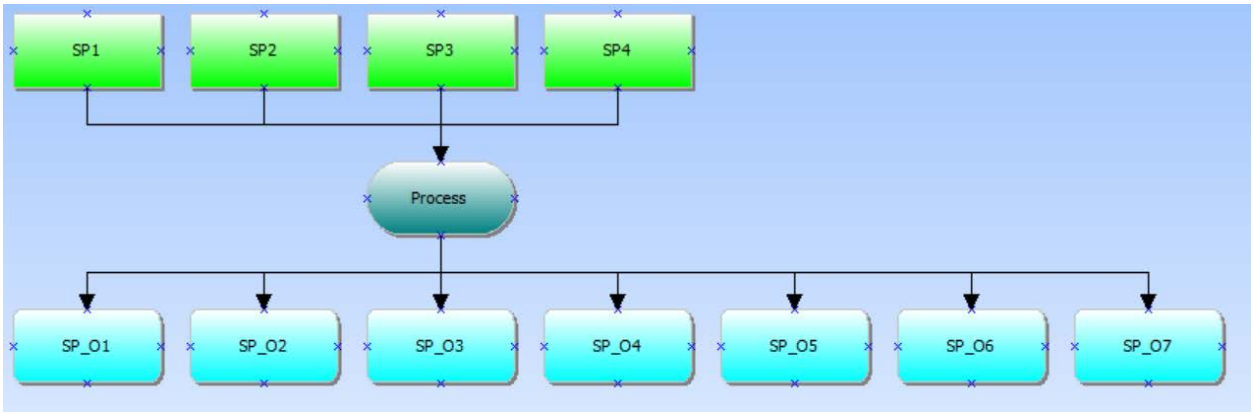

Figure P-10. DEA model for SP component

Table P-9. Efficiency table for SP component

Unit name	Score	Efficient	Condition
10	100.00%	TRUE	Green
15	100.00%	TRUE	Green
22	100.00%	TRUE	Green
31	100.00%	TRUE	Green
33	100.00%	TRUE	Green
5	100.00%	TRUE	Green
8	100.00%	TRUE	Green
16	91.30%	FALSE	Amber
18	84.40%	FALSE	Red
19	69.40%	FALSE	Red
20	57.70%	FALSE	Red
30	40.60%	FALSE	Red
4	31.00%	FALSE	Red
11	29.50%	FALSE	Red
26	27.20%	FALSE	Red
28	24.80%	FALSE	Red
9	24.00%	FALSE	Red
25	17.90%	FALSE	Red
21	16.40%	FALSE	Red
3	13.90%	FALSE	Red
1	12.00%	FALSE	Red
2	8.20%	FALSE	Red
32	0.00%	FALSE	Red
13	0.00%	FALSE	Red

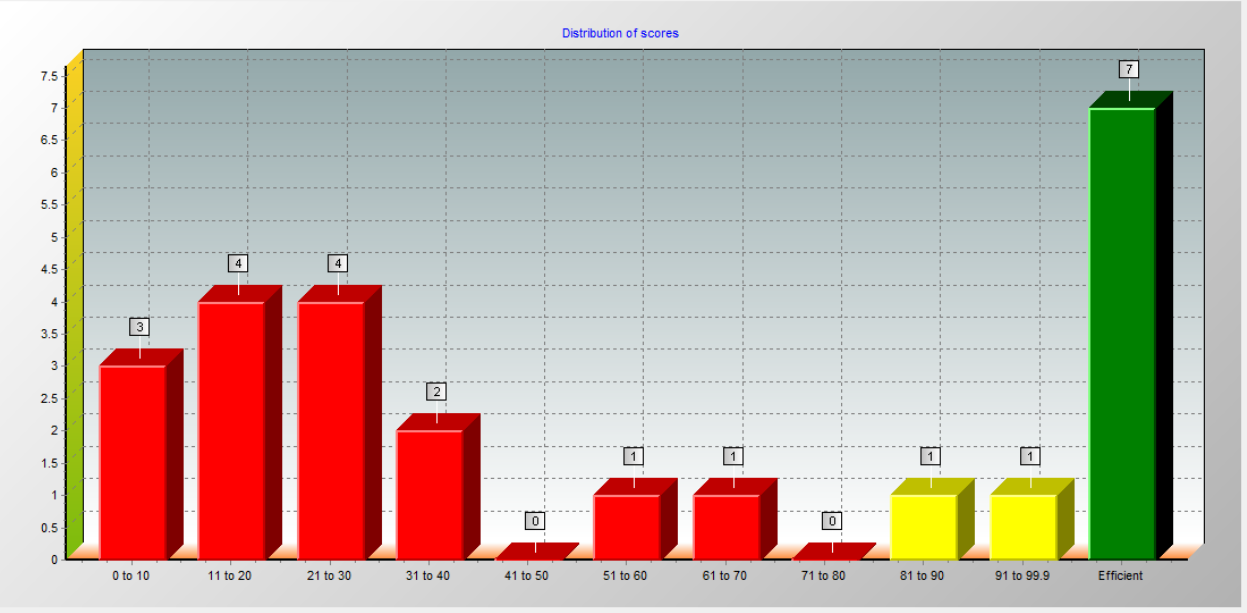

Figure P-11. Distribution of scores for SP component

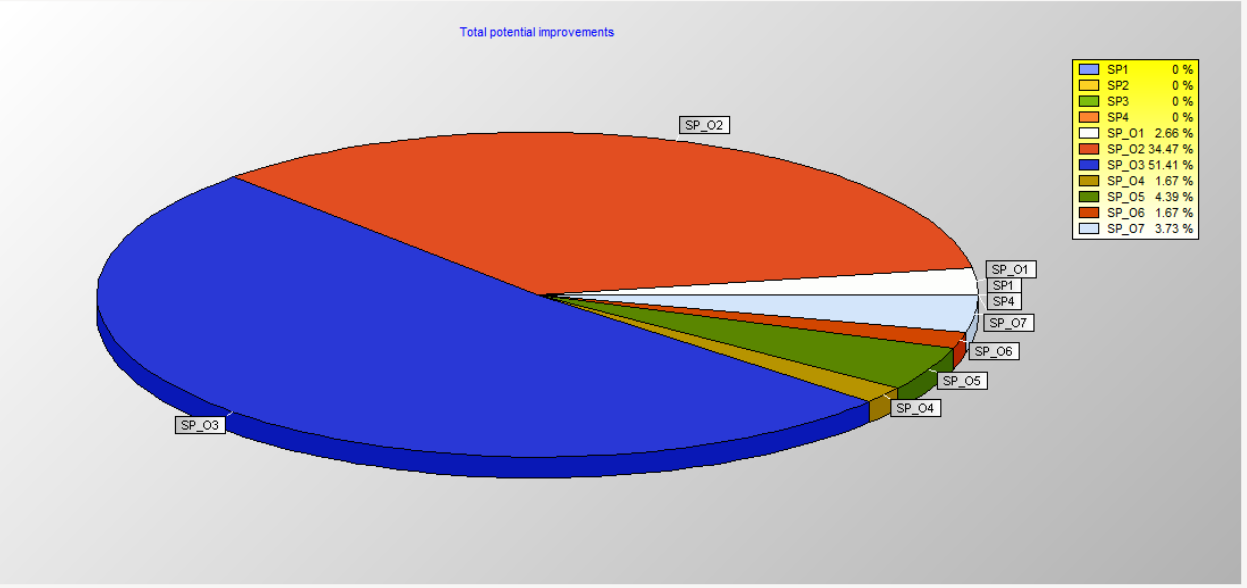

Figure P-12. Total potential improvements for SP component

Table P-10. Individual potential improvements for SP component

Unit name	Score	SP1	SP2	SP3	SP4	SP_O1	SP_O2	SP_O3	SP_O4	SP_O5	SP_O6	SP_O7
10	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
31	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
33	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	91.3%	0.0%	0.0%	-20.4%	-38.7%	9.5%	9635.2%	4766.2%	9.5%	119.0%	9.5%	229.6%
18	84.4%	-28.2%	-6.3%	0.0%	-39.8%	200.0%	3057.9%	1577.6%	18.4%	89.5%	18.4%	334.2%
19	69.4%	-25.0%	0.0%	-40.0%	-55.0%	44.0%	1746.2%	11999900.0%	44.0%	188.0%	44.0%	2060.0%
20	57.7%	0.0%	0.0%	-21.4%	-35.8%	73.4%	5687.2%	2790.1%	73.4%	246.8%	73.4%	427.2%
30	40.6%	-25.0%	0.0%	-42.5%	-58.1%	146.6%	4033.6%	4009.0%	146.6%	393.1%	146.6%	688.9%
4	31.0%	0.0%	0.0%	-16.6%	-33.2%	222.3%	2574.2%	1245.6%	222.3%	488.0%	222.3%	753.7%
11	29.5%	0.0%	0.0%	-22.2%	-33.5%	239.4%	7459.2%	11311581.8%	239.4%	578.7%	239.4%	945.2%
26	27.2%	0.0%	0.0%	-32.3%	-39.5%	267.7%	3900.0%	1964.5%	267.7%	441.9%	267.7%	616.1%
28	24.8%	0.0%	0.0%	-20.8%	-16.8%	302.7%	13330.7%	6611.4%	302.7%	705.4%	302.7%	1116.1%
9	24.0%	-33.3%	-33.3%	-50.0%	0.0%	316.5%	45973.3%	6319.3%	316.5%	699.6%	316.5%	34350.9%
25	17.9%	0.0%	-13.8%	-25.5%	-37.1%	459.0%	9306.1%	4647.7%	459.0%	1117914.8%	459.0%	1577.0%
21	16.4%	0.0%	0.0%	-21.8%	-34.5%	509.2%	10070.2%	10051.9%	509.2%	1118.3%	509.2%	1763.9%
3	13.9%	-50.0%	0.0%	-60.0%	-70.0%	479900.0%	7900.0%	3999900.0%	239900.0%	479900.0%	239900.0%	620.0%
1	12.0%	0.0%	0.0%	-25.0%	-25.0%	732.5%	75904.4%	12992.9%	732.5%	1515.1%	732.5%	52166.2%
2	8.2%	-20.2%	-0.2%	0.0%	-0.9%	1120.0%	1120.0%	561885.5%	33709.6%	67423.0%	33709.6%	197294.1%
32	0.0%	0.0%	0.0%	-9.7%	-19.4%	490222.6%	7999900.0%	4128932.3%	490222.6%	722480.6%	490222.6%	954738.7%
13	0.0%	-37.5%	-16.7%	0.0%	-25.0%	1199900.0%	19999900.0%	9999900.0%	599900.0%	1199900.0%	599900.0%	1799900.0%

APPENDIX Q—SURVEY QUALITATIVE DATA ANALYSIS DETAILS

Table Q-1. Consolidated job titles

Consolidated job title	Count	Percentage
Safety Officer or Manager	7	21.2%
Director of Safety	5	15.2%
SMS Manager	4	12.1%
Chief Pilot	2	6.1%
Professor	2	6.1%
QA Manager	2	6.1%
Contract Safety Manager	1	3.0%
Emergency Medical Technician	1	3.0%
Human Factors in Maintenance Trainer	1	3.0%
Manager Risk Management Process Improvement SMS	1	3.0%
Manager of Aircraft Maintenance	1	3.0%
Manager Safety & Compliance	1	3.0%
Nonsensical	1	3.0%
QA Auditor	1	3.0%
Safety and Quality Inspector Aircraft Maintenance	1	3.0%
Senior Manager	1	3.0%
SMS Specialist	1	3.0%

Table Q-2. Consolidated job responsibilities

Consolidated job responsibility	Count	Percentage
SMS Implementation	8	24.2%
Safety Management	7	21.2%
SMS Management	5	15.2%
SMS Regulatory Compliance	4	12.1%
Incident and Accident Investigation	2	6.1%
Manage Flight Operations	2	6.1%
Research	2	6.1%
SMS and SP	2	6.1%
Asap Manager	1	3.0%
Aviation Safety	1	3.0%
Certify SMS	1	3.0%
Flight Crew Training	1	3.0%
Flight Department Admin.	1	3.0%
Flight Operational QA	1	3.0%

Table Q-2. Consolidated job responsibilities (continued)

Increase the Organizations Safety Level	1	3.0%
Maintenance and Operations QA	1	3.0%
Maintenance Human Factors Training	1	3.0%
Maintenance Programs	1	3.0%
Maintenance Regulatory Compliance	1	3.0%
Manage Aircraft Requirements	1	3.0%
Manage Maintenance Technicians	1	3.0%
Manage Safety Personnel	1	3.0%
Nonsensical	1	3.0%
Patient Care	1	3.0%
Project Manager for SMS Implementation	1	3.0%
Quality Audits	1	3.0%
Regulatory Liaison	1	3.0%
Safety Audits	1	3.0%
SMS Planning	1	3.0%
SMS Risk Management	1	3.0%
SMS Training	1	3.0%
Teaching	1	3.0%
Technical Reviews	1	3.0%

APPENDIX R—SURVEY LIKERT AND NUMERICAL DESCRIPTIVE STATISTICS

In the Likert-related tables that follow, Likert responses 1–5 correspond to:

1 = Undocumented and not implemented
2 = Documented but not fully implemented
3 = Fully implemented but unsatisfactory
4 = Implemented and satisfactory
5 = Implemented and effective

Table R-1. Safety policy Likert question aggregate responses

	Likert response				
Question	1	2	3	4	5
Q10	1	7	6	9	10
Q11	4	5	6	9	9
Q12	3	8	3	12	7
Q13	5	8	6	6	8
Q14	3	7	3	11	9
Q15	5	8	4	10	6
Q16	3	5	4	13	8
Q17	3	6	4	13	7
Q18	2	7	5	12	7
Q19	7	4	7	11	4
Q20	4	7	1	16	5
Q21	5	6	5	11	6
Q22	3	8	4	11	7

Table R-2. Safety policy numerical question aggregate responses

Question	Min	Max	Mean	Median	StDev
Q32	0.00	70,000,000.00	2,208,668.91	25.00	12,174,699.22
Q33	0.00	2000.00	75.70	5.00	346.45
Q34	0.00	2000.00	71.09	5.00	346.82

Table R-3. SRM Likert question aggregate responses

	Likert response				
Question	1	2	3	4	5
Q26	5	4	6	14	4
Q27	5	4	8	11	5
Q28	6	4	7	14	2
Q29	6	4	7	12	4
Q30	3	4	5	10	11
Q31	2	6	3	8	14

Table R-4. SRM numerical question aggregate responses

Question	Min	Max	Mean	Median	StDev
Q32	0.00	70,000,000.00	2,208,668.91	25.00	12,174,699.22
Q33	0.00	2000.00	75.70	5.00	346.45
Q34	0.00	2000.00	71.09	5.00	346.82
Q35	0.00	65,000.00	2023.27	4.00	11,306.80
Q36	0.00	99.00	5.76	2.00	17.64
Q37	0.00	100.00	17.67	3.00	28.80

Table R-5. SA Likert question aggregate responses

	Likert response				
Question	1	2	3	4	5
Q38	5	5	6	14	3
Q39	6	5	8	11	3
Q40	6	5	5	13	4
Q41	5	7	7	10	4
Q42	5	4	7	13	4
Q43	7	4	5	13	4
Q44	7	3	3	11	9
Q45	4	4	4	15	6

Table R-6. SA numerical question aggregate responses

Question	Min	Max	Mean	Median	StDev
Q46	0.00	200.00	9.52	2.00	34.51
Q47	0.00	2000.00	74.36	4.00	346.62
Q48	0.00	2000.00	67.09	3.00	347.42
Q49	0.00	1000.00	40.67	2.00	173.67
Q50	0.00	50.00	5.67	2.00	10.59
Q51	0.00	500.00	33.27	2.00	99.79

Table R-7. SP Likert question aggregate responses

	Likert response				
Question	1	2	3	4	5
Q52L	4	5	5	12	7
Q53L	5	4	7	10	7
Q54L	3	7	4	15	4
Q55L	4	6	6	11	6
Q56L	8	6	4	10	5
Q57L	7	4	6	11	5

Table R-8. SP numerical question aggregate responses

Question	Min	Max	Mean	Median	StDev
Q58	0.00	100.00	12.30	5.00	20.36
Q59	0.00	400.00	19.00	3.00	70.54
Q60	0.00	200.00	11.67	2.00	37.95
Q61	0.00	16.00	2.79	2.00	3.94
Q62	0.00	30.00	4.48	2.00	6.97
Q63	0.00	30.00	4.09	2.00	6.18
Q64	0.00	36.00	5.12	2.00	8.60

APPENDIX S—SURVEY AS ADMINISTERED

Informed Consent

Welcome to this survey related to Safety Management Systems (SMS) in Aviation. The entire survey should take no longer than 15 minutes. First, we need your agreement to participate.

***1. Considering the "Agreement to Participate" document below, do you agree to participate?**

- ◯ I Agree
- ◯ I Do Not Agree

NOTE: To continue the survey SCROLL to the BOTTOM of the page and hit NEXT.

Page 1

AGREEMENT TO PARTICIPATE IN
Determining the Effectiveness of Safety Management Systems:
A Research Investigation

STUDY LEADERSHIP. I/We am/are asking you to take part in a research project that is led by Dr. Alan Stolzer, Chair of Doctoral Studies, College of Aviation, Embry-Riddle Aeronautical University.

SPONSORSHIP. This study is being paid for by Federal Aviation Administration (FAA).

PURPOSE. The purpose of this study is to develop a model for determining SMS effectiveness in an aviation/aerospace organization.

ELIGIBILITY. To be in this study, you must be 18 years or older and knowledgeable on SMS effectiveness within ICAO, FAA, a U.S. air carrier, an aviation service providers, or an international aviation organization.

PARTICIPATION. During the study, you will be asked to complete a survey and supply information about safety management within your organization.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal.

BENEFITS OF PARTICIPATION. I/We do not expect the study to benefit you personally; however, the long-term benefit to the aviation industry in the United States may have an indirect, positive impact on your organization and your position within that organization.

COMPENSATION. There is no compensation for participating in this study.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time or refuse to answer any particular question without it being held against you. Your decision whether or not to participate will have no effect on your current or future connection with anyone at ERAU and/or your employer.

RESPONDENT PRIVACY. Your individual information will be protected in all data resulting from this study. Your responses to this survey will be CONFIDENTIAL or ANONYMOUS. In order to protect the confidentiality of your responses, I will DESCRIBE DATA PROTECTION METHODS.

"Anonymity" means that no identifying information such as email, street address, affiliate organization is being collected, so you will not know and it would be very difficult to infer or discover the identity of the person from whom any specific data were collected.

"Confidentiality" means that you will know or can readily learn the participant's identity, but you will not disclose or make it possible for anyone outside of the research team to learn it.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Alan Stolzer at stolzera@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By agreeing below means that you understand the information on this form, that someone has answered any and all questions you may have about this study, and you voluntarily agree to participate in it. Please print a copy of this form for your records. A copy of this form can also be requested from Dr. Mark Friend at mark.friend@erau.edu.

Demographic Questions

***2. Please specify whether the whole organization or only specific departments within the organization are being measured. If only specific departments within the organization are using SMS, then only provide input based on those specific departments.**

- ◯ Whole Organization
- ◯ Specific Departments

***3. Please provide the number of full-time equivalent employees (FTEs) in the operations being measured. This may be the whole organization or only the specific departments now utilizing SMS.**

All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period. Note: A close estimate is preferred over skipping the question.

***4. What best describes your organization?**

- ◯ Passenger Airline
- ◯ Cargo Airline
- ◯ Airport
- ◯ Manufacturer
- ◯ Other

Other (please specify)

***5. How large is your company?**

Annual Revenue

Years in Business

***6. What stage of SMS adoption is your organization?**

- ◯ Not using SMS
- ◯ Exploring SMS
- ◯ Using SMS without any regulatory requirements
- ◯ Using SMS and preparing to submit to regulatory authorities
- ◯ Using SMS and have submitted to regulatory authorities
- ◯ Using SMS and monitored by regulatory authorities

Other (please specify)

***7. How many years has your organization been practicing "Safety Management Systems" (SMS)?**

***8. Please tell us a little about yourself as the individual respondent.**

Job Title

Primary Responsibilities

***9. ...And tell us a little more about yourself as the individual respondent.**

Years With the Company

Total Years Experience with SMS

Safety Policy and Objectives

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***10. Either the chief executive officer, the chief operating officer, or the equivalent fulfills the role of accountable executive.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***11. A professional manager, qualified in terms of education and experience and directly reporting to the accountable executive, manages, monitors, and coordinates the system safety process.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***12. The organization has developed, documented, and fully implemented a comprehensive system safety plan, accessible to all employees.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***13. Safety policies, procedures, and processes based on the safety management plan, are clearly defined, documented, communicated, and implemented throughout the organization.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***14. Procedures have been clearly developed and implemented for response to accidents, incidents, and operational emergencies.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***15. The safety plan is clearly tied to the organizational mission, aligned with corporate objectives, and integrated throughout the organization.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***16. Procedures have been clearly developed and implemented for response to accidents, incidents, and operational emergencies.**

Undocumented and not implemented	Documented but not fully implemented	Fully implemented but unsatisfactory	Implemented and satisfactory	Implemented and effective
◯	◯	◯	◯	◯

***17. Procedures have been clearly implemented for response to accidents, incidents, and operational emergencies.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***18. Expectations, accountabilities, responsibilities, and authorities for safety-related policies, processes, and procedures are clearly defined, documented, and communicated throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***19. Safety competencies for all applicable positions are identified and documentation provides evidence that all competency requirements are met for all positions.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***20. There are clear standards for acceptable operational behavior as it relates to system safety for all employees.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***21. Appropriate responsibilities and authorities can be clearly traced from any level or position to the accountable executive in the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***22. Resources in terms of personnel and budgets are appropriate for implementation and maintenance of system safety throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***23. What is the number of full-time personnel with safety in their job titles? Enter -99 for all.**

***24. What is the number of other full-time personnel with system safety in their job descriptions? Enter -99 for all.**

*25. What percentage of overall budget within the organization is allocated toward system safety?

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Safety Risk Management

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***26. Processes are clearly defined, communicated, and implemented to ensure that all hazards likely to cause death, physical harm, or equipment or property damage are identified and documented at all stages of the system, process, and/or product life cycles.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***27. Safety risk analysis processes for all identified hazards are clearly defined, communicated, and implemented throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***28. During a GAP analysis or other systematic procedure, safety risk assessment processes for all identified hazards were clearly defined, documented, communicated, and implemented throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***29. Risk control and mitigation processes, above an appropriate, acceptable, and clearly defined level of risk, are implemented and applied to all hazards.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***30. Within corporate guidelines a closed-loop system for the reporting of safety issues by any and all employees and relevant constituents without fear of reprisal is strongly encouraged and clearly communicated. Anonymity or confidentiality is available when preferred.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***31. Anonymity is always available to all personnel when preferred.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period. Note: A close estimate is preferred over skipping the question.

***32. How much was spent on direct property damage losses?**

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***33. How many reviews of safety procedures and processes were completed by management personnel?**

***34. How many written policy and/or procedure adjustments resulted from safety reviews?**

***35. How many safety audits were done?**

***36. What was the average number of personnel performing each safety audit?**

***37. How many deviations from policies and/or procedures were found during safety audits and corrected?**

Safety Assurance

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***38. Clear documentation and evidence exists showing the organization has a clear and effective system in place to monitor, measure, evaluate, and document the performance and effectiveness of all risk controls.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***39. Clear documentation and evidence exists showing the organization continuously monitors operational data, including products and services received from contractors, safety reports, and employee safety feedback to determine and document conformity to established risk controls and evaluate system safety performance.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***40. Clear documentation and evidence exists showing clear and relevant system safety outputs are generated regularly, thoroughly reviewed, and incorporated into policies, procedures, and processes by top management.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***41. Clear documentation and evidence exists showing there are timely and appropriate periodic reviews of all safety policies, procedures, and processes to ensure relevance and appropriateness.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***42. Clear documentation and evidence exists showing comprehensive audits of system safety are performed at least annually on all safety-related operational processes, including those performed by contractors, to verify safety performance and evaluate the effectiveness of safety risk controls.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***43. Clear documentation and evidence exists showing audit(s) demonstrate that all system safety functions are in conformance with the safety management plan and are utilized for continuous improvement of system safety processes and performance.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***44. Clear documentation and evidence exists showing auditors possess appropriate professional qualifications and are independent of any processes or work evaluated.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***45. Clear documentation and evidence exists showing procedures are clearly defined, documented, communicated, and implemented to collect data and investigate incidents, accidents, and instances of regulatory non-compliance to identify potential new hazards or risk-control failures.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***46. How many reviews of safety outputs were completed by accountable executive?**

***47. How many reviews of safety procedures and processes were completed by management personnel?**

***48. How many written policy and/or procedure adjustments resulted from safety reviews?**

***49. How many internal safety audits were accomplished?**

***50. How many external safety audits were accomplished?**

***51. How many deviations from policies and/or procedures were found during safety audits and corrected?**

Safety Promotion

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***52. Clear documentation and evidence exists of thorough publication and distribution to all employees of senior management's stated commitment to safety whereby top management demonstrates the growth of a positive safety environment throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***53. Clear documentation and evidence exists of frequent and visible demonstration of management commitment to the safety system through both verbal and written communications.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***54. Clear documentation and evidence exists demonstrating the organization ensures all personnel are appropriately trained and competent to perform duties related to the safety system; training scope is commensurate with required competencies and responsibilities in the safety system; and initial and periodic safety system training for all employees is clearly outlined, scheduled, and performed.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***55. Clear documentation and evidence exists demonstrating the safety system training requirements are met for all new hires and transfers within the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***56. Clear documentation and evidence exists demonstrating appropriate safety system refresher training for all employees is updated and instituted at least annually.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***57. Clear documentation and evidence exists demonstrating top management documents communication of safety system outputs throughout the organization, the rationale behind controls, and preventative or corrective actions and provides its oversight organization access to this information.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***58. How many publications promoting the safety system were distributed to employees?**

***59. How many hours were spent in training for each newly hired employee on the safety system?**

***60. How many hours were spent in training for each transferred employee on the safety system?**

***61. How many hours were spent on safety system refresher training per employee at the top management level?**

***62. How many hours were spent on safety system refresher training per employee mid-management level?**

***63. How many hours were spent on safety system refresher training per employee front-line management level?**

***64. How many hours were spent on safety system refresher training per employee non-management level?**

Final Comments

65. Do you have any other comments, questions, or concerns?

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Thank you!

Thank you for your time in completing this survey. The information will be utilized to help organizations further develop and enhance their safety system.

APPENDIX T—REVISED FINAL SURVEY

ADAPTED FROM NUMEROUS SOURCES:

- FEDERAL AVIATION ADMINISTRATION [42].
- INTERNATIONAL CIVIL AVIATION ORGANIZATION, 2013
- MINNESOTA [36]
- SAFETY MANAGEMENT INTERNATIONAL COLLABORATION GROUP [43]
- TRANSPORT CANADA [3]
- U.S. JOINT HELICOPTER SAFETY TEAM [44]

SMS Effectiveness - Final

Informed Consent

Welcome to this survey related to Safety Management Systems (SMS) in Aviation. The entire survey should take no longer than 15 minutes. First, we need your agreement to participate.

***1. Considering the "Agreement to Participate" document below, do you agree to participate?**

- ◯ I Agree
- ◯ I Do Not Agree

NOTE: To continue the survey SCROLL to the BOTTOM of the page and hit NEXT.

SMS Effectiveness - Final

AGREEMENT TO PARTICIPATE IN
Determining the Effectiveness of Safety Management Systems:
A Research Investigation

STUDY LEADERSHIP. I/We am/are asking you to take part in a research project that is led by Dr. Alan Stolzer, Chair of Doctoral Studies, College of Aviation, Embry-Riddle Aeronautical University.

SPONSORSHIP. This study is being paid for by Federal Aviation Administration (FAA).

PURPOSE. The purpose of this study is to develop a model for determining SMS effectiveness in an aviation/aerospace organization.

ELIGIBILITY. To be in this study, you must be 18 years or older and knowledgeable on SMS effectiveness within ICAO, FAA, a U.S. air carrier, an aviation service providers, or an international aviation organization.

PARTICIPATION. During the study, you will be asked to complete a survey and supply information about safety management within your organization.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal.

BENEFITS OF PARTICIPATION. I/We do not expect the study to benefit you personally; however, the long-term benefit to the aviation industry in the United States may have an indirect, positive impact on your organization and your position within that organization.

COMPENSATION. There is no compensation for participating in this study.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time or refuse to answer any particular question without it being held against you. Your decision whether or not to participate will have no effect on your current or future connection with anyone at ERAU and/or your employer.

RESPONDENT PRIVACY. Your individual information will be protected in all data resulting from this study. Your responses to this survey will be CONFIDENTIAL or ANONYMOUS. In order to protect the confidentiality of your responses, I will DESCRIBE DATA PROTECTION METHODS.

"Anonymity" means that no identifying information such as email, street address, affiliate organization is being collected, so you will not know and it would be very difficult to infer or discover the identity of the person from whom any specific data were collected.

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FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Alan Stolzer at stolzera@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By agreeing below means that you understand the information on this form, that someone has answered any and all questions you may have about this study, and you voluntarily agree to participate in it. Please print a copy of this form for your records. A copy of this form can also be requested from Dr. Mark Friend at mark.friend@erau.edu.

SMS Effectiveness - Final

Demographic Questions

***2. Please specify whether the whole organization or only specific departments within the organization are being measured. If only specific departments within the organization are using SMS, then only provide input based on those specific departments.**

- ◯ Whole Organization
- ◯ Specific Departments

***3. Please provide the number of full-time equivalent employees (FTEs) in the operations being measured. This may be the whole organization or only the specific departments now utilizing SMS.**

All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period. Note: A close estimate is preferred over skipping the question.

***4. What best describes your organization?**

- ◯ Passenger Airline
- ◯ Cargo Airline
- ◯ Airport
- ◯ Manufacturer
- ◯ Other

Other (please specify)

***5. How large is your company?**

Annual Revenue

Years in Business

SMS Effectiveness - Final

***6. What stage of SMS adoption is your organization?**

- ◯ Not using SMS
- ◯ Exploring SMS
- ◯ Using SMS without any regulatory requirements
- ◯ Using SMS and preparing to submit to regulatory authorities
- ◯ Using SMS and have submitted to regulatory authorities
- ◯ Using SMS and monitored by regulatory authorities

Other (please specify)

***7. How many years has your organization been practicing "Safety Management Systems" (SMS)?**

***8. Please tell us a little about yourself as the individual respondent.**

Job Title

Primary Responsibilities

***9. ...And tell us a little more about yourself as the individual respondent.**

Years With the Company

Total Years Experience with SMS

10. (Optional) Do you have any comments, questions, or concerns about this survey or SMS in general (you will be asked this question on each page of the survey)?

SMS Effectiveness - Final

Safety Policy and Objectives

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***11. Either the chief executive officer, the chief operating officer, or the equivalent fulfills the role of accountable executive.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***12. A professional manager, qualified in terms of education and experience and directly reporting to the accountable executive, manages, monitors, and coordinates the system safety process.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***13. The organization has developed, documented, and fully implemented a comprehensive system safety plan, accessible to all employees.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***14. Safety policies, procedures, and processes based on the safety management plan, are clearly defined, documented, communicated, and implemented throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***15. Procedures have been clearly developed and implemented for response to accidents, incidents, and operational emergencies.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***16. The safety plan is clearly tied to the organizational mission, aligned with corporate objectives, and integrated throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***17. Procedures have been clearly developed and implemented for response to accidents, incidents, and operational emergencies.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

SMS Effectiveness - Final

***18. Procedures have been clearly implemented for response to accidents, incidents, and operational emergencies.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***19. Expectations, accountabilities, responsibilities, and authorities for safety-related policies, processes, and procedures are clearly defined, documented, and communicated throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***20. Safety competencies for all applicable positions are identified and documentation provides evidence that all competency requirements are met for all positions.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***21. There are clear standards for acceptable operational behavior as it relates to system safety for all employees.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***22. Resources in terms of personnel and budgets are appropriate for implementation and maintenance of system safety throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***23. What is the number of full-time personnel with safety in their job titles? Enter -99 for all.**

***24. What is the number of other full-time personnel with system safety in their job descriptions? Enter -99 for all.**

***25. What percentage of overall budget within the organization is allocated toward system safety?**

SMS Effectiveness - Final

26. (Optional) Do you have any comments, questions, or concerns about this survey or SMS in general (you will be asked this question on each page of the survey)?

Page 7

SMS Effectiveness - Final

Safety Risk Management

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***27. Processes are clearly defined, communicated, and implemented to ensure that all hazards likely to cause death, physical harm, or equipment or property damage are identified and documented at all stages of the system, process, and/or product life cycles.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***28. Safety risk analysis processes for all identified hazards are clearly defined, communicated, and implemented throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***29. During a GAP analysis or other systematic procedure, safety risk assessment processes for all identified hazards were clearly defined, documented, communicated, and implemented throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***30. Risk control and mitigation processes, above an appropriate, acceptable, and clearly defined level of risk, are implemented and applied to all hazards.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***31. Within corporate guidelines a closed-loop system for the reporting of safety issues by any and all employees and relevant constituents without fear of reprisal is strongly encouraged and clearly communicated. Anonymity or confidentiality is available when preferred.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***32. Anonymity is always available to all personnel when preferred.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period. Note: A close estimate is preferred over skipping the question.

***33. How much was spent on direct property damage losses?**

SMS Effectiveness - Final

***34. How many reviews of safety procedures and processes were completed by management personnel?**

***35. How many written policy and/or procedure adjustments resulted from safety reviews?**

***36. How many safety audits were done?**

***37. What was the average number of personnel performing each safety audit?**

***38. How many deviations from policies and/or procedures were found during safety audits and corrected?**

39. (Optional) Do you have any comments, questions, or concerns about this survey or SMS in general (you will be asked this question on each page of the survey)?

SMS Effectiveness - Final

Safety Assurance

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***40. Clear documentation and evidence exists showing the organization has a clear and effective system in place to monitor, measure, evaluate, and document the performance and effectiveness of all risk controls.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***41. Clear documentation and evidence exists showing the organization continuously monitors operational data, including products and services received from contractors, safety reports, and employee safety feedback to determine and document conformity to established risk controls and evaluate system safety performance.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***42. Clear documentation and evidence exists showing clear and relevant system safety outputs are generated regularly, thoroughly reviewed, and incorporated into policies, procedures, and processes by top management.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***43. Clear documentation and evidence exists showing there are timely and appropriate periodic reviews of all safety policies, procedures, and processes to ensure relevance and appropriateness.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***44. Clear documentation and evidence exists showing comprehensive audits of system safety are performed at least annually on all safety-related operational processes, including those performed by contractors, to verify safety performance and evaluate the effectiveness of safety risk controls.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***45. Clear documentation and evidence exists showing auditors possess appropriate professional qualifications and are independent of any processes or work evaluated.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

SMS Effectiveness - Final

***46. Clear documentation and evidence exists showing procedures are clearly defined, documented, communicated, and implemented to collect data and investigate incidents, accidents, and instances of regulatory non-compliance to identify potential new hazards or risk-control failures.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***47. How many reviews of safety outputs were completed by accountable executive?**

***48. How many reviews of safety procedures and processes were completed by management personnel?**

***49. How many written policy and/or procedure adjustments resulted from safety reviews?**

***50. How many internal safety audits were accomplished?**

***51. How many external safety audits were accomplished?**

***52. How many deviations from policies and/or procedures were found during safety audits and corrected?**

53. (Optional) Do you have any comments, questions, or concerns about this survey or SMS in general (you will be asked this question on each page of the survey)?

SMS Effectiveness - Final

Safety Promotion

Respond to the following statements related to the Safety Management System (SMS) in your organization according to the scale below.

***54. Clear documentation and evidence exists of thorough publication and distribution to all employees of senior management's stated commitment to safety whereby top management demonstrates the growth of a positive safety environment throughout the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***55. Clear documentation and evidence exists of frequent and visible demonstration of management commitment to the safety system through both verbal and written communications.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***56. Clear documentation and evidence exists demonstrating the organization ensures all personnel are appropriately trained and competent to perform duties related to the safety system; training scope is commensurate with required competencies and responsibilities in the safety system; and initial and periodic safety system training for all employees is clearly outlined, scheduled, and performed.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***57. Clear documentation and evidence exists demonstrating the safety system training requirements are met for all new hires and transfers within the organization.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

***58. Clear documentation and evidence exists demonstrating appropriate safety system refresher training for all employees is updated and instituted at least annually.**

◯ Undocumented and not implemented ◯ Documented but not fully implemented ◯ Fully implemented but unsatisfactory ◯ Implemented and satisfactory ◯ Implemented and effective

Remember, All of the following questions will relate EITHER to the whole organization OR only the specific departments being measured over a one-year period.

***59. How many publications promoting the safety system were distributed to employees?**

SMS Effectiveness - Final

***60. How many hours were spent in training for each newly hired employee on the safety system?**

***61. How many hours were spent in training for each transferred employee on the safety system?**

***62. How many hours were spent on safety system refresher training per employee at the top management level?**

***63. How many hours were spent on safety system refresher training per employee mid-management level?**

***64. How many hours were spent on safety system refresher training per employee front-line management level?**

***65. How many hours were spent on safety system refresher training per employee non-management level?**

66. (Optional) Do you have any comments, questions, or concerns about this survey or SMS in general (you will be asked this question on each page of the survey)?

SMS Effectiveness - Final

Final Comments

67. (Optional) Do you have any other comments, questions, or concerns about this survey or SMS in general?

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Thank you!

Thank you for your time in completing this survey. The information will be utilized to help organizations further develop and enhance their safety system.