

Determining the Value of SMS



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Safety Management International Collaboration Group

Determining the Value of SMS

This document was prepared by the Safety Management International Collaboration Group (SM ICG). In this document, the term "organization" refers to a product or service provider, operator, business, and company, as well as aviation industry organizations; the term "authority" refers to the regulator, authority, Civil Aviation Authority (CAA), National Aviation Authority (NAA), and any other relevant government agency or entity with oversight responsibility.

The purpose of the SM ICG is to promote a common understanding of Safety Management System (SMS)/State Safety Program (SSP) principles and requirements, facilitating their application across the international aviation community.

The current core membership of the SM ICG includes the Aviation Safety and Security Agency (AESA) of Spain, the National Civil Aviation Agency (ANAC) of Brazil, the Civil Aviation Authority of the Netherlands (CAA NL), the Civil Aviation Authority of New Zealand, the Civil Aviation Authority of Singapore (CAAS), the Civil Aviation Safety Authority (CASA) of Australia, the Direction Générale de l'Aviation Civile (DGAC) in France, the Ente Nazionale per l'Aviazione Civile (ENAC) in Italy, the European Aviation Safety Agency (EASA), the Federal Office of Civil Aviation (FOCA) of Switzerland, the Finnish Transport Safety Agency (Trafli), the Irish Aviation Authority (IAA), Japan Civil Aviation Bureau (JCAB), the United States Federal Aviation Administration (FAA) Aviation Safety Organization, Transport Canada Civil Aviation (TCCA) and the Civil Aviation Authority of United Kingdom (UK CAA). Additionally, the Civil Aviation Department of Hong Kong (CAD HK), the International Civil Aviation Organization (ICAO), and the United Arab Emirates General Civil Aviation Authority (UAE GCAA) are observers to this group.

Members of the SM ICG:

- Collaborate on common SMS/SSP topics of interest
- Share lessons learned
- Encourage the progression of a harmonized SMS/SSP
- Share products with the aviation community
- Collaborate with international organizations such as ICAO and civil aviation authorities that have implemented or are implementing SMS and SSP

For further information regarding the SM ICG please contact:

Regine Hamelijnc
EASA
+49 221 8999 000
regine.hamelijnc@easa.europa.eu

Jacqueline Booth
TCCA
(613) 952-7974
jacqueline.booth@tc.gc.ca

Amer M. Younossi
FAA, Aviation Safety
(202) 267-5164
Amer.M.Younossi@faa.gov

Igor Penna
ANAC
+55 613 3144 826
igor.penna@anac.gov.br

Mike Hutchinson
CASA
+03 9518 2774
Mike.Hutchinson@casa.gov.au

SM ICG products can be found on SKYbrary at:

[http://www.skybrary.aero/index.php/Safety_Management_International_Collaboration_Group\(SM_ICG\)](http://www.skybrary.aero/index.php/Safety_Management_International_Collaboration_Group(SM_ICG))



Foreword

This document is for safety professionals who understand that the investment in safety interventions and Safety Management Programs are necessary to ensure safe operations. Safety professionals and their economic partners know the human and financial impact of a serious event or accident. Prevention of such loss is the return on the safety investment. However, return on investment is also impacted by operational savings like adherence to schedules, satisfied customers, healthier workplaces and employees, less engineering rework, and increased cooperation with authorities, to name a few examples. This document clarifies the steps needed for the safety professional to calculate return on investment. The math is simple; however, the complexity lies in balancing your costs with the value of events that did not happen—the intangible high value of safe operations. The document helps all parties better appreciate and calculate both the cost and the value of safety.

The term “Return-on-Investment” (ROI) or Cost-Benefit Analysis is more likely to be used on an economist’s spreadsheet than in a meeting of safety professionals. Today’s aviation business organizations do not have the option of separating finance from safety. Economics/profit and safety are mutually inclusive; you cannot have one without the other.

William B. Johnson – FAA

FAA Chief Scientist for Human Factors in Maintenance



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1. Introduction

Profitability is part of the objectives of any business organization; therefore, organizations should treat the financial aspects of Safety Management Systems (SMS) and related safety actions like any other business-related decision-making process.

A thorough understanding of costs and benefits associated with SMS implementation will help ensure proper resource allocation and prioritization of actions and will create a sound basis for continual improvement of the SMS.

The challenges:

Traditional cost-benefit analysis generally focuses on determining costs associated with implementation, usually for tangible assets, such as costs of system components and salaries, and on estimating related return on investment (ROI) in financial terms. Cost-benefit analysis for SMS is more challenging, however, due to the very nature of safety. Intangible benefits, such as improved safety culture, effective regulatory compliance, management commitment to safety, shareholder value, and public confidence are difficult to quantify. Also, an effective SMS results from the interactions of many different organizational elements, actions, and processes that are ideally embedded within the organization's existing system. Therefore, the effects of individual elements of the SMS framework are not always easy to isolate for the purpose of cost-benefit analysis. In particular, the overall impact of effective SMS implementation on the organization's safety culture may be significantly greater than a sophisticated cost-benefit analysis may suggest.

In reality, SMS creates immediate and direct costs, while its benefits are mostly intangible and will likely take time to materialize. Over time, an effective SMS cannot only address the risks of major occurrences, but also identify and tackle production inefficiencies, improve communication, foster a better organization culture, and more effectively control contractors and suppliers. In addition, through an improved relationship with the authority, SMS implementation could result in a reduced oversight burden. Whereas traditionally aviation safety regulations have not been primarily driven by cost-benefit considerations, SMS should bring about greater authority sensitivity to the economics of safety.

Thus, by viewing SMS as something implemented not solely to prevent incidents and accidents but to ensure the success of as many elements of an organization's business as possible, any investment in safety will be seen as an investment in productivity and organizational success.

2. Considerations Regarding Costs

Before you can adequately consider the costs (or investment) associated with SMS, you must identify the system boundaries to which SMS will apply. Once the system boundaries are identified, it will be easier to identify existing systems and processes—such as Quality Management Systems (QMS) based on industry standards, employee reporting systems, and compliance monitoring functions—that meet the intent of some of the SMS elements. Organizations should use the existing systems and processes to their maximum extent to reduce implementation costs.¹

Additionally, you should consider your organization's existing internal knowledge when identifying positions to support the implementation and ongoing maintenance of the SMS. If you already have the necessary expertise within your organization, there is no need to hire someone to provide it, thereby keeping costs lower. If your organization uses outside assistance, ensure it is managed so the SMS fits the organization and does not sit on a shelf. A number of consulting companies and SMS programs are available to provide assistance, and although we cannot recommend what will work best for your organization, we can caution that costs will be higher if the staff are not well trained or knowledgeable about SMS. If your organization uses consultants, it should not turn over the SMS wholly to them but instead use their services in support of the system. Typically, SMS is a case in which shortcuts are not only ineffective, but they will end up costing you more than expected.

¹ More information on integration of multiple management systems within organizations can be found here:
http://www.skybrary.aero/index.php/SMS_Integration_%E2%80%9393_Points_to_Consider

Although the initial costs associated with SMS may seem high when viewed alone, it is important to examine the benefits or ROI that SMS can provide. Think about incidents you know could have been avoided with a more robust risk management process and consider those for future cost or efficiency gains that could lead to better operations, faster product-to-market times, or higher quality products.

In addition, both direct and indirect costs associated with the SMS generally will be included in the organizational overhead, and both must be considered when determining the organization's overall investment in SMS. You will most likely find that information technology (IT) systems development, IT maintenance, training, and human resources are your main direct cost drivers with SMS. Indirect costs are much harder to quantify, but trying to capture as many as possible is an important means of determining a sense of your overall investment. Tables 1 through 4 below provide some guidance on costs to consider in these areas.

3. Considerations Regarding Benefits

It is often thought that a balance between safety and production exists that results in either a high safety level at the expense of production or high productivity at the expense of safety. This could be true when taken to extremes, but from a big-picture perspective, safety and production are not in opposition. In fact, investments made in safety management activities often yield both direct and indirect benefits to an organization's productivity. An investment in safety makes good business sense even in the absence of accidents and serious incidents.

Considering a QMS, it is relatively easy to identify cost and benefits; for example, a lower component rejection rate directly results in increased profitability. Similarly, direct financial benefits can be attributed to the effective implementation of SMS. Safety actions, such as controlling or eliminating the risk associated with a hazard that may result in not only an accident, or incident, but also in operational inefficiencies with financial impact (e.g., flights canceled, higher component rejection rates, cases requiring rework), will have a positive effect on profitability. A link between safety and efficiency can be demonstrated, as these benefits are measurable and can be added to the production side (profitability) of the business.

Perhaps more impressive are the potential benefits when considering protection against losses. Safety is sometimes defined as a condition whereby risks are held to an acceptable level or in which nothing bad happens. Any time an accident or serious incident occurs, there will be collateral costs that directly detract from the operation's profitability. The costs are easy to calculate after the fact to provide proof of the benefit in investing in safety mitigations before the event. One of the important aspects for an organization to consider is its ability to determine the value of avoided costs. This should include lower level issues such as lost time and rework. Both safety risk management (SRM) and financial ROI management require proactive consideration of "what if" scenarios and an ability to quantify potential loss.

There are additional indirect and sometimes non-monetary benefits that should be considered when implementing SMS. They may materialize in areas other than safety, such as security, health, or environmental protection, which will directly benefit from the organization's efforts to foster its capability to manage risks and maximize opportunities.

Integration of SMS in existing management systems will be more efficient than a stand-alone approach to safety. Internally, this will allow optimized use of existing expertise and contribute to improved employee satisfaction. Externally, the integrated SMS will contribute to a competitive advantage as well as increase public (and shareholder) confidence in the organization's ability to manage risks. Once all elements of the SMS are implemented and operating effectively, a reduced oversight burden can also be expected as the authority gains confidence in your safety management capabilities.

In summary, direct and indirect benefits of effective SMS implementation will materialize through:

- Better governance;
- A more holistic view of the organization;
- Better change management;
- Organized systems;
- Synergy with quality systems;
- Decreased likelihood and severity of findings;
- Ability to demonstrate due process;

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- Employee satisfaction, better acceptance of changes, and lower staff turnover rates;
- Shareholder confidence;
- Decreased operating costs; and
- Increased confidence by the authority, a decrease in regulatory involvement, and a related decrease in direct and indirect oversight costs.

4. SMS Cost-Benefit Analysis

A good cost-benefit analysis, conducted alongside with safety management activities, will support your decision-making process and aid in the allocation of resources to the safety program(s) to reduce risks to an acceptable level.

This section provides an overview of elements to consider in cost-benefit analysis, structured around the International Civil Aviation Organization (ICAO) SMS framework components and elements.

This overview and the tables below can help determine the costs and benefits of SMS, as well as ideas for metrics to estimate the efficiency of the investment. Although the items contained in the tables are representative, they are not meant to be all inclusive. The lists of items can be expanded and are not intended to be the only costs, benefits, and ideas for metrics to measure the ROI.

The tables include direct and indirect costs and benefits. Depending on the organization's structure, the phase of SMS implementation, and the nature of safety action, the categorization of costs and benefits as either direct or indirect may change (for example, staff training may be considered a direct cost if it is an ad-hoc training course, or an indirect cost if it is embedded into the organization's regular training activities). For a balanced view, the indirect benefits, although difficult to quantify, must be included when considering the cost-benefit analysis.

The "Potential Metrics" columns provide some proposals for performance measures that can be used to help quantify the effectiveness of SMS implementation. Use of an SMS effectiveness coefficient is proposed to obtain a realistic determination of SMS ROI (see Appendix 1, *ROI for SMS Implementation as a Whole – Spreadsheet Calculator*).

a. General Costs and Benefits (for the Whole SMS/Organization)

As with any element of the management system, there are costs and benefits that can be attributed to the overall organization. Therefore, it makes sense to build on what is currently in place at each organization. This will be cost effective and should take less time. To maximize the benefits of SMS, you must have all the SMS components in place and effective. Similarly, the SMS should be implemented across the entire organization and address all your aviation services.

Upon initial implementation, a description of your system and processes should be available. You are likely to have a system description as part of your existing operating manuals or QMS. In this case, you could build on that existing system description by adding the safety risk and safety assurance focus. Likewise, if your organization has already implemented typical QMS processes for regular management reviews, internal auditing, follow-up of actions, performance measurement, and control of suppliers, you may build on those same processes and tools to implement SRM, which will help minimize the costs for the general administration of your SMS. For example:

- Standard office software to track corrective actions could easily be adapted to also track risk mitigation actions; and
- Standard tools to report process inefficiencies or suggest improvements may be adapted for internal safety reporting.

For initial SMS implementation, you also need to clearly define the boundaries of your organization and the compliance and safety-critical interfaces both within the organization and with third parties, such as partner organizations, contractors, or suppliers. The better the understanding of the overall system and the interactions between your management, operational, and support processes, the better you will be able to proactively identify opportunities for improvement and identify and manage non-compliances and risks associated with your activities.

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Following initial implementation, the system description will be helpful in managing risks related to organizational or operational changes and should help ensure your SRM processes are properly embedded into your operational processes. Therefore, the costs associated with the initial effort to implement SMS, including a thorough analysis of your system and processes, may pay off through increased operational efficiency, safety performance, and regulatory compliance, as well as a decrease in insurance premiums and workers compensation premiums.

b. Safety Policy and Objectives

ICAO SMS Framework component 1, Safety Policy and Objectives, includes the “PLAN” component of the “PLAN-DO-CHECK-ACT” cycle.

This covers five distinct elements:

- Management commitment and responsibility, including the obligation to do the following:
 - Define a safety policy and safety objectives as a basis for performance measurement; and
 - Implement safety reporting procedures, applying just culture principles.
- Safety accountabilities, including the obligation to document and communicate safety responsibilities, accountabilities and authorities;
- Appointment of key safety personnel, including the appointment of a safety manager;
- Coordination of emergency response planning; and
- SMS documentation, including the development of an SMS manual and processes.

The elements that are generally directly associated with SMS implementation costs are (1) appointing a safety manager, (2) creating and maintaining documentation associated with the SMS, (3) implementing internal safety reporting schemes, and (4) introducing additional safety meetings that may have not previously existed. Related costs will depend on the level of integration with existing systems and processes. The costs for appointing or recruiting a safety manager partially or exclusively dedicated to SMS-related tasks may be a significant investment upon initial SMS implementation. Depending on the resources available and the complexity of aviation products or services, the organization may choose to assign responsibilities for the implementation and maintenance of the SMS to one or more persons as their sole function or combined with other duties, as long as those assignments do not result in any conflicts of interest.

Ensuring clarity of the safety policy and objectives forming the basis for safety performance monitoring and measurement (see Section 4d, *Safety Assurance*) will provide more efficient implementation. Uncertainties in this area tend to be costly, as this is what provides the overall direction.

Resources spent on communicating the safety policy, demonstrating management commitment to safety, and promoting open reporting are vital to the success of your SMS. Creating a positive safety culture, although not measurable in financial terms, will contribute to the success of the overall system.

Table 1: Costs and Benefits for SMS Component “Safety Policy and Objectives”

	Direct Costs	Indirect Costs	Benefits
<i>Initial Implementation</i>	- Consultancy - Additional resources or reallocation of existing resources - Developing manuals and procedures	- Communication of the policy - Dissemination of the objectives and review of existing documents - Time spent in meetings - attendance of managers/personnel	- Providing clear direction and framework for safety performance measurement - Senior management commitment - Improved organizational (safety) culture - Better control over safety and business risks
<i>SMS Operation</i>	- Maintaining manuals and procedures	- Maintaining policy and reviewing objectives (management reviews)	

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	Direct Costs	Indirect Costs	Benefits
		- Demonstrating commitment - Time spent in meetings - attendance of managers/personnel	
Potential Metrics to Determine an SMS Effectiveness Coefficient			
- Awareness of safety policy at all levels - Evidence of senior management commitment:² - o Number of management walk-arounds dedicated to safety/SMS per month/quarter/year - o Number of management meetings dedicated to safety per month/quarter/year - o Attendance of key managers at safety meetings - Safety reports - o Number of reports received per month/quarter/year and trend - o Percentage of reports for which feedback to reporter was provided within 10 working days - o Percentage of reports followed by an investigation			

c. Safety Risk Management

Safety Risk Management covers the following elements:

- Hazard identification through reactive and proactive methods; and
- Analysis, assessment, and control of safety risks associated with identified hazards and mitigation.

Managing safety risks is at the heart of your SMS. This means trying to prevent bad things from happening, or if something does go wrong or slips through the cracks, trying to minimize the consequences of the event. To be able to manage your safety risks, your organization must have effective and active hazard identification processes and a sound safety culture. You can manage safety risks only if you are aware of the potential hazards connected to your organization's operations.

The ability to recognize hazards is at the heart of your organization's SRM process. It is also important to manage the life cycle of your risks to ensure the assumptions made for the hazard identification and risk assessment are still valid.

One clear benefit that will materialize with widespread SMS implementation is the increase in shared risk reduction across industry. For example, if you are an operator and both operators and design approval holders implement SMS, it is much easier to see how their systems can work together. This facilitates sharing of information, interconnection between operation and design, and, hopefully, better risk management.

The assessment of costs and benefits associated with specific operational risks is straightforward compared to the assessment of less tangible SMS elements. Appendix 2, *ROI Examples for Specific Safety Actions*, contains some examples of safety actions for specific operational risks. They provide basic ROI calculations to help determine how the SRM process can be seen from a business point of view.

Table 2: Costs and Benefits for SMS Component "Safety Risk Management"

	Direct Costs	Indirect Costs	Benefits
<i>Initial Implementation</i>	• Data collection and analysis system • Action tracking system	• Analyst (reallocation of staff – retraining) • Implementation time (downtime – retraining of staff)	• Prevention of occurrences (reducing severity/probability) • Increased awareness of potential safety issues and opportunities for improvement

² Further information can be found in SM ICG document "The Senior Manager's Role in SMS," available at: <http://www.skybrary.aero/bookshelf/books/1781.pdf>

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	Direct Costs	Indirect Costs	Benefits
	(those two could be part of a general SMS software package) • Training costs (development and delivery) • Analyst (recruitment/training) • Changes to systems or hardware		• Demonstration of due diligence • Informed decision making • Targeted management of risks • Regulatory compliance • Increased productivity • Recognition by customers and partner organizations • Market access • Improved competitiveness
SMS Operation	• Collection and analysis system, and tracking system maintenance • Recurrent training costs (analyst, etc.)	• Changes in operational documentation and procedures (such as training syllabi, work cards, check lists, and standard operating procedures (SOP)) • Downtime during safety analysis/investigations	
Potential Metrics to Determine an SMS Effectiveness Coefficient			
• Overall risk score per activity • Overall risk score for the organization • Number of high severity risk events • Reporting culture (safety reports): ○ Ratio of proactive versus reactive reports ○ Ratio of voluntary reports to mandatory reports • Number of safety committee meetings (planned versus actual) • Event reoccurrence rate • Additional funds allocated to new risk controls (not included in the initial budget)			

d. Safety Assurance

Effective safety assurance in your organization will be directly visible to your aviation authority.

Safety assurance includes three elements:

- Monitoring and measuring safety performance against the safety objectives;
- The management of change – making use of the established safety risk management process; and
- Continuous improvement of the SMS.

The first element is often seen as the more challenging one within safety assurance. Once you've defined your safety objectives (see Section 4b, *Safety Policy and Objectives*), you will need to identify safety performance indicators (SPI) that are connected to your safety objectives and to the risks in your operation. General indicators should be defined with regard to the safety objectives, and operational indicators can be defined for specific risk mitigation actions. You also use SPIs to measure how well your risk management processes are working, so it is important for you to select indicators that are reflecting the risks in your operations. To maximize the investment in a set of SPIs, results obtained through the collection, analysis, and interpretation of SPIs must be conveyed to your organization's management for decision and action.

The second element, effective change management, plays an important role in ensuring sustainability of any organization. Managing change requires a planned and systemic process to identify and mitigate risks entailed by a change as well as to identify and maximize opportunities. Managing the changes may rely on existing system descriptions and will make use of the established SRM processes and tools. However, setting up the management of change process and the supporting documentation such as a safety case template will incur direct costs. Effective management of change is widely recognized

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as a precondition for operational efficiency, and financial results will reflect this through a better allocation of resources and reduction or elimination of subsequent rework or adjustments in production or operations.

The third element in safety assurance is continuous improvement of SMS. The SMS is working in organizations where things change all the time, including the environment, aviation technology, and regulations. The SMS should be checked and updated to reflect those changes, and the organization should strive to improve its operation and maintain the SMS as a living system for the benefit of all users.

If you have already implemented a QMS or a compliance monitoring function, you may use it to determine the need to improve your SMS. QMS, compliance monitoring, and SMS have some common processes, such as reporting, auditing, and inspecting, but the perspective from which the process is completed differs. When building up or improving the SMS, you have two options: (1) combine the SMS with your QMS or the compliance monitoring function to integrate it within the general management system, or (2) keep the systems separate. However, combining the systems into a single system with a set of common objectives could save you money.

Table 3: Costs and Benefits for SMS Component “Safety Assurance”

	Direct Costs	Indirect Costs	Benefits
Initial Implementation	• SPI development: expertise required • System to collect data and monitor SPIs (could be part of a general SMS software package)	• Reallocation of resources	• Authority confidence • Stakeholder confidence • Demonstration of commitment to manage risk • Targeted assurance of risk controls • Validation of system performance • Better resource allocation • Safe and efficient implementation of changes
SMS Operation	• SPI monitoring and revision of the set of SPIs • Internal audits/internal evaluations • Safety cases (change management) • Collation of data into performance reports	• Maintenance of data collection systems	
Potential Metrics to Determine an SMS Effectiveness Coefficient			
• Achievement of operational safety targets • Reduction in number of findings from internal/external audits • Reduction in reoccurrence of findings • % of follow-up audits carried out within the agreed post change safety assurance plan. • % of changes to standard operating procedures (SOPs) for which a formal safety risk assessment has been performed • Increase in annual safety survey scores • Number of safety audits carried out			

e. Safety Training and Promotion

This covers two elements, which are interrelated:

- Safety training and education, and
- Safety communication.

Safety training is essential when implementing and running the SMS. You should consider who is best placed to deliver SMS training and whether it is done internally or using external trainers. Effective training takes time to develop, and safety managers may not always have the time or the training skills to deliver it. SMS training can be used to gather hazard information, which can bring additional benefits.

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The accountable manager plays a key role when promoting safety culture in your organization. His or her attitude in daily discussions and refresher seminars when talking with staff can help cover important aspects of safety promotion. The organization's safety policy is often written by the accountable manager, so he or she is the best person to share its content with the staff. The only cost of this kind of promotion is duty time of the accountable manager and staff.

All key personnel should have some dedicated safety management training, ideally integrated into other training courses and directly relevant to their areas of responsibility. For your accountable manager and safety manager, it could be reasonable to participate in external training courses, which also serve as a means to demonstrate senior management commitment. This investment may then be exploited further by having the safety manager relay important information and new concepts to the rest of the organization.

You may also take part in national authority SMS seminars and industry meetings where best practices on SMS operations and implementation are shared.

Training for and promotion of SMS should be integrated with your daily business so the safety aspect can be embedded in all your aviation activities. Discussing safety topics while performing daily work may be an effective way to spread the knowledge and foster a positive safety culture.

Table 4: Costs and Benefits for SMS Component “SMS Training and Promotion”

	Direct Costs	Indirect Costs	Benefits
<i>Initial</i>	• Training needs analysis • Training material development • Potential consultancy • Training delivery • Promotion delivery	• Production downtime	• Tailored education • Increased competence • Positive safety culture – more SMS buy-in • Reinforcing corporate decision-making process
<i>Follow-up</i>	• Monitoring the effectiveness of training • Recurrent training • Promotion delivery, also considering SRM outcomes	• Production downtime	• Demonstrating due process • Increased effectiveness and efficiency in SRM • Active risk reduction • Improved horizontal communication and cooperation • Improved corporation with partner organizations, industry associations, or federations
Potential Metrics to Determine an SMS Effectiveness Coefficient			
• Increase in reporting rates ○ All reports ○ Reports suggesting process improvements without any associated safety events • % of time and money spent on SMS training, including HF training, compared to other training • Personnel awareness of safety communication • Number of meetings and information sessions • % of new employees given SMS induction training • % of personnel who have completed required training • Average score on SMS training exams • Number of SMS courses reviewed for improvement • Number of audit findings related to the training program			

5. Additional Guidance

Other SM ICG documents that may be of interest in providing guidance on how to implement an effective SMS include:

- [SMS Evaluation Tool](#);
- [The Senior Manager's Role in SMS](#);
- [The Frontline Manager's Role in SMS](#);
- [Measuring Safety Performance Guidelines for Service Providers](#); and
- [SMS Integration – Points to Consider](#).

6. Appendices

This document includes three appendices.

Appendix 1, *ROI for SMS Implementation as a Whole – Spreadsheet Calculator*, provides a simple spreadsheet SMS calculator to establish the costs and benefits of SMS implementation over 5 years. It combines general costs and benefits with costs and benefits for specific operational safety actions.

Appendix 2, *ROI Examples for Specific Safety Actions*, provides examples for ROI calculations that may be useful to establish the ROI on specific, operational safety actions.

A.2.1 Production Organization

Example 1 - Opening a new production facility in another State

A2.2 Aerodrome Operator

Example 1 - Aircraft ground damage events

Example 2 - Ramp accidents resulting in damage to aircraft, ground vehicles, and personnel

A2.3 Maintenance Organization

Example 1 - Introduction of a new system to control access to ground vehicles

A2.4 Pilot Training Organization

Example 1 - Updating of stall recovery techniques

Example 2 - Review of all manuals, exam questions, checklists, etc., to ensure that proper and plain English is used

A2.5 Air Operations

Example 1 - Replacement of probes and sensors before manufacturer's recommended time

Example 2 - Line operational safety audit intervention

Example 3 - Correction of recurring breaking of a switch on the Flight Management System control panel

Example 4 - Flight Data Monitoring Program

Appendix 3, *Reference Documents*, includes a list of reference documents.



Appendix 1: ROI for SMS Implementation as a Whole – Spreadsheet Calculator

SMS Calculator					
To calculate the return on investment (ROI) and economics of SMS					
Items in pink are for general costs and benefits; items in light blue are for specific safety interventions linked to core activities.					
Cost of Implementing & Maintaining SMS					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
General administration of the SMS	\$	\$	\$	\$	\$
Communication	\$	\$	\$	\$	\$
Downtime due to SMS implementation (e.g., due to training delivery)	\$	\$	\$	\$	\$
Internal audits & assessments	\$	\$	\$	\$	\$
Consultancy	\$	\$	\$	\$	\$
Additional resources or reallocation of existing resources	\$	\$	\$	\$	\$
Data collection and analysis system	\$	\$	\$	\$	\$
Action tracking system	\$	\$	\$	\$	\$
Training costs (development of training material and/or contracting)	\$	\$	\$	\$	\$
Meetings & reporting (e.g., senior management meetings, Safety Review Board (SRB) meetings)	\$	\$	\$	\$	\$
Safety Action 1 - SA 1	\$	\$	\$	\$	\$
Safety Action 2 - SA 2	\$	\$	\$	\$	\$
Safety Action 3 - SA 3	\$	\$	\$	\$	\$
Total Implementation Cost	\$	\$	\$	\$	\$
Monetary Benefits & Probability of Achieving Those (SMS Effectiveness)					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Employee satisfaction - decrease in turnover rate & recruitment costs	\$	\$	\$	\$	\$
Regulatory compliance - decrease in regulatory oversight costs	\$	\$	\$	\$	\$
Decrease in insurance premiums and/or workers' compensation premiums	\$	\$	\$	\$	\$
Other (e.g., decreased operating costs, increased productivity)	\$	\$	\$	\$	\$
Safety Action 1 - SA 1	\$	\$	\$	\$	\$
Safety Action 2 - SA 2	\$	\$	\$	\$	\$
Safety Action 3 - SA 3	\$	\$	\$	\$	\$
Total Savings	\$	\$	\$	\$	\$
SMS Effectiveness (%)					
not applied to SA 1-3					

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SMS Calculator <i>To calculate the Return on Investment (ROI) and economics of a SMS investment</i>						
Results						
	1st Year	2nd Year	3th Year	4th Year	5th Year	Total
Year Investment	\$	\$	\$	\$	\$	\$
Year Benefits	\$	\$	\$	\$	\$	\$
Probable ROI	\$	\$	\$	\$	\$	\$
Probable Projected Savings	\$ #VALUE!	\$ #VALUE!	\$ #VALUE!	\$ #VALUE!	\$ #VALUE!	\$ #VALUE!

To obtain an editable Microsoft Excel copy, contact smicg.share@gmail.com.

SMS calculator guidance:

Costs can be allocated to the following rows:

1. *General administration of the SMS*
2. *Communication*
3. *Downtime due to SMS implementation (e.g., due to training delivery)*
4. *Internal audits & assessments*
5. *Consultancy*
6. *Additional resources or reallocation of existing resources*
7. *Data collection and analysis system*
8. *Action tracking system*
9. *Training costs (development of training material and/or contracting)*
10. *Meetings and reporting (e.g., senior management meetings, SRB meetings)*

The first item is intended for any fixed, recurrent administrative costs that cannot be related to items 2 to 10. If you do not wish to enter SMS implementation costs for each of those detailed items, you can determine the overall costs and enter them in any of the COST rows, 1 to 10.

Benefits (savings) can be allocated to the following rows:

1. *Employee satisfaction - decrease in turnover rate & recruitment costs*
2. *Regulatory compliance - decrease in regulatory oversight costs (authority fees and time spent in audits and inspections)*
3. *Decrease in insurance premiums and/or workers' compensation premiums*
4. *Other (e.g., decreased operating costs, increased productivity)*

If you do not wish to make entries for each of the detailed benefit items, you can determine the overall benefits and enter them in any of the BENEFITS rows from 1 to 4.

This SMS calculator is based on the traditional ROI formula:

$$\text{ROI} = \frac{\text{Payback} - \text{Investment}}{\text{Investment}}$$

The calculator proposes the use of an **SMS effectiveness coefficient**, which is automatically applied to the "benefit" items, items 1 to 4. This allows modulating the ROI over the implementation period in accordance with the estimated effectiveness or maturity of your safety management processes.

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Example of entries for this coefficient, for initial SMS implementation:

	1st Year	2nd Year	3rd Year	4th Year	5th Year
SMS effectiveness %	25%	40%	60%	75%	85%

If you do not wish to adjust the ROI based on this coefficient, you will need to enter “100” in all five cells. Note that this “effectiveness coefficient” is not applied to the specific safety actions SA1 to SA3, as for those, the real costs and benefits should be established through a dedicated ROI calculation. Examples for such dedicated ROI calculations are included with Appendix 2, *ROI Examples for Specific Safety Actions*.

Safety action rows: You can enter up to three “safety action” items for specific, operational safety improvements. Should you wish to include costs and benefits for additional safety actions, you will need to add the relevant amounts to any of the three safety action rows. Adding additional rows to the Excel table will affect the embedded formulas, and the ROI calculation will not work.

Appendix 2: ROI Examples for Specific Safety Actions

A2.1 Production Organization – Change Management

[illegible]

A2.2 Aerodrome Operator

Aerodrome Operator - Example 1

Background	An airport is experiencing an average of 0.5 aircraft ground damage events each month over the past 12 months. The average cost per incident is 200,000 USD (repairs, delays, rescheduling, etc.) or 1,200,000 USD annually.	
Safety Action	Of the six incidents annually, it is reasonable to address four, since two may be beyond the control of the airport operator. Therefore, the interventions are addressing potential losses of 800,000 USD. SAFETY ISSUES BEING ADDRESSED: • Poor ramp markings for clear zones • Inadequate maintenance of ground equipment • Inadequate adherence to procedures • Lack of availability of sufficiently trained staff	
Costs		
	Repainting safety zones on ramps	50,000 USD
	Refurbishing selected ground equipment	200,000 USD
	Improved procedures & personnel training	30,000 USD
	Incentive program to reduce ground damage	100,000 USD
	Total investment for the airport	380,000 USD
Benefits	Costs avoided: LOSS without interventions per year 4 Incidents x 200,000 USD = 800,000 USD	
ROI	ROI = $(800,000 \text{ USD} - 380,000 \text{ USD}) \div 380,000 \text{ USD}$ ROI = 110 %	

Aerodrome operator - Example 2

Background	An international airport incurs annual costs of approximately 2,000,000 USD due to ramp accidents resulting in damage to aircraft, ground service vehicles, and personnel. The costs are composed of: repairs to aircraft, repairs to ground equipment, expenses related to delays and rescheduling of flights, injury-related medical costs, etc. The majority of the costs are covered by the insurance companies. One effective mitigating action that has been employed is the introduction of an annual safety awareness/refresher forum.	
Safety Action	Introduction of dedicated Safety "Walk-in-days" (4-5 days per year) for airport personnel to provide heightened awareness for ramp safety issues.	
Hazard to be addressed	Inadequate separation on ground	
Possible consequences	Ramp accidents with significant damage to one or more aircraft, major injuries	
Costs	"Walk-in-day" organization & execution (Annual recurrent cost)	30,000 USD
	Due to the effectiveness of the mitigation, the costs are carried by the airport's insurer.	-30,000 USD
	Total cost for the airport	0 USD

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Benefits (future costs avoided)	Based on the airport's SMS data, it has been determined that the introduction of the "Walk-in-day" campaign has resulted in a 5% reduction of ramp accidents 5% of annual 2,000,000 USD loss (demonstrated, not estimated)	100,000 USD
	Total benefits expected	100,000 USD
ROI	ROI = (100,000 USD – 30,000 USD) ÷ 30,000 USD ROI = 233 %	

A2.3 Maintenance Organization

Safety Action	A large maintenance, repair, and overhaul (MRO) organization servicing multiple airlines installed a new system to control access to all their ground vehicles, including those used in line maintenance and base maintenance. Each staff member must swipe his or her personal card at the smartcard reader at a vehicle before he/she can start the engine. If the staff member tries to use a vehicle he/she is not qualified and authorized to drive, he/she won't be able to start the engine. In addition, the speed and location of the vehicles are tracked in real time, and overspeed will be automatically recorded and reported.	
Hazard to be addressed	Unauthorized use of ground vehicle Improper use of ground vehicles by authorized staff	
Possible consequences (direct)	Ground vehicle traffic accidents Damage to aircraft in base or line maintenance	
Worst-case outcome	Accidents with significant damage to one or more aircraft, major injuries of maintenance personnel	
Costs		
	Cost to introduce the smartcard readers (parts and labor)	30,000 USD
	Cost of allocating individual smartcards to staff (including downtime)	10,000 USD
	Cost of related software to track speed and location	4,000 USD
	Total cost incurred for implementing the new system for all ground vehicles	44,000 USD
	Annual costs for maintaining the system and analyzing tracking data	5,000 USD
Benefits (future costs avoided)	Over the last five years, the MRO encountered on average of 1.5 major incidents per year due to ground vehicle accidents. The average costs per incident amounted to 22,000 USD (damage to aircraft and/or damage to ground vehicle)	33,000 USD
	Estimate of costs avoided over 3 years	99,000 USD
	Estimate of costs avoided over 5 years	165,000 USD
ROI over 3 years	Costs avoided: 99,000 USD Cost of implementing the system + annual maintenance costs: 44,000 USD + 15,000 USD 59,000 USD ROI = (99,000 USD – 59,000 USD) ÷ 59,000 USD ROI = 67 %	
ROI over 5 years	Costs avoided: 165,000 USD Cost of implementing the system + annual maintenance costs: 44,000 USD + 25,000 USD 69,000 USD ROI = (165,000 USD – 69,000 USD) ÷ 69,000 USD ROI = 139 %	

A2.4 Pilot Training Organization

Pilot Training Organization - Example 1

Safety Action	Updating of stall recovery techniques outlined in the Pilot Training Manual to conform with the latest recovery techniques as published by the authority	
Hazard to be addressed	Pilot Training Organization releases students with inadequate training	
Possible consequences (direct)	Reputation of the Pilot Training Organization, regulatory confidence is affected, possibly leading to a decrease in the number of students	
Worst-case outcome	If it goes undetected (airline flying): accident - loss of control in airline operation	
Costs	Need for additional flight training to include latest stall-recovery techniques	
	Retraining of instructors (including downtime)	40,000 USD
	Updating of pilot training manuals (including authority approval) Not considered: Costs for the airline due to unavailability of the aircraft used for retraining	12,000 USD
	Total cost for the Pilot Training Organization	52,000 USD
Benefits (future costs avoided)	Avoidance of future retraining needs through safe and correct training. - Example: 1 flight hour (FH) per student x 7,000 USD/FH 50 students would have passed the training (based on current number of students for this organization) - Conservative estimate is that 20% (= 10 students) of those would eventually have been “detected” by the airline	70,000 USD
	Avoidance of costs due to a loss of reputation for the Pilot Training Organization leading to a decrease in the number of students over the next 24 months. - Example: 5 % decrease in the average number of students (200 per year) = 10 students less - Average income for this estimate: 15,000 USD per student	150,000 USD
	Overall benefit	220,000 USD
ROI over 2 years	ROI = (220,000 USD – 52,000 USD) ÷ 52,000 USD ROI = 323 %	

Pilot Training Organization - Example 2

Safety Action	Following introduction of an internal safety reporting scheme, the Pilot Training Organization was made aware of a problem related to language difficulties. After analysis of the extent of the problem, the organization decided to review all of its manuals, exam questions, checklists, and teaching lessons to ensure that proper and plain English is used.
Hazard to be addressed	Negative training may occur due to language difficulties. Although English is the language of aviation, those whose first language is not English may just have a working

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	<i>knowledge of the language and may not be able to understand little-used or complex words and phrases. Added to that, cultural traits may prevent some from admitting to their lack of understanding.</i>	
Possible consequences (direct)	<i>Increase in the duration of training, reduction in the number of students, loss of reputation</i>	
Worst-case outcome	<i>Aircraft accident or incident due to negative training.</i>	
Costs	Costs for reviewing all relevant documents:	
	Manuals	10,000 USD
	Exam questions	12,000 USD
	Checklists	16,000 USD
	Teaching material	22,000 USD
	Costs of implementing a feedback mechanism for students to report ambiguities	4,000 USD
	Total cost for the Pilot Training Organizations	64,000 USD
	Annual costs for maintaining the feedback mechanism, analyzing feedback, and making changes where necessary	5,000 USD
Benefits (future costs avoided)	Avoidance of possible increase in duration of training - Example: 3 % increase in duration of training - Basis 200 students per year x average income 15,000 USD per student A 3 % increase in average training duration due to language issues would mean that the Pilot Training Organization would train six students less, meaning it would have a potential loss of income of 6 x 15,000 USD/year.	90,000 USD
	Avoidance of costs due to a loss of reputation for the Pilot Training Organization leading to a decrease in the number of students over the next 12 months. - Example: 2 % decrease in the average number of students - Basis 200 students per year x average income 15,000 USD per student A 2 % decrease in the number of students would mean that the Training Organization would train four students less, meaning it would have a potential loss of income of 4 x 15,000 USD/year.	60,000 USD
	Overall benefit	150,000 USD
ROI over 1 year	Costs avoided:	150,000 USD
	Cost of implementing the system + annual maintenance costs: 64,000 USD + 5,000 USD	69,000 USD
	ROI = (150,000 USD – 69,000 USD) ÷ 69,000 USD	
	ROI = 117 %	
ROI over 2 years	Costs avoided:	300,000 USD
	Cost of implementing the system + annual maintenance costs: 64,000 USD + 10,000 USD	74,000 USD
	ROI = (300,000 USD – 74,000 USD) ÷ 74,000 USD	
	ROI = 305 %	

A2.5 Air Operations

Air Operations - Example 1

Safety Action	B737 fleet: Replacement of probes and sensors before manufacturer's recommended time following hazard identification through pilot report of malfunction or spurious alerts
Hazard to be addressed	Sensor malfunction leading to erroneous indication of flight parameters
Possible consequences (direct)	Aircraft cannot be dispatched
Worst-case outcome	Loss of control in flight (LOC-I)
ROI	COST of modification per aircraft : 1,200 USD Total cost : 1,200 USD x 8 = 9,600 USD BENEFIT ("downtime" prevented) 3,400 USD per aircraft over the next 3 years Total benefit: 3,400 USD x 8 = 27,200 USD ROI = (27,000 USD – 9,600 USD) ÷ 9,600 USD ROI = 183 %

Air Operations - Example 2

Safety Action	Line Operational Safety Audit (LOSA) Intervention in the areas of flight, materials, dispatch, maintenance, air traffic, and ramp operations	
Costs	Typical costs for LOSA observations are personnel costs, data analysis costs, and intervention costs (training, pre- and post-training assessment)	
	Flight	15,000 USD
	Materials	12,500 USD
	Dispatch	15,000 USD
	Maintenance	15,000 USD
	Air Traffic	4,000 USD
	Ramp Operations	15,000 USD
	TOTAL	76,500 USD
Benefits	Typical benefits from LOSA include reduced regulatory violations, increased adherence to standard operating procedures, reduced fuel costs, reduced lost time injuries, reduced equipment damage, and proactive identification of systemic threats/failures.	
	Flight	70,000 USD
	Materials	10,000 USD
	Dispatch	90,000 USD
	Maintenance	75,000 USD
	Air Traffic	50,000 USD
	Ramp Operations	50,000 USD
	TOTAL	345,000 USD
ROI	ROI = (345,000 USD – 76,500 USD) ÷ 76,500 USD ROI = 351 %	

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Air Operations - Example 3

Safety Action	<i>Correction of recurring breaking of a switch on the Flight Management System (FMS) control panel for two aircraft (fleet of eight aircraft)</i>	
Hazard to be addressed	<i>The switch is located in a position that when flightcrew enter the cockpit and step over the center instrument pedestal, their foot could kick the switch and break it</i>	
Possible consequences (direct)	<i>The FMS might be rendered unserviceable</i>	
Worst-case outcome	<i>With this switch broken, the aircraft could not be dispatched</i>	
Costs		
	<i>Cost to remove and replace the switch (parts and labor)</i>	1,775 USD
	<i>Cost of schedule delay penalties, and cost to provide alternate lift (renting another aircraft)</i>	18,000 USD
	Total cost incurred for the two incidents for the organization	19,775 USD
	<i>Cost of developing the fix</i>	1,200 USD
	<i>Cost of replacing the toggle switch with a push-button switch (modification including approval, parts and labor) for two aircraft</i>	4,600 USD
	Total cost to eliminate the hazard	5,800 USD
ROI 1	Had the hazard been eliminated, the corresponding ROI would have been: ROI = (19,775 USD – 5,800 USD) ÷ 5,800 USD ROI = 241 %	
Benefits (future costs avoided)	<i>Costs to fix the issue on the remaining six aircraft within the fleet (4,600 USD per aircraft)</i>	27,600 USD
	<i>Estimate of costs avoided including additional event across the remaining six aircraft and repeat events (18,000 USD per aircraft)</i>	108,000 USD
ROI 2	ROI = (108,000 USD – 27,600 USD) ÷ 27,600 USD ROI = 291 %	
<i>This example is derived from: Aviation Safety Management Systems Return on Investment Study Center for Aviation Safety Research – St Louis University – February 2011</i>		

Air Operations - Example 4

Flight Data Monitoring (FDM)					
Arguably, the main purpose of an FDM Program is to improve safety by correcting negative trends and behaviors that occur in different phases of flight. Many States do not make this mandatory, but through a Safety Management System (SMS), the introduction of FDM is a straightforward safety analysis program with generally positive implications on the bottom line. Detailed research on the cost-benefit of FDM is somewhat limited, but an interesting thesis paper titled <i>An Analysis of the Potential Benefits to Airlines of Flight Data Monitoring Programmes</i> ³ concludes that "...as well as the safety benefits, there are a range of other benefits which an airline with an FDM program can enjoy. Some of these will reduce the costs incurred by the airline and these cost savings are likely to be more than sufficient to cover the costs of running the FDM program."					
Safety Benefits			Cost Benefits		
The report concluded that safety benefits were found in: 1. Improved pilot training programs; 2. Better operating procedures; 3. Improved safety in flight operations; and 4. More thorough investigations of safety reports.			The report also found the following cost benefits, to name a few: 1. Reduced maintenance and warranty claims; 2. Increased aircraft availability; 3. Maximized fuel consumption; 4. Decreased insurance costs; and 5. Reduced fines for noise violations.		
The Numbers					
The following tables taken from the thesis paper summarize the costs and savings (note that these calculations were conducted between 1997 and 2002):					
Table 1: Estimated Total Annual Savings From an FDM Program Over 5 Years. ⁴					
ITEM	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Reduced Engine Removals	\$ 125,000.00	\$ 500,000.00	\$ 500,000.00	\$ 500,000.00	\$ 500,000.00
Engine on Wing Extensions	\$ 412,500.00	\$ 1,650,000.00	\$ 1,650,000.00	\$ 1,650,000.00	\$ 1,650,000.00
Detection of out-of-trim conditions	\$ 3,141.00	\$ 12,563.00	\$ 12,563.00	\$ 12,563.00	\$ 12,563.00
Fuel Savings	\$ 14,692.00	\$ 58,769.00	\$ 58,769.00	\$ 58,769.00	\$ 58,769.00
Break Wear Reduction	\$ 6,000.00	\$ 24,000.00	\$ 24,000.00	\$ 24,000.00	\$ 24,000.00
Insurance Reduction	\$ -	\$ 1,269.00	\$ 1,269.00	\$ 5,000.00	\$ 5,000.00
Advanced Qualification Program (AQP) Single Visit Training (SVT) Savings	\$ -	\$ 162,667.00	\$ 162,667.00	\$ 162,667.00	\$ 162,667.00
TOTAL BENEFIT	\$ 561,333.00	\$ 2,409,268.00	\$ 2,409,268.00	\$ 2,412,999.00	\$ 2,412,999.00

³ R. Vaz Fernandes, I. Stockman *An Analysis of the Potential Benefits to Airlines of Flight Data Monitoring Programmes* Cranfield University, September, 2002

⁴ Cobert, Harlan and Harris, Regina. UTRS. (2000). Justifying a Flight Operations Quality Assurance (FOQA) Program. FOQA 2000 Symposium, 29 March 2000.

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Table 2 Estimated Startup Costs	
EQUIPMENT FOR CAPTURING FLIGHT DATA (i.e., Quick Access Recorders (QARs))	\$ 303,500.00
LABOR FOR DOWNLOADING FLIGHT DATA	\$ 343,500.00
CONSULTING, SOFTWARE AND OTHER HARDWARE	\$ 180,500.00
ANALYST SALARY	\$ 75,000.00
TOTAL START UP COSTS	\$ 902,500.00

ESTIMATED COSTS AND BENEFITS BY FLEET SIZE

In 1997, the FAA estimated the costs of flight data monitoring based on size of fleet. This data is presented in the tables below:

Table 3: Estimated Costs and Savings Based on Fleet Size

FLEET SIZE	15	50	100
EQUIPMENT COSTS	\$ 98,500.00	\$ 259,000.00	\$ 492,000.00
PERSONNEL COSTS	\$ 385,000.00	\$ 500,000.00	\$ 775,000.00
FUEL SAVINGS	-\$ 145,800.00	-\$ 48,500.00	-\$ 972,000.00
ENGINE SAVINGS	-\$ 300,000.00	-\$ 1,000,000.00	-\$ 2,000,000.00
SAFETY SAVINGS	-\$ 49,500.00	-\$ 165,000.00	-\$ 330,000.00
TOTAL ANNUAL COSTS MINUS TOTAL ANNUAL SAVINGS	-\$ 11,800.00	-\$ 454,500.00	-\$ 2,035,000.00
	<i>NET SAVINGS</i>	<i>NET SAVINGS</i>	<i>NET SAVINGS</i>

CONCLUSIONS

The use of FDM as a method of safety analysis in your safety management system, though somewhat cost-intensive initially, can produce sizeable savings for medium and large operators. Examples such as this demonstrate the hidden costs of safety and analysis and can be used to further advance your SMS.

Appendix 3: Reference Documents

Return on Investment Tool for Assessing Safety Interventions

William B. Johnson, Ph.D. / Katrina Avers, Ph.D. – FAA

https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/media/2012-10_return_on_investment_examples.pdf

Assessment of Relative Benefits and Associated Costs of SMS

TCCA – RDIMS 8946200



Assessment of
relative benefits and

Aviation Safety Management Systems Return on Investment Study

Center for Aviation Safety Research – St Louis University – February 2011

<http://parks.slu.edu/research/centers-labs-facilities/CASR/research-papers/aviation-safety-management-systems-roi-study>

Part 21/SMS Aviation Rulemaking Committee (ARC) – Cost Benefit Analysis Final Report

Cost Benefit Analysis Work Group – June 2014

To request a copy, contact smicg.share@gmail.com

An Analysis of the Potential Benefits to Airlines of Flight Data Monitoring Programmes

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<http://webcache.googleusercontent.com/search?q=cache:mdABu00P30MJ:www.aviassist.org/imageslog/o/Cranfield%20M.sc%20Thesis%20on%20Flight%20Data%20Monitoring.pdf%20>