Aviation Safety Management Systems Return on Investment Study

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Executive Summary

Safety professionals have always known that there are humanistic benefits of safety programs, but they have not been able to document the financial benefits and make a sufficiently strong business case for safety programs. The Safety Management System (SMS) is an organized approach for systemic safety improvements based on guidance from the International Civil Aviation Organization, and challenges the safety professionals to quantify the return on investment from safety programs. This concept paper attempts to illustrate the business benefits of safety programs such as an SMS program. As this research continues and grows, the Center for Aviation Safety Research (CASR) will publish subsequent findings that will produce a comprehensive document that presents models to account for various types of costs associated with safety programs, CASR will also present the ways to quantify the benefits resulting from the specific safety program.

A macro-to-micro analytical framework is used to present the business benefits of safety programs and ultimately a program-level justification is presented.

The macro-level analysis presents a sample analysis of stock value of a particular airline after a major accident. This example illustrates how the net worth of an airline can decrease by as much as 25% after an accident and not fully recovery from that loss for more than a year. Such a loss could easily render the airline in bankruptcy. Thus, at a very high level, this example illustrates the financial significance of an airline accident.

A mid level review was performed by analyzing how specific safety interventions or incidents can affect an organizations overall financial performance and lead to a macro level impact. Historically, the aviation industry has not extensively tracked the financial benefits of safety programs, so a review of three organizations from other high consequence industries was performed. Both positive and negative Return on Investment (ROI) examples are discussed because the amount of ROI harvested from a particular safety program depends whether or not the program was sufficiently targeted toward a specific behavioral change.

At the micro-level, examples illustrate how a particular safety intervention's cost can be calculated and the corresponding benefits tracked. These examples also illustrate that not all interventions will achieve the desired return on investment within the first year; some investments take longer and may rely on multiple factors outside the control of the safety manger.

Ultimately, a safety investment model is presented as a way to characterize SMS in terms of an investment portfolio consisting of multiple safety programs with varying rates of return, risk, and maturity terms. This allows safety professionals to present the financial case more clearly to the Chief Finance Officer, and other top executives. If this approach is accepted, it would change the perception of safety programs from "costs" to "investments," thereby achieving implementation of procedures and savings sharing mechanisms that will align the company's espoused safety culture with adequately aligned financial reward systems.

Introduction

Currently, an SMS Aviation Rulemaking Committee (ARC) is making recommendations to the Federal Aviation Administration (FAA) regarding the creation of stand-alone rule-making regarding SMS. The rule-making would "require certain 14 CFR Part 21, 119, 121, 125, 135, 141, 142, and 145 certificate holders, product manufacturers, applicants, and employers to develop and implement SMS" (SMS ARC Recommendations, 3/31/2010, pg. 1). Such action would achieve the FAA's stated goal of aligning FAA SMS requirements with the International Civil Aviation Organization (ICAO) framework to promote international acceptability of U.S. product/service provider safety management systems with all ICAO member states and interoperability among certificate holders ..." (SMS ARC, Pg. 5).

The ICAO expects the FAA to achieve Safety Management System compliance for all certificated aviation operators, which includes airlines, repair stations, airports, and the FAA itself (ICAO, 2009). From the FAA's perspective, in order to get the SMS regulation approved through the U.S. legislative process, the FAA has to demonstrate that the financial burden of compliance with this rule is manageable, even for small operators, because the FAA has the unusual dual mandate of safety regulation and business promotion (FAA, 2010). Therefore, it is essential to develop the business benefits case for SMS. CASR at Parks College of Engineering, Aviation and Technology, Saint Louis University, was tasked with developing a model to show the investment benefit of SMS implementation and sustainment vs. the costs of developing the program as well as costs associated with incidents and accidents.

The model is built around the concept that the large costs associated with accidents could be reduced or avoided with the implementation of a safety management system. These reduced or avoided costs could then be seen as a net gain and placed into an ROI model for safety management system investment calculations.

First, the macro level costs of an aircraft hull loss and its effect on the stock prices of the airline industry were examined. The stock performance of several airlines was examined during the twelve month period following a major accident and demonstrates the severe impact accidents can have on an air carrier.

Second, a mid-level or organizational level review was performed to examine the financial impact of specific safety interventions or incidents on an organization. This review looked at other high consequence industries in the absence of extensive data from aviation safety programs, as there are very few that have been measured in terms of financial benefit for a sufficient amount of time. Two other industries for which data were available were the construction and healthcare industries. These industries were chosen because they are both highly affected by the public perception of safety reputation due to the potential for large-scale safety related accidents. Internal data were obtained from a local construction firm that allowed evaluation at the micro-level effects of safety programs. Two healthcare product manufacturers that experienced large-scale public recalls on their products were selected and data were gathered related to the macro level losses associated with these incidents.

Third, the micro level costs were examined by reviewing actual incidents from two aviation organizations and actions taken to correct the problem. A major benefit of effective safety interventions is avoiding costs associated with safety incidents which otherwise may have happened without such action. Historically, safety professionals have struggled with determining a return on investment of such programs that avoid safety related costs. An analysis of one of these safety interventions provides a method of determining the value of avoided costs and ROI. A model was created to demonstrate what combinations and levels of investment in a safety management system would obtain the best return on investment.

Literature Review

While there is a wealth of literature regarding the calculation of ROI and cost-benefit analysis in high risk industries, there is little literature that directly addresses such analyses in aviation safety systems. Regulatory guidance acknowledges the appropriateness of a business management approach to safety (ICAO, 2009), and further insists that such analyses should be performed to predict the economic impact of such activity on the businesses tasked to do it (FAA, 2010).

General information on aviation economics and the current state of cost assignment into different departments of aviation businesses is readily available, and it addresses such topics as airline metrics (Dresner, 2002), costs specific to aircraft operation (Radnoti, 2002) and cost accounting categories (O'Connor, 1995).

A review of cost-benefit analyses as applied to other high consequence industries has produced insight into cost-benefit analysis of proactive accident prevention programs and their effect on injury rates in the mining industry (Bhattacherjee, 1991), the cost of safety capital and operating expense (CAPEX, OPEX, respectively) in the Process Industry (Kemps, 1998) and Incident-specific costs, direct and indirect (LaBelle, 2000).

The Australian government has provided definitions of the terms associated with various methods of cost-benefit analysis (Net Present Value (NPV), Discounted Cash Flow (DCF), Internal Rate of Return (IRR) and Sensitivity Analysis, etc.) for its own Civil Aviation Safety Authority (CASA, 2007). Similarly, an FAA-requested report (FAA 2007) provides analysis of key economic values, often called "critical" values, used in the conduct of benefit-cost and other evaluations of investments. These include even esoteric cost items such as the value of time lost by waiting travelers, whether on personal or company business.

The purpose of this concept paper is to provide a model for the calculation of the systematic round-up of SMS expenses and the subsequent financial benefits attributable to the investment in SMS of both material and manpower by aviation organizations. It is based on the simple premise that it is a better use of aviation company funds to invest in SMS programs that will prevent accidents than to forego SMS and absorb the financial impact of accidents that could have been avoided.

Methodology and Analysis

Macro-Level Analysis

At the macro-level analysis of safety business benefits, SMS creates benefits by preventing major accidents that threaten a company's entire market value. Even before the cascade of indirect costs resulting from a large-scale accident or incident - loss of available seats, loss of personnel, work time loss among personnel, morale, reputation, etc. - catastrophic incidents and accidents may produce large direct costs, such as a "hull loss," (destruction of the airframe and its component parts), loss of life or injuries, or other physical damage to facilities and property on the ground. In a recent CASR study of three major air carrier accidents resulting in hull losses in all three and loss of life in two, the accidents also contributed to declines in the stock and market values of these companies. These accidents occurred on 31 January 2000 (Alaska Airlines Flight 261) (NTSB 2003), 12 November 2001 (American Flight 587) (NTSB 2004); and 15 January 2009 (US Air Flight 1549, the so-called "Miracle on the Hudson") (NTSB 2010). In all three cases, parent company stock prices dropped following these accidents measured at one, three, six, and twelve months after the accident, suggesting a correlation between the accidents and the losses of stock value. (Evans, et al, 2010).

It is notable that US Airways, despite being in potentially the least vulnerable position due to no loss of life and the glowing press coverage that ensued, turned in results far below an index of other airline stocks, underperforming their competitors by as much as 154% at one point. Appendix 1, Figure 1 illustrates US Air's post-accident performance compared to the S&P 500 Index. Appendix 1, Table 1 illustrates their post-accident performance compared to an index of airlines, using the S&P 500 Index as a baseline, and Appendix 1, Table 2 shows the decline in US Airways Market Value (Evans, et al, 2010).

A loss of over 25% of its market value represents a loss of $328,000,000 in capital for US Airways, or, expressed in other terms, the equivalent cost of four more of the same type Airbus 320 aircraft lost in the accident (Airbus, 2008).

Mid-Level Analysis

The mid-level analysis looks at the circumstances of two other high consequence industries to demonstrate how safety management positively affected one company, while the lack of SMS threatened the financial performance of two others. We look to other industries in the absence of extensive data from aviation safety programs, as there are very few that have been measured in terms of financial benefit for a sufficient amount of time.

McCarthy Building Companies, Inc., the 10th largest general contractor in the United States with $3.5 billion in annual revenue, began implementation of a purposeful, business-managed safety system in 1997. The system included both broader safety culture concepts and the systems management policies and procedures (Evans, et al, 2010).

The results were exceptional, with a 92% decrease in lost time incidents over just twelve years. Appendix 2, Figures 1 and 2 show the decrease in lost time and recordable incident rates at McCarthy since safety programs were implemented in 1997.

These statistics display economic significance when workers compensation costs are taken into account. Companies in the construction industry benefit from cost reduction in workers compensation expenses through a mechanism known as the experience modifier rate (EMR) (St. Louis CNR, 2010), also known as X-MOD (Levitt, Samelson, 1993). EMR provides a discount on workers compensation premiums that increases as the incidents and accidents that a company experiences decreases.

Appendix 3, Table 1 shows how quickly the return on safety investments at McCarthy Inc. materialized thanks to its effective use of SMS. In 2009, their safety management investment reduced their annual workers compensation layout to just fewer than 8% of the $3 million spent in 1997.

McCarthy's initial investment of $2.3 million in 1997 represented only 1.6% of the company's total general and administrative expense at the time. This investment covered software and hardware for their new safety program, plus salary and benefit expenses related to additional hiring and staff to support the new system. Organizational learning since the initial implementation has resulted in a reduction of the number of employees devoted to maintaining the safety program, and further long term savings (Evans, et al, 2010).

The case of Baxter International Inc. (NYSE: BAX), provides a contrasting experience. Baxter is a leader in the healthcare industry in the development, manufacture, and marketing of medical equipment. In 2006, Baxter entered into a consent decree with the Food and Drug Administration (FDA) that permitted the FDA to require the recall of Baxter manufactured infusion pumps, and required the company to provide monetary consideration or replacement pumps to customers on a timeline determined by the FDA and based on medical need. Baxter worked with the FDA to create a corrective action plan, including procedures to upgrade the problematic infusion pumps.

Nonetheless, Baxter has suffered financially from this series of Class I FDA recalls on their infusion pumps over the past 5 years, culminating with the FDA ordering in May 2010 that all 200,000 pumps be recalled and destroyed (Baxter, 2010). According to the corporation's 2009 10-K filing, Baxter has recorded charges related to the infusion pump recalls totaling $337 million (See Appendix 4, Table 5: Baxter's Infusion Pump Recalls: Financial Effect on Baxter). The latest FDA order is expected to push this cost total close to $600 million ("FDA Orders", 2010).

KV Pharmaceutical suspended shipments of all its drugs in tablet form and recalled a single production lot of the painkiller Hydromorphone HCl 2 mg tablets because the tablets were oversized (Anonymous, 2009). The suspension allowed KV to review and enhance the company's manufacturing and quality systems, and to implement improvements to its production facilities.

KV faced a series of class-action lawsuits that alleged its officers made false statements to inflate the company's stock price. The SEC's investigation prompted the firing of the company's Chief Executive Officer. The company laid off 1,020 of its employees and defaulted on their bank line of credit. The company lost $313.6M in fiscal 2009, compared with a profit of $86.4M in 2008. KV reported revenue of $312.3M in 2009, down 46 percent from $577.6M in 2008.

In February 2010, the company was forced to pay $26.7M in fines and restitution, thus prompting an additional layoff of 289 employees (Doyle, 2010). KV's auditor, KPMG, raised substantial doubts about KV's ability to continue as KV struggled with is liquidity and financial losses. KV hired a law firm that specializes in bankruptcies and restructuring.

An officer of KV said "Any governmental enforcement action could require the company to operate under significant restrictions, place substantial burdens on management, hinder the company's ability to attract and retain qualified employees and/or cause the company to incur significant costs." (Volkmann, 2009). All of these unfortunate situations are a direct result of a safety and quality lapse in the company's process and could have been avoided with the proper controls and systems in place.

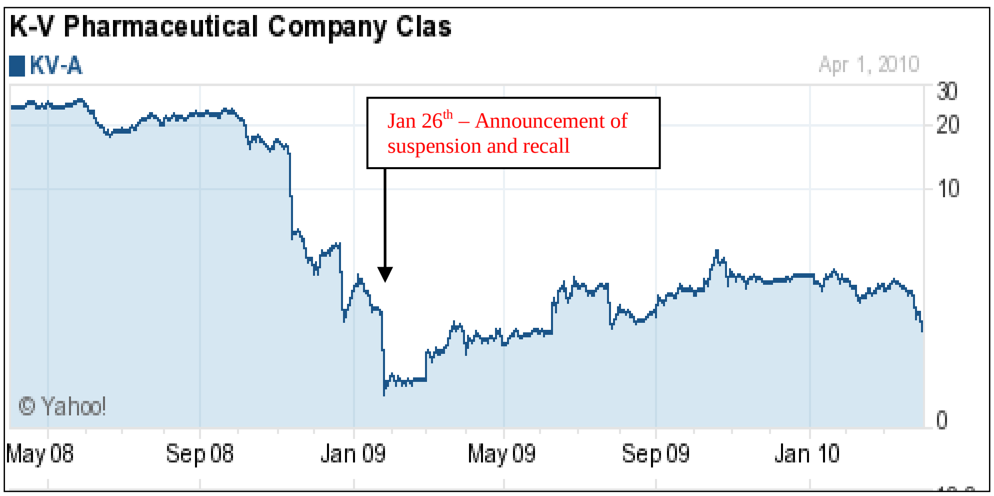

Figure 11

On the day of the announcement, the company's stock dropped 49.7 percent (Figure 11) and on the following afternoon, lost 72 cents, or 26.6 percent, to $1.99. The stock hit an all-time low of $1.93 that day.

The moral of these two preceding healthcare provider analysis is simple; consumers and investors don't like safety related issues. In addition to potential market value loss, an incident of this magnitude can be a public relations nightmare, as well as various oversight organizations penalties, potential lawsuits, loss of consumer confidence, and risk of bankruptcy. In the 21st century, consumers and investors expect a certain level of perfection which doesn't allow for safety/quality related issues. Those companies, such as McCarthy, who have invested in an extensive safety program, have been able to prevent these types of unfortunate events by reducing their risk, saving money in the long term, and use their best-in-practice safety programs as a competitive edge. It's a win-win situation for all involved.

Micro-Level Analysis

The micro-level analysis requires the use of examples from actual actions taken at aviation organizations. It also requires the identification not only of costs associated with SMS, but also the costs associated with an incident or accident that most likely would have occurred if no appropriate SMS program were in effect.

To demonstrate this method of identifying and collecting SMS-related costs and calculating the financial benefits of SMS mitigation, let us examine two different events from two Maintenance, Repair and Overhaul (MRO) organizations, one a large business aviation service provider and the other a large general aviation service provider and defense contractor.

The first event, an aircraft manufacturer released a mandatory Service Bulletin (SB) involving the locking mechanism of the main entry door which was to be performed at the aircraft's next major maintenance event. The work required that the electrical connector from the airframe to the door be disconnected. This disconnect is located in the hinge area of the door. When these aircraft were in for major maintenance, most often it also included a new paint job. The SB required parts which themselves required a long lead-time, and there was an extended period of idle time with the door disassembled for long periods.

Because painting of the aircraft was also scheduled during this maintenance operation, the aircraft was scheduled for paint during the middle of the maintenance cycle, which meant the door would need to be closed for painting. Unfortunately, the electrical harness and connector were not reconnected prior to closing the door, and the harness and connector were caught in the hinge area. The damage was significant, leading to the removal of the door, structural repairs, new harness, new connector, production hours, engineering hours, lead time on parts, and schedule delays.

After such an incident, the responsible manager would complete the necessary incident reports, notify the proper people, counsel the employees involved, and send out an email to a few employees telling them to beware, etc. Nonetheless, this type of error happened three more times before the recurring problem was identified. The MRO did not have a process or system in place to enable employee reporting or hazard identification. If such systems had been in place this problem likely would have been identified sooner and future occurrences avoided. It was estimated that the average cost per incident was $27,000 with these four events costing the company a total of $108,000.

Once this was identified as a recurring problem, a team of five employees was assembled to develop a long term fix. Team members included representatives from the maintenance, avionics, quality, and engineering departments. The team found that the wire harness routed under the entryway floorboard had an additional disconnect just under the floor. By removing the floor board and disconnecting the other end, the entire harness could be removed from the aircraft thus eliminating the hazard. The team met over a two week period and developed a fix which included a documented process with employee sign-offs. The total time spent developing the fix was 16 hours. At an average compensation of $65 per hour, the development of this solution came to $1040.

The additional hours to remove and reinstall the floor board and harness resulted in an addition to the cost of maintenance of 6hrs @ $65/hr., or $390.

Appendix 5, Tables 1-2 detail the MRO's incident/accident expenses, and illustrate that the cost of this particular incident was $27,000 each, with four occurrences, causing a total unexpected expense of $108,000 in less than a year's time. The tables also demonstrate that the total cost of assembling a team of employees to carry out some basic functions of Safety Management Systems - risk assessment, risk analysis, mitigation development, and mitigation implementation - was $1,040, plus an additional $390 per aircraft serviced.

In the simplest of terms, this MRO's action of assembling a committee to investigate and develop a solution to the wiring harness/door hinge problem is a $1430 fix for a $27,000 problem. Assuming four aircraft of that type are serviced per year, the ROI calculation for avoiding just one incident is:

Return on Investment = (Payback – Investment) ÷ Investment

or:

ROI = ($27,000 – $2,600) ÷ $2,600

ROI = 938%

Another event occurred when the flight crew was performing their pre-departure cockpit checks and discovered that a switch on a Flight Management System (FMS) control panel was broken. The switch was a toggle type with the switch lever broken off. With this switch broken, the aircraft could not be dispatched. The cost to remove and replace the switch was $1775 in parts and labor but the lead time to receive a replacement part, subsequent schedule delay penalties, and cost to provide alternate lift (renting another aircraft) were significant, amounting to a cost total of $18,000. The company reputation was also tarnished due to the fact that the aircraft owner and business associates were on board waiting to depart. This was the second aircraft in which this switch was found broken at this repair station.

The company launched an investigation which discovered the switch was located in a position that when the flight crew people entered the cockpit and stepped over the center instrument pedestal, their foot could kick the switch. The company contacted the aircraft manufacturer to inquire if this problem had been reported previously and if a corrective action had been developed. The manufacturer reported no history of this type of event. The company then performed a phone survey of customers with the same model aircraft and found that this switch was breaking quite often with the consensus being that the switch was kicked when people entered and exited the pilot's seat. The survey results concluded that 13 out of 23 aircraft, or 56%, had suffered a broken switch. Employee interviews (including pilots) revealed that most employees were aware of this hazard, but simply replaced the broken switch or knew through tribal knowledge to be especially aware of this hazard when entering the pilot's seat. This company also did not have a robust reporting system to allow effective information dissemination, hazard and risk identification, and corrective action.

Once this hazard was identified as high risk, the company's Quality Control and Engineering personnel contacted the aircraft manufacturer and developed a solution which called for replacing the toggle switch with a low profile push button switch. The time spent to develop the fix equated to $1200. The parts and labor cost to replace the toggle switch with a push button switch was $2300 per aircraft. The manufacturer issued a SB for replacement of this switch and thus eliminated the hazard. These two incidents cost the repair station $19,775 while the cost to eliminate the hazard totaled $5800 for two aircraft. The ROI analysis of these two repair station incidents is calculated below.

Return on Investment = (Payback – Investment) ÷ Investment
or:
ROI = ($19,775 – $5,800) ÷ $5,800
ROI = 241%

The additional cost benefits of corrective actions that eliminate a future hazard, or cost avoidance, are not as easily calculated but can be significant and should not be ignored. By incurring just one additional event, these companies would have incurred large cost penalties. Using the broken switch example from above, an estimated ROI value can be determined for implementing the corrective action and avoiding the cost of future events. For this exercise a conservative cost estimate of $3000 across 8 aircraft was utilized. Additionally, given the high frequency of broken switches, the likelihood of future occurrences without any corrective action is very high. To calculate recurring cost savings, a 25% future failure rate across the same 8 aircraft is utilized with a cost estimate of $2000 for these repeat events. The final ROI calculation for cost avoidance is outlined below with the detailed analysis provided in Appendix 5, Tables 3-4.

Return on Investment = (Payback – Investment) ÷ Investment
or:
ROI = ($28,000 – $18,400) ÷ $18,400
ROI = 52%

When the two ROI calculations from the FMS switch example are combined, the resulting ROI total is 97% with a total cost savings of $23,575 across ten aircraft. This is a very robust return on investment even with the very conservative recurring cost estimates compared to actual costs incurred from past events. The combined ROI calculation is below.

Return on Investment = (Payback – Investment) ÷ Investment
or:
ROI = [($28,000 + $19,775) – ($18,400 + $5800)] ÷ [$18,400 - $5800]
ROI = 97%

Calculating Multiple SMS Investments in an Organization

Calculating the true value of a Safety Management System to an aviation organization such as a major air carrier is a very complex endeavor. Not only are the costs high and the hierarchy of spending controls diverse within such an organization, but the search for synergy as these companies implement SMS across their various operations creates overlapping jurisdictions, shared expenses, and great numbers of SMS expenses credited to indirect and overhead costs that are not easily identified as SMS-related cost drivers. Nonetheless, once accomplished, an organization-wide Safety ROI - naturally, with different values from area to area - may be thought of in terms of an investment portfolio consisting of multiple safety programs with varying rates of return, risk, and maturity terms. This allows safety professionals to present the financial case more clearly to other vice presidents the Chief Finance Officer, and of course, the CEO/President.

Examples 1 through 3 in Appendix 6 provide summaries of ROI in three typical functional areas of SMS. They are, Training, Aviation Safety Action Programs (ASAP), and Line Operations Safety Audits (LOSA). Each area has its own distinct investment costs, benefits, and ROI calculations. In a large aviation organization, there will be multiple functions that will fall under SMS, which will cause some synergy, some overlap, and most likely benefits that will flow across the entire organization from action taken in any one area.

The combined financial benefit of the interventions in all three SMS areas is measured with a Safety Investment Combination Matrix (SICM). The SICM provides a framework for summarizing the effects of all ROI throughout the organization. One such method suggested is the SICM formula in Figure 1.

Additionally, the choice as to which intervention areas an organization wishes to implement and in what order they shall be implemented is also taken into account. For example, if current restraints prevent an organization-wide financial commitment, interventions with a predicted higher ROI may be implemented first, or those interventions which provide learning that has higher organization-wide relevance. The above formula takes into account such reductions in the initial investment cost due to learning curve, the spreading of institutional knowledge from earlier implementations to later implementations, or even through the use of jointly usable material or tools.

Appendix 7, Table A shows the potential permutations of three safety intervention areas, training, ASAP, and LOSA. Table B show potential priority rank orders for these actions, and Table C puts quantitative values to changes in costs and benefits caused by the order in which the three interventions are implemented.

The SICM formula (Figure 1) can now demonstrate the combined costs of all the three SMS programs within a single organization and their effects on one another. As a reminder, the benefits and costs appear in Table 1, below.

Figure 1

<table>
<tr><th>SICM Formula</th><th>Key</th></tr>
<tr><td rowspan="3">$ROI_{TAL} = (a_T)B_T + (b_A)B_A + (c_L)B_L$
$ROI_{TAL} = (a_T)B_T + (b_A)B_A + (c_L)B_L$</td><td><u>Subscript</u>:
A = ASAP, L = LOSA, T = Training</td></tr>
<tr><td><u>UPPERCASE</u>:
B = BENEFIT, C = COST</td></tr>
<tr><td><u>lowercase:</u>
a, b, x, y, and z = reduced implementation benefits and costs due to learning curve</td></tr>
</table>

Table 1

$$ROI_{\mathrm{TAL}} = \frac{(a_T)B_T + (b_A)B_A + (c_L)B_L}{(x_T)C_T + (y_A)C_A + (z_L)C_L}$$

SICM Formula with weights added

$$ROI_{\mathrm{TAL}} = \frac{(1.0)B_T + (.80)B_A + (.60)B_L}{(1.0)C_T + (.95)C_A + (.70)C_L}$$

$$\mathrm{ROI}_{\mathrm{TAL}} = \frac{(1.0)1{,}540{,}000 + (.8)\ 660{,}000 + (.6)\ 795{,}000}{(1.0)\ 359{,}400 + (.95)\ 45{,}500 + (.7)\ 26{,}500}$$

$$\mathrm{ROI}_{\mathrm{TAL}} = \frac{1{,}540{,}000 + 528{,}000 + 477{,}000}{359{,}400 + 43{,}225 + 18{,}550}$$

$$\mathrm{ROI}_{\mathrm{TAL}} = 2{,}545{,}000 \div 421{,}175 = 6.04261 = 604\ \%$$

Conclusion

Accidents and incidents affect the financial results of an aviation organization at three levels.

At the Macro-level, shareholder and market value are lost for multiple reasons enumerated in a number of recent publication that demonstrate relationships between equity loss and post-accident changes such as a change in public perception of air travel safety. While this literature proposes opposing views to SMS business benefits, it can be safely stated that there are multiple opportunities for correlation between accidents/incidents and overall value loss of the organization.

At the Mid-level, losses are absorbed as part of the regular costs of doing business most particularly if SMS programs do not exist that would prevent such incidents from occurring. Examples of such typical costs include workers compensation premiums, or the logistical costs of a product recall, or time vital equipment is out of service.

Finally at the Micro-level, individual departments or individual SMS interventions incur costs and /or savings associated with safety, or the lack thereof. When risks and hazards are not readily identified and no corrective action taken to mitigate the associated costs, organizations absorb costs at the micro level and expose themselves to increased risk at the macro level.

The examples provided earlier demonstrate how SMS safety interventions can provide a significant financial benefit to an organization across all three levels. A properly executed ROI analysis of safety interventions allows organizations to compare safety investments with other competing business investments and assist in decisions regarding financial resources. SMS institutes a proactive process of identifying risks and hazards followed by appropriate corrective actions which eliminate the hazards or reduce the risks to an acceptable level, thus reducing costs.

Recommendations

However favorably they may view the goals of safety and international alignment, organizations in the aviation industry must weigh the potential financial burden of any such regulation. Depending on their current state of safety and quality processes, some operators may be required to make significant investments in material, training, information technology, and personnel to bring the organization up to industry standards in order to meet many of the requirements of SMS regulation. Organizations will need to assess their current operation then compare it to current industry standards and SMS requirements. This assessment will help identify operational gaps and enable a cost determination of the required actions of SMS compliance. Organizations can significantly reduce costs by leveraging existing systems or processes that already comply with aspects of SMS.

SMS should be managed and reviewed like any other business process and utilize the same financial principles to monitor its performance. These financial processes should allow for tracking of SMS operational costs, cost savings, and cost avoidance. Reviewing this data can provide valuable insight into how efficiently the system is operating and help identify SMS inefficiencies, opportunities for improvement, and enable better resource management.

Because SMS implementation is in its infancy, further research and data are required to examine the long term financial benefits of Aviation Safety Management Systems. With a model to calculate the cost-benefit of SMS in hand, further testing must be done using data from actual SMS operations. The costs associated with accidents, incidents, safety interventions, and the cost savings associated with these interventions historically have not been accurately tracked by the aviation industry. Accounting methods must be developed by organizations to better track these costs in order to better assess investments into safety programs and process improvements.

Even without creating separate budgets, if a cost tracking system will simply identify what costs are incurred as part of SMS efforts, the SMS ROI model will provide key information to aviation industry operators, regulators, and service providers that will enable them to meet the mutually beneficial goals of safety and financial health.

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Appendices

Appendix 1

Figure 1. USAirways Stock performance compared to the S&P 500 Index for the 12-month period following the accident of USAirways Flight 1549, 15 January 2009.

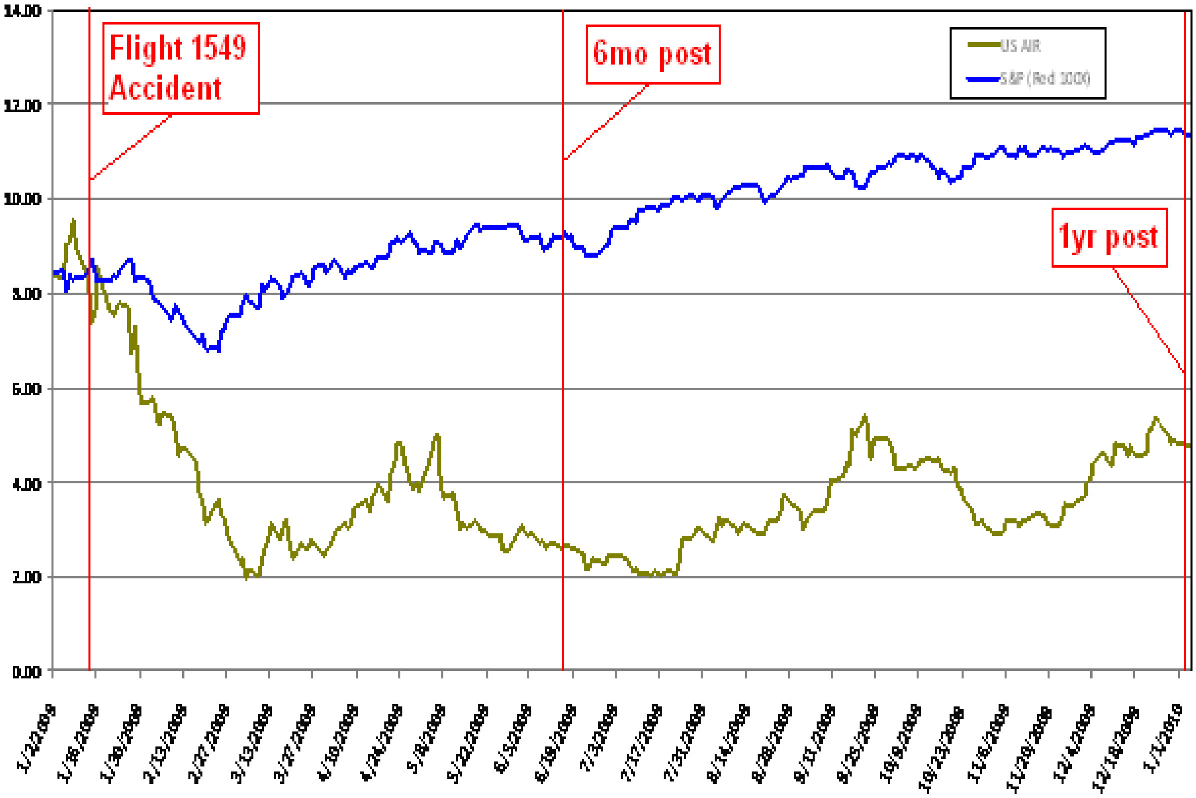


Table 1. Stock value for the 12-month period following the accident of US Airways Flight 1549, 15 January 2009.

	6 Months After	12 months After
US Airways	(71.58%)	(25.58%)
Airline Index	(26.63%)	+129.16%
S&P 500	Baseline	Baseline

Table 2. US Airways Market Value following the accident of US Airways Flight 1549, 15 January 2009.

Date	US Air stock	S&P500	US Air MV
Day of accident	2.12%	0.13%	$1.208B
1 day	15.43%	0.83%	$1.39B
6 month	(72.19%)	8.66%	$336M
1 year	(27.15%)	25.73%	$880M
Correlation of US Air to S&P500 (2008):		0.68	

(Mondello, et al, 2010)

Appendix 2

Figure 1. McCarthy Builders Inc. Lost Time Incident Rates, 1997-2009

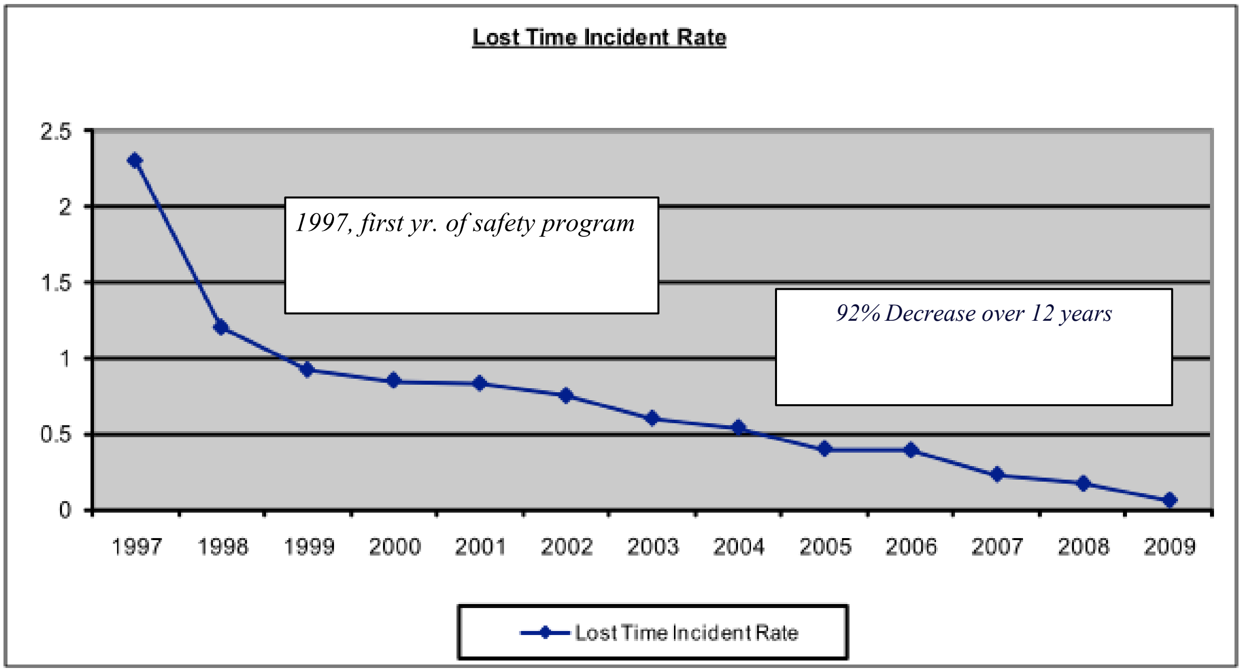
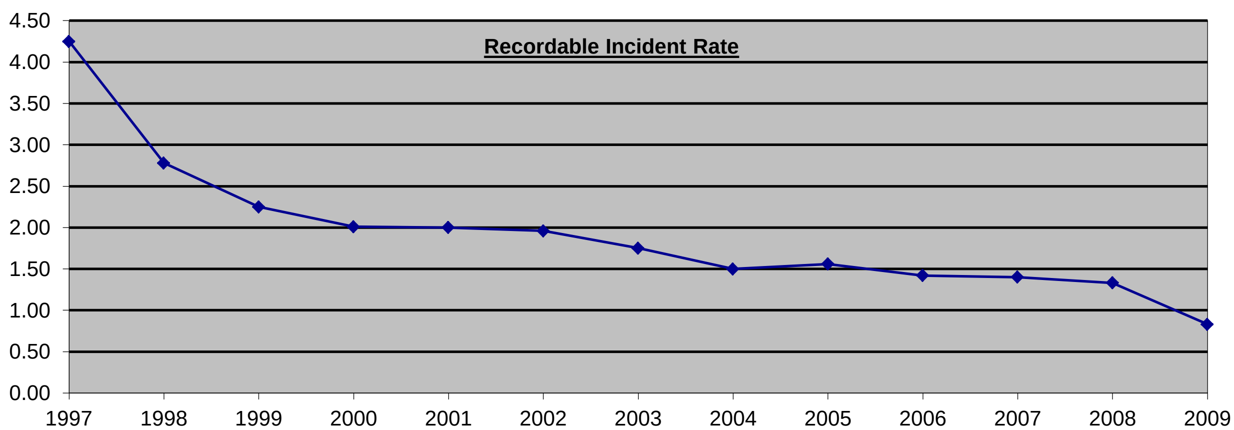


Figure 2. McCarthy Builders Inc. Reportable Incident Rates, 1997-2009



Appendix 3

Table 1. Reduction in Workers Compensation insurance losses at McCarthy, 1997-2009.

Year	Worker Compensation Insurance Losses	% increase or decrease over previous year
1997	$3,009,833	
1998	$2,442,553	-19%
1999	$1,191,562	-51%
2000	$1,184,449	-1%
2001	$798,512	-33%
2002	$735,451	-8%
2003	$733,249	0%
2004	$620,887	-15%
2005	$584,285	-6%
2006	$562,497	-4%
2007	$446,178	-21%
2008	$413,941	-7%
2009	$240,282	-42%

Appendix 4

Figure 1. Baxter Infusion Pump Recalls

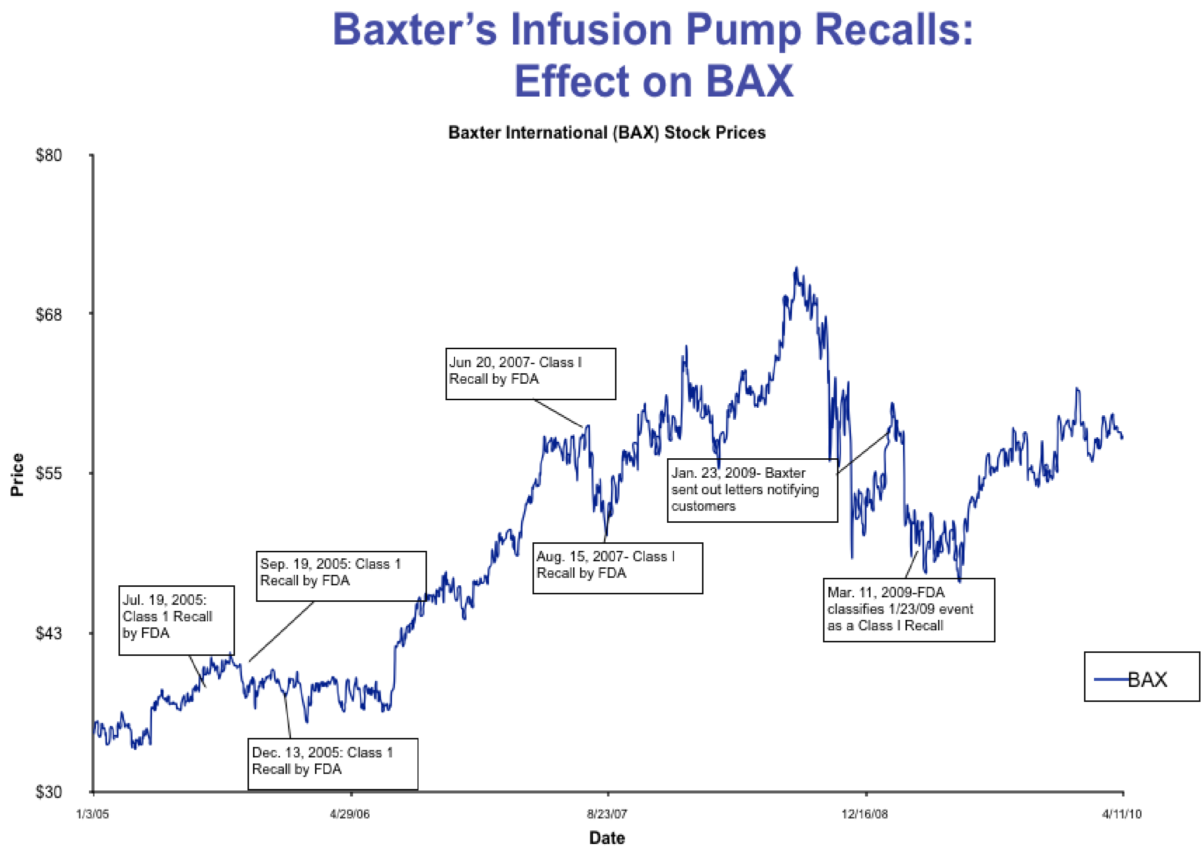


Table 1. Baxter's Infusion Pump Recalls: Financial Effect on Baxter

Year	Amount Recorded
2005	$77 million
2006	$94 million
2007	$14 million
2008	$125 million
2009	$27 million

Appendix 5

Table 1. MRO Example #1 Summary

SMS Line Item Expenses:	MRO EXAMPLE
Incident Type	During maintenance, detached wiring harness and connector left in door hinge are destroyed and structure damaged when door closed for aircraft painting.
Number of Occurrences	4
Cost per Occurrence	$27,000
Total Cost	**$108,000**

Table 2. MRO Example #1 Corrective Action Costs

Team to Develop Corrective Action	Hours Utilized	Cost/Hr.	Cost per Employee
Maintenance Rep	4	$65	$260
Avionics Rep	4	$65	$260
Quality Rep	4	$65	$260
Engineering Rep	4	$65	$260
Total Development Cost			$1040
Corrective Action	Detach wiring at two connectors and remove the entire assembly from under a floorboard. Notate this action in regular paperwork, which will assure reattachment.		
	Hours Utilized	Cost/Hr.	Total
Corrective Action Cost per Aircraft	6	$65	$390
Corrective Action Cost (4ea aircraft)			$1560
Total Corrective Action Cost = Total Development Cost + Corrective Action (4 aircraft)			**$2600**

Table 3. MRO Example #2 Summary.

SMS Line Item Expenses:	MRO EXAMPLE
Incident Type	Recurring cost associated with breaking FMS switch if problem is not identified and corrective action taken to eliminate the hazard.
First Event: # of aircraft	8
Cost per aircraft	$3000
Total Cost: First Event	**$24,000**
Second Event: # of aircraft	2
Cost per aircraft	$2000
Total Cost: Second Event	**$4000**
Total Recurring Cost	**$28,000**

Table 4. MRO Example #2 Corrective Action Costs

Corrective Action	Detach wiring at two connectors and remove the entire assembly from under a floorboard. Notate this action in regular paperwork, which will assure reattachment.		
Corrective Action Cost per Aircraft			$2300
Total Corrective Action Cost (8ea aircraft)			**$18,400**

Appendix 6

Example 1: Training Dept. ROI

	Training Costs	Training Benefits	Training ROI
Instructors	24,000		
Materials	9,000		
Workers-time off	192,000		
Additional labor costs	134,400		
Decreased workman's comp claims		1,500,000	
Decreased fines		40,000	
TOTALS	**359,400**	**1,540,000**	**22%**

$$\text{Training ROI} = \left(\frac{\text{[Net Training Benefits] x Causal Operator}}{\text{Training Costs}} \right) \text{X 100}$$

Assumptions:

- Training three times a year for 2 consecutive days; 2 trainers at $8,000 per session; materials are $3,000 per session
- 100 employees at average hourly rate of $40 for 6 days; additional labor costs for 100 persons at 70% pay for 6 days
- Decreased workman's comp payouts by 60%
- Causal factor from pre and post feedback: .0672

Example 2: ASAP Interventions ROI

	ASAP Costs	ASAP Benefits	ASAP ROI
Personnel	24,000		
Materials	500		
Training	1,000		
Communication	20,000		
Decrease in fines		660,000	
TOTALS	**45,500**	**660,000**	**32%**

Assumptions:

- Costs reflect training, materials and internal web communication to implement procedural changes
- Prior to intervention paying $1.2M/year in fines. With proper changes, able to decrease fines by $660,000 per year

Appendix 6 con't

Example 3: LOSA Intervention ROI

Areas of Intervention	LOSA Costs	LOSA Benefits	LOSA ROI
Flight	5,000	70000	
Materials	2,500	10000	
Dispatch	5000	90000	
Maintenance	5000	175000	
Air traffic	4000	250000	
Ramp Operations	5000	200000	
TOTALS	26,500	795000	29%

Assumptions:

- Typical costs for LOSA observations are personnel costs, data analysis costs, and intervention costs (training, pre- and post-training assessment)
- 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

Appendix 7

Table 1. Potential permutations of three safety intervention actions.

Intervention	Potential Combinations							
Training	0	0	0	0	1	1	1	1
ASAP	0	0	1	1	0	0	1	1
LOSA	0	1	0	1	0	1	0	1

Table 2. Potential priority rank orders for these intervention actions.

	Rank Order	Optimal Sequence
Intervention	1	ALT
	2	ATL
	3	LAT
	4	LTA
	5	TLA
	6	TAL

- Table A represents all possible combinations for the three interventions, including not doing anything (0,0,0).
- Assuming all three interventions should be implemented, Table B represents the optimal sequence of interventions for maximization of return on investment.
- A “0” indicates that the program was never put into place, benefits for this area cannot be included, and the benefits should be moved back into the costs column
- A “1” indicates that the program is implemented an f both its benefits and costs must be included in the overall organizational ROI.

Appendix 7 con't

Table 3. Adjustments to Costs and Benefits caused by implementation order.

	Training	
Position in Sequence	Cost - C_T	Benefit - B_T
1	1	1
2	0.8	0.75
3	0.6	0.5
	ASAP	
Position in Sequence	Cost - C_A	Benefit - B_A
1	1	1
2	0.95	0.8
3	0.8	0.75
	LOSA	
Position in Sequence	Cost - C_L	Benefit - B_L
1	1	1
2	0.85	0.8
3	0.7	0.6