A COST-BENEFIT ANALYSIS OF SAFETY MANAGEMENT SYSTEM IMPLEMENTATION IN THE TRANSPORTATION INDUSTRY

by

Peter Okwera

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Middle Tennessee State University

Aerospace Department

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Thesis Committee:

Dr. Wendy Beckman, Department Mentor and Chair

Dr. Andrea M. Georgiou, Committee Member

I dedicate my thesis research work to my family and friends. A special feeling of gratitude to my loving and unique set of parents, Dr. Otto Y. Aron and Mrs. Otto Jacinta, Mr. Opige Vincent and Ms. Arach Mary, whose words of encouragement and push for tenacity ring in my ears. My brothers and sisters, some of whom sacrificed their education to see me achieve my academic dreams. I also in a special way want to dedicate this thesis to my mentors; Mr. Dean Hayes and the entire Blue Raider Athletics Department, Mr. Abdullah Mohammed, and the entire Gombe Secondary School staff members for the financial and moral support throughout my academic journey. All of you have been my best cheerleaders.

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ABSTRACT

The transportation industry across the world operates in a well-choreographed dance. This well-choreographed dance continues to face many threats; a smooth operation of the industry relies on the safety program that are in place. One such safety program is safety management systems. Safety Management Systems (SMSs) is defined variably by different organizations. For example, the Australian Transportation Safety Bureau (ATSB) defined SMS as a planned, documented, and verifiable way of managing aviation risks (ATSB, 2011). The Federal Aviation Administration (FAA) defined SMS as a creative and proactive response to system safety (FAA, 2015). Given the complex nature of the industry and the evolution of new risks or threats in the transportation industry, the success of managers and operators of transportation firms have much relied on balancing productivity, profitability, and the effectiveness of safety programs implemented. In fact, safety professionals, companies, and agencies have always documented humanistic benefits related to safety programs, but little research has documented the costs and benefits of implementing a safety program. This study reviewed studies by highly placed transportation scholars on the costs and benefits of SMS implementation. Findings from the study suggest companies and agencies within the transportation industry will experience some costs and benefits from the implementation of SMS. It was also discovered that it is very difficult to quantify the benefits from SMS implementation. The study concluded that even if companies will incur costs with implementing SMS, the benefits from the implementation are derived from the savings made when accidents are avoided.

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

CHAPTER I: INTRODUCTION

The aviation, railway, highway, maritime, and pipeline industries provide gateways to the global village by connecting places from the most remote to the most modern cities. These industries operate in a well-choreographed dance meant to enhance the interface between the more developed and least developed areas. The constant entry of new players and the steady increase in traffic volumes in the last decade have not only shown shifts in societal organization from rural to urban areas, but also magnified how the transport industry has created links between manufacturers and potential markets.

While industries such as manufacturing, construction, mining, and nuclear plants have had a long history of safety mainly under the watch of the Occupational Safety and Health Administration (OSHA), the aviation industry, railways, and highway industry among other transport industries in the United States, Canada, Australia, UK and New Zealand have relied mainly on regulations guided by administrative bodies. Some of these regulatory bodies includes the following: Federal Aviation Administration (FAA), Civil Aviation Safety Authority (CASA) and Transport Canada (TC). The increase in the demand for transportation services has necessitated the development and design of safety measures. Programs that enables and promote the safety of passengers and commodities across the transport spectrum have developed. Numerous safety and regulatory agencies like the Federal Aviation Administration, Civil Aviation Safety Authority, and Transport Canada work to develop and improve safety, some of their policies have also conflicted with other safety regulatory agencies. For example, while the FAA exercises its statutory role to fully regulate cockpits, crew, and aircraft operation safety, OSHA emphasizes employee safety. This includes the time from when the crewmembers board the aircraft until the crew disembarks from the aircraft; meanwhile, OSHA standards involves protection of crew members from exposures to pathogens. Furthermore, OSHA may require the installation of special receptacles on board an aircraft but the FAA may argue such devices are not airworthy. Therefore, the complex and ever evolving safety features for the transport industry requires a strong emphasis on the importance of safety programs and their implementation. One such program is Safety Management Systems (SMS).

Safety Management Systems (SMS) are defined variably by different organizations. For example, the Australian Transportation Safety Bureau (ATSB) defined SMS as a planned, documented, and verifiable way of managing aviation risks (ATSB, 2011). The Federal Aviation Administration (FAA) defined SMS as a creative and proactive response to system safety (FAA, 2015). Given the complex nature of the industry and the evolution of new risks or threats in the transportation industry, the success of managers and operators of transportation firms has much relied on balancing productivity, profitability, and the effectiveness of safety programs implemented.

Literature Review

The global implementation of SMS presents tough challenges to the transportation domain. In 2009, the International Civil Aviation Organization (ICAO) stipulated minimum requirements for implementation. This stipulation was taken up by regional regulatory agencies. The Australian Civil Aviation Safety Authority (CASA), mandated that most of the regular public transportation modes implement a functional and effective

SMS. In Canada, Transport Canada (TC) requires the aviation industry to implement a safety management system as a layer of protection against threats in an effort to save loss of lives and properties. The Civil Aviation Authority (CAA) of New Zealand encourages aviation organizations to adopt the SMS approach. The SMS concept has already become a functional component of safety in risk susceptible industries in many countries. In the U.S aviation industry, the concept of SMS has been theoretical for many years, even though other risk susceptible industries like construction, highways, railways, nuclear plants, and medical institutions, have embraced SMS or components of SMS. However, the FAA has now mandated that all US-based commercial airlines fully implement SMS by 2018 (FAA, 2015).

Safety management in the aviation industry has become a paradigm that looks at the society as it is rather than what it ought to be (Wong & Sze, 2010). SMS is a contributor to this paradigm shift. Generating debates from micro to macro levels, SMS exhibits unique features that requires chronological studies aimed at ascertaining the variables required by safety managers in the implementation of SMS (Ender, 2015). SMS emphasizes the need to have a strong safety culture starting with top management inputs towards ensuring that line employees adhere to SMS standards or policies. The second component of SMS requires that timely and continuous assessment of risks is made. The third component of SMS encapsulates safety assurance, thus requiring procedural audits and assessments to ascertain the effectiveness of safety. Lastly, the level of safety awareness and promotion is a critical component of the safety culture that SMS emphasizes (FAA, 2014).

The complex nature of the aviation industry requires setting acceptable standards across all borders. Countries have to appreciate the importance of uniform safety procedures or standards if a smooth operation is to be attained. The ICAO requires CASA, FAA, CAA, and TC, along with other regulatory agencies worldwide, to meet SMS compliance for aviation or other certified public transport operators. Most of the agencies, like the FAA, have a dual mandate of safety regulation and promotion of aviation the industry. SMS theoretically looks great on paper but to date no business approach to analyze its impact has been made. This has made the mandate for companies to implement SMS more of a regulatory safety program than a safety promotion program (Damon, Eddie, Manoj, Rich, & Suzanne, 2011).

Cost-Benefit Analysis (CBA) and Benefit-Cost Ratio (BCR) are indicators that summarize and approximate the value of specific policies and procedures. The concept is built on the idea that as risks and threats continue to increase and become more complex in nature, the demand for policies or projects that would minimize the effect of such threats also increases, especially for risk susceptible industries like transportation (Shreve & Kelman, 2014). The CBA and BCR are often used by the World Bank in estimating disaster risk reduction (DRR). The World Bank estimates that DRR saves $7 for every $1 invested in a project. This standard 7:1 ratio continues to be used in reference to project management and implementation.

Research into aviation safety has always been theoretically documented, mainly outlining the human benefits of safety programs (Damon et al., 2011). No sufficient business case has been built to highlight the business benefits associated with implementing safety programs. Cost-benefit analysis (CBA) can be used to validate employment of public funds to show the monetary significance of safety programs. However, a study by Ezra (2010) on road safety illustrated that CBA as a tool lacks numerous variables. He noted that CBA is based on estimates of statistical values of life and injuries. Secondly, that CBA is based primarily on welfare economics which focuses on optimal allocation resources, this is a rare circumstance in road safety. This means CBA seeks to identify the least costly and efficient method of improving road safety. Thus, it does not cater for the alternatives to the road safety program as long as the primary safety program is assumed cost effective. Lastly, the CBA may require calculating present values which ought to be critiqued when discounting future lives and time. As such, CBA tends to present biased decisions on investment into road safety (Ezra, 2010). Research on CBA in road safety programs have predicted the same economic significance as the implementation of SMS in risk susceptible industries.

The costs associated with implementing a safety program depends on numerous factors. The factors may or may not be controllable by an aviation operator like airlines, airports, and general aviation operators. Numerous safety tools that reinforce SMS's foundation, like Aviation Safety Action Program (ASAP) and Flight Operations Quality Assurance (FOQA) require installing advanced sets of technology that allows for efficient data collection. The Government Accounting Office's (1997) report to the United States' Congress highlighted that implementing FOQA would enhance aviation safety. It further stated that the costs associated with implementing FOQA depended on numerous variables, for example the type of technology used, the number of aircraft owned by a carrier/company, and personnel costs. The diversity in the costs associated with implementing such a program made it extremely difficult to accurately quantify the benefits of such a safety program. In 1997, the Government Accounting Office (GAO) report to Congress, the FAA developed a cost estimate of $760,000 per year for companies with 50 aircraft for the implementation of FOQA and the yearly maintenance of the program. It further noted that the FAA's estimates suggested that such a company would be able to realize a net saving of $892,000 per year if FOQA was implemented (GAO, 1997).

The implementation of SMS, especially in United States, has been more theoretical than financially practical, as no quantified data associated with the costs and benefits of the program has been established, neither on macro or micro levels. The FAA's Advisory Circulars (AC) to Part 121, 135, and 139 provides details on SMS and how it should be implemented. The FAA's final rulemaking for 14 of the Code of Federal Regulations (CFR), Part 121 is the only quantified costs and benefits of implementing SMS reference in the industry (FAA, 2015). The 2015 rule noted that airlines will be able identify safety glitches. Mitigating some of these safety issues are estimated to translate into savings of about $205 to $472.3 million over a period of 10 years, depending on the size of airline. The implementation of the SMS program under the rulemaking would cost around $135.1 million industry wide over 10 years (FAA, 2015). Even though this rulemaking on SMS implementation works to extend FAA safety regulations, airline companies will benefit from the program significantly. Some of the benefits stem mainly from reducing the cost of accidents, compensation for victims, cost of property destroyed, and accident investigations.

In 2012, the Australian government through CASA, carried out a case study of aviation companies in Australia and the findings drew some important business conclusions regarding SMS implementation. They noted that the costs of implementing and maintaining SMS varies significantly depending on the size and complexity of an organization. The study also found that developing an SMS for a small to medium sized company would cost approximately $20,000 to $30,000, with ongoing expenditures of $15,000 to $17,000 (CASA, 2012). When these costs are weighed against the costs of accidents, then it becomes obvious that the implementation of SMS produces some business benefits to the company. The most insight this study provided was that aviation companies incur direct and indirect costs associated with aircraft that get into accidents.

Direct costs are those costs that are associated with physical damage of an aircraft, compensation for property damage, and injuries. CASA’s study of 2012 found that for a small to medium sized company, it would cost around $15,000 to $20,000 for a propeller strike on a light twin engine aircraft. It further stated that for a recovery of a 20-seat regional aircraft, the costs would be approximately $200,000. However, it is estimated that indirect costs will most likely more than double the direct cost (CASA, 2012). Indirect costs include legal claims, recovery, loss of staff productivity, short-term replacement, business reputation, and loss of equipment. It is also clear from the cost structures above that SMS implementation suggests numerous business benefits, but most importantly a reduction in accident and incident rates.

Along with air carriers, the implementation of SMS is likely to present both business and safety benefits to Part 139 airports. Airports operate under the direct regulation from the FAA, and as such, any changes or mandates at federal levels directly affects airports (FAA, 2012). Being an entry and exit point, airports that opt to implement SMS have to adjust to the changes and evolution of safety culture of the organization. Fortunately for most airports in the United States, there are standing safety procedures with foundations that make the implementation of SMS an easy process. The ease of implementation is because most existing airport safety programs have components that are similar to SMS. Like other players in the aviation industry, airports in United States have not had much experience with SMS implementation.

A 2011 FAA pilot study found that participating airports had ideas about SMS, but most of the airports did not have a functioning SMS. Interestingly, a few safety mangers gave a cost breakdown of SMS implementation. The study was able to establish that airports accrue some benefits beyond safety regulations under 14 CFR 139. One of the participating airports was North Las Vegas airport (VGT), found that SMS required employing a full-time SMS management analyst, costing the airport approximately $84,460 per year including benefits. Thirty employees also had to be trained, at an estimated cost of $57,120 yearly. This means the cost of implementing SMS at VGT was $141,580 on the first year. The FAA does not quantify any benefit from this investment.

Compliance to safety programs are essential in operations. An in-depth analysis of a report on Piper Alpha Oil rig of 1988 revealed that absence of SMS, complacency, and negligence caused a fire that led to the loss of 167 lives and insurance payouts of $2.8

million. Recommendations to Piper Alpha Oil management highlighted adopting a Quantitative Risk Assessment (QRA) approach to enhance safety at the company. Just like Piper Alpha Oil Company, since airports are a risk susceptible environment, adopting an approach that enhances the ability to detect the occurrence and identify the severity of abnormalities/disasters is important. QRA is similar to Safety Risk Management, one of the pillars of SMS (NASA, 2013).

The history of SMS in marine transportation dates as far as the establishment of the International Safety Management (ISM) Code in the 1980s. The ISM Code can best be described as the cornerstone for the implementation of SMS in maritime transportation. The main goal for the establishment of SMS in maritime transportation is to enhance safety and protection of ocean going men and commodities. This is due to the fact that human factors contributed to nearly 60-80% of accidents in the industry. SMS became an essential safety component in the industry in 1998. Ship owners and firms were required to conduct regular safety audits and checks for oil and chemical tankers, bulk carriers and cargo high speed craft of 500 gross tonnages, passenger ships, and gas carriers. Firms in the maritime industry struggled to ensure compliance to the ISM Code mandate for implementation of SMS across the industry (Gary, 2012).

Commercial vessels are operated and maintained in highly threat susceptible environments. Vessel owners and companies use safety management systems in many countries to enhance safety and guard against massive losses resulting from avoidable accidents and incidents. Ships and vessel owners across the world have been responsible for ensuring the safety of the vessels in the water. While many countries like Australia, New Zealand, United States and members of the European Union (EU) have mandated the implementation of SMS in commercial vessels, there has been no clear research to prove a business case for the mandate (Maritime New Zealand, 2014).

In fact, in New Zealand, EU member states, Canada and Australia, the concept of SMS is adapted from other industries like aviation, nuclear plants, and construction. Safety of life at sea (SOLAS), which has been used as benchmark for SMS implementation in New Zealand, is only operational under Maritime Rule Parts 19 and 44. These are basically restricted vessels. Thus, vessels are categorized on the number of passengers, nature of goods, and overall weight of the vessel. Therefore, tracing the costs and benefits of implementing the program are extremely difficult. Secondly, the frequency of accidents and incidents in the maritime transportation has been very low over the past decade. This also makes tracing the impact of SMS really difficult (Maritime New Zealand, 2014).

In 2004, the United States Coast Guard drafted the proposed Subchapter M which included Towing Safety Management System (TSMS). The estimates from the Subchapter indicated that 1,059 firms and vessel owners would meet the costs for implementing SMS. Furthermore, 92% of those firms were categorized under the small business administration (SBA). A study by Gary (2012) noted that to implement all the components of SMS, companies and vessel owners needed to understand the cost of compliance to each component. The study further stated that the cost of SMS-related equipment ranged from $32,000 to $72,000 for small and large companies respectively. Meanwhile the cost for SMS development, implementation, and post-implementation cost ranged from $750 to $2.9 million. The study noted distinctive costs related to each item required in setting up a functional SMS program. For example, the one-time costs are far smaller than costs for maintenance, and internal and external audits of the SMS program (Gary, 2012).

The concept of SMS is not new to the railway industry. Even though most of the implementation processes has been on legislative level in the United States, countries like Canada, the UK, Sweden, and other European countries have been able to implement SMS. Transport Canada, for example, set a regulatory framework in 2001 which mandated all firms adhere to the new railway safety management system regulations. Accidents and incidents have become a rare occurrence in most transit routes over the years.

In fact, the railway industry is considered one of the safest. However, the occurrence of an accident always results in massive loss of property on cargo trains and lives on subways or passenger trains (Transport Canada [TC], 2014). The losses resulting from accidents show gaps that exist in safety programs mainly due to human errors. The effect of such accidents are not only catastrophic, but also the economic effects are far-reaching. For example, compensation for damages, increase in insurance premiums, and repairs are expenses beyond the regular costs that companies have to meet. These expenses threaten the viability and profitability of the companies, thus leaving many companies with limited options but to exit business. Both Transport Canada and Transit Rail Advisory Committee for safety in United States agree that the basic principles of SMS enhance the safety of rail industry (TC, 2014).

The implementation of SMS in the railway industry attracts numerous criticisms as there is no proven case or success story from a similar industry in another country where SMS was able to spur a rapid decrease in accident rates. In Canada, the debate shifted from looking at the benefits of implementing the program to what the costs and actual dollar amount of the returns were from implementing SMS. The new railway regulations were applied to 28 federal railway companies and 35 local companies whose expenditure were instantly affected by the regulation (TC, 2014).

The costs of implementation varied across the industry with the federal railways companies estimated to incur about $13.8 million over a 10-year period; meanwhile, local railway companies were estimated to incur about $9.9 million (TC, 2014). Furthermore, the proposed regulation was estimated to have a net present value of $26.8 million over a period of 10 years. This also translates to approximately a net present value of $3.8 million per year. On an individual company level, small to medium sized companies were estimated to incur an average of $33,710. Railway companies that implemented SMS incurred numerous costs that stemmed from creating new roles and responsibilities for employee positions (TC, 2014). The regulation estimated that each SMS employment position created would be paid an average wage rate of $35.70. This is an example of the various expenses that railway companies incurred as a result of the regulation.

Transport Canada recognized that most of the benefits from the implementation of SMS is qualitative as the SMS idea is based on the assumption that hazards and human errors will inherently exist in operations. The benefits accrued over time are therefore reflected in terms of improved safety records, thus fewer accidents or incidents. Accident and incident data from 2005 to 2014 have given a clear view of the benefits of SMS in the railway industry. It is estimated that accidents and incidents have declined by over 40% in the last decade as a result of the implementation of SMS in the industry (TC, 2014). The categorization of accidents and incidents are based on the definition that accidents are unintentional damages and injuries suffered as a result of operating a transportation equipment, while incidents refer to intentional, unintentional, good or bad event resulting from the operation in the transportation industry on which the attention of the safety department is called. Powerful and sharp declines in accident rates were noticed between 2004 to 2007. There were few sharp spikes after those years mainly resulting from personal suicides, which remains an uncontrollable variable even with the existence of SMS.

In Europe, the railway industry is widely used for either transporting passengers or cargo. SMS has been a very instrumental tool in enhancing the safety of the railway industry among European Union (EU) members. In fact, the EU members use SMS as a proactive mechanism to identifying precursors to accidents. The European Railway Agency in 2014 reported that there were over 10,000 precursors to accidents that the proactive monitoring safety had arrested (European Railway Agency, 2014).

The agency furthermore noted that if these precursors went unnoticed the possibilities of accidents occurring were very high. In fact, it noted that the ratio of precursors to accident occurrence is 5:1. This significantly outlines the importance of monitoring the precursors as indicators to accidents. This proactive approach by the EU member states have yielded some safety benefits as accident levels are declining significantly. Table 1 below shows how accident occurrence has declined among EU members from 2007 to 2012 due the presence of SMS. The European Union member states have enjoyed quite a reasonable amount of improvement in the railway industry as a result of SMS being used to identify potential precursors to accidents in the industry. Even though the EU members did not reveal the exact costs and quantified financial expenses and savings from the SMS investment, it is clear that the decline in accident and incident rates directly means fewer accident related compensations and increases in insurance premiums (European Railway Agency, 2014).

Table 1 *Accident Rates for European Railway Agency After SMS Implementation*

Year	Fatalities	Severe Injuries
2007	1517	1367
2008	1478	1380
2009	1384	1104
2010	1272	1125
2011	1207	1050
2012	1133	1016

In Australia, the ATSB has mandated SMS in the aviation, marine, and railway domains. Most of the recommendation are from tested results of the effectiveness of SMS seen in the aviation. Cooperation between CASA and the ATSB resulted in the implementation of SMS in the railway industry. The Australian Transportation Safety Board (ATSB) report on the accident occurrences in the financial year 2009-2010 reflected some rather interesting figures, as the rates of accidents had declined significantly in the railway industry compared to the previous years. Even though the report does not directly point at the decline in accident and incidents as being an impact of SMS implementation, it noted that continuous monitoring, audit, and evaluation of safety and security programs were responsible for decline in accident rates. Monitoring, audit, and evaluation of safety programs are key components of the safety management system (ATSB, 2012).

Safety is a core interest of most federal government agencies and commercial investors concerned with transportation. The United States is unique among many countries because of the heavy investment into the transportation industry. In fact, the U.S. has one of the most developed highway networks in the world, yet has some of the highest accidents rates. The National Highway Traffic Safety Administration (NHTSA) estimated that over 115 people died daily in road related accidents in 2001 on road-related accidents. It also stated that the economic cost of the damages resulting from the accidents accumulated to about $230.6 billion (Daniel & David, 2012). The costs were reflecting loss in wages due to injuries, increase in insurance premiums, medical expenses, and property damages. The NHTSA recognizes that traveling is a huge activity done by most segments of the U.S. population, therefore, safety becomes a prime goal of the agency. The agency manages numerous road networks across the country. However, there are unique authorities that are tasked with enforcing and implementing safety programs for highway users. The NHTSA involves local, states, tribal, and federal authorities in developing safety programs. One such program has been the implementation of SMS for highway users like trucking companies, motorists, buses, and other private or commercial users.

The traditional role of promoting road safety remains with the federal, states, tribal, and local enforcement. This is mainly because it is extremely difficult to implement a safety program for individual motorists. Therefore, authorities have focused on making sure the basics of safety programs are understood by citizens. This awareness campaign included designing road signs, traffic signal repair, constructing speed bumps, seatbelt policies and drug, and alcohol policies (GAO, 2014). The Federal Motor Carrier Safety Administration (FMCSA), the agency charged with ensuring safety investigations and recommendations for road users, has been updating and initiating the implementation of SMS to trucking and bus companies since 2010. Unlike the other transportation industry, the FMCSA's SMS methodology is based on ideas aimed at Behavior Analysis and Safety Improvement Categories (BASICs), which includes fatigued driving, driving under the influence of controlled substances/alcohol, vehicle mechanical conditions, and the use of energy drinks. In fact, FMCSA has also created a FAA-like self-reporting tool where drivers can report violation of SMS's BASICs.

FMCSA uses SMS to categorize carriers with safety problems that require immediate attention. In fact, in BASICs, safety management system is used to quantify the carrier's safety performance. This means carriers can be categorized based on their performance on the road and hence priorities are given to those companies with high BASICs percentiles or acute safety violations. Surprisingly, there has been no quantified financial data documented for implementing the SMS methodology by FMCSA. Most of the arguments for SMS is based on theoretical benefits of SMS. Furthermore, even though SMS is a significant component of the Fixing America's Surface Transportation (FAST Act) of 2015, there has been no specific financial document to show how the program will be run. A GAO 2014, study found that SMS is part of the Compliance, Safety and Accountability (CSA) received about $59 million from the U.S. Department of Transportation and FMCSA. This funding was meant to cover expenses by the three components of CSA, SMS, Intervention and Safety Fitness Driving Determination.

The concept of cost-benefit analysis has widely been used in other transport modes besides road safety. Using CBA to set priorities in road safety has been controversial, especially given the fact that there are no quantified monetary returns from improving or implementing a safety program. Countries like the United States, Canada, Australia, and European Union members use CBA mainly to estimate the cost of road accidents, but not for implementing a safety program like SMS. Furthermore, the benefits accrued from implementing a safety program like SMS can only be reflected in terms of reduction in the rates of accidents and increase in incident reporting (Elvik, 2010). In the United States, a GAO 2014 report has noted that implementing SMS increases incidence reporting and intervention. This is because the SMS concept in the U.S. road transport industry helps policy makers in identifying unsafe behaviors by their severity, and hence call for immediate intervention.

The pipeline mode of transportation is probably the least discussed transport mean in the public sphere due to the limited contact with the population. Even though most pipelines pass and have a gigantic underground network in nearly every community in the United States, not much safety attention is given to safeguard against possible accidents. This is because the pipeline transport industry is probably one of the safest modes of transportation in the world compared to surface means of transport. Most pipelines transport unique but highly volatile goods whose contact with the public/population can create numerous damages. The U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), and Office of Pipeline Safety (OPS) classify most commodities transported by pipeline as hazardous liquid. Most of the pipes that cover the vast majority of the lines or network in the United States today were planted in the early 1940's, 50's, 60's and 90's (GAO, 2006). Some of the pipes have become weak over the years due to chemical reactions with the liquid transported, regular wear and tear, and because of environmental pressure.

The development of new technology and continued research in pipeline safety has been able to identify the possibilities of accident occurrence. However, the absence of a holistic safety program like SMS proves to be a challenge as numerous cases of accidents have unearthed a combination of complacency, negligence by companies, and shallow inspection by local and federal authorities. Even though pipeline accidents and incidents are few in their frequency of occurrence, their impact on society can be very devastating. The immediate damage may not be much, but spillover impact on the population and environment can be tremendous.

In 1999, a 16 inch-diameter pipe that ruptured near Bellingham, Washington. discharged over 237,000 gallons of fuel into the nearby creek. This fuel was ignited and killed 3 people, while injuring eight others (NTSB, 2002). The NTSB report stated the probable causes were negligence, and limited inspection. The damages from the discharge was estimated to be around $45 million. The Olympic pipeline company had to settle legal claims as a result of the accident. The legal settlement was estimated at $113 million. It became clear after the NTSB investigation that a combination of the Olympic pipeline company's failure to test and inspect, and negligence on the side IMCO General Construction Inc. was a lethal combination, one that would kill again if no safety precautions are put in place (NTSB, 2002).

Furthermore, in 1994, a large natural gas pipe ruptured in Edison, New Jersey, torching apartments and destroying the environment around the surrounding communities, although no death was reported in the accident (PHMSA, 2004). Furthermore, in 1988, an Alpha Piper oil refinery experienced one of the most disastrous oil rig accidents in history off the coast of Aberdeen, killing 167 workers. In 2013, the National Aeronautics and Space Administration (NASA) conducted an investigation into the accident and discovered that complacency, and negligence caused the accident. The Alpha Piper company paid about $3.4 billion in damages and settlements in the years after the accident. NASA's research also found that the UK's Health and Safety Executives made recommendations to risk susceptible industries to implement SMS. It is clear that whether accidents or incidents in the pipeline industry occur, including death or physical injuries inflicted on the population, the damages and loses that the company can incur are incredibly high. SMS has been adapted by Pipeline and Hazardous Materials Safety Administration and other sister agencies in regional countries like Canada, Britain, and

Australia as a mechanism to assess and provide continuous appraisal of safety in pipeline transportation (PHMSA, 2004).

Safety management systems have become an instrumental tool in identifying threats in the pipeline transport industry, not because it was implemented alone, but because SMS has been integrated into some of the existing risk management strategies that were already in place. Countries and pipeline companies that have implemented SMS have enjoyed incredible amount of benefits that relate to the large continued decreases in accident rates. In 2014, the Transportation Safety Board of Canada (TSBC) issued the regulations that have changed the reporting of incidents in the pipeline industry. In fact, it established a live database on which operators would non-punitively report incidents. This effort is a core component of the SMS philosophy that Transport Canada had already mandated in most of transportation industries. TSBC did not specifically quantify the cost of implementing SMS in the pipeline industry. There have also been no financial benefits identified as a result of implementing SMS. Instead, the pipeline transport industry has seen tremendous increase in the level of incidence reporting and decrease in accident rates. Table 2 below shows how the trend of incidence reporting is helping reduce accidents (TSBC, 2015).

Table 2 *Accident Rates Verses Incidence Reporting*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Accidents	5	9	7	6	15	11	5	7	11	5
Incidence Reporting	79	62	64	84	118	145	167	173	118	133

Even though the TSBC and Transport Canada did not attach financial benefits to SMS implementation, Table 2 gives an overview of how SMS is transforming safety in pipeline transportation. There is a negative relationship between accident occurrence and incidence reporting. Thus, as operator reports more incidents, fewer accidents occur. In this case, incidence reporting is being used as accident precursors to the 37 federally related companies. The increase in the number of accidents from 2005 to 2010, warranted the need to establish the 2014 regulation that would encourage reporting of incidents or precursors. It is from these accident precursors that safety managers employ mechanisms to avert the possibilities of the accidents (TSBC, 2015).

Statement of the Research Questions

Safety Management Systems is an evolutionary concept that the FAA and other regulatory agencies are mandating aviation companies to implement. The purpose of this study is to ascertain the costs and benefits of implementing safety management systems in the aviation industry in the United States. Numerous safety financial reviews, legislative and regulatory reports, and research studies on aviation safety will be reviewed to determine the costs and benefits of SMS implementation. Overall, the information attained will clearly show the business impact of SMS implementation on the aviation companies by laying out the precise costs of putting in place SMS, maintaining its continuity, and identifying the financial benefits of the program. The study will focus on answering the following research questions:

1. What level of expenditures have been experienced by companies or agencies that have implemented SMS?
2. What cost savings have been experienced by firms or agencies that have implemented SMS?
3. From a financial standpoint, are the returns from SMS expenditures adequate to justify the investment?

CHAPTER II: METHODOLOGY

This study consists of an in-depth literature review of research findings by both domestic and international scholars in order to answer the research questions. The reviews were specifically used to determine the exact financial costs of implementing and maintaining a functional SMS program. It looked at major transport industries that have implemented SMS including aviation, highway transportation, and railroad. Conclusions were drawn from both domestic and international industries that have initiated the implementation of SMS and its components.

Literature Search Database

When doing a study, especially one that involves a qualitative literature review, the source of information included in the study is very essential. This study used ten databases to search for peer-reviewed articles related to SMS implementation. The search engines and databases used includes the following:

- Academic Search Premier
- Science Direct
- National Transportation Safety Board
- Federal Aviation Administration
- Australian Transportation Safety Board
- Transport Canada
- Google Scholar
- National Aeronautics and Space Administration
- Government Accounting Office

- Civil Aviation Authority of New Zealand

Since there is no standardized ratio for the cost of implementing SMS, each article from the industry was interpreted differently. This was an attempt to demonstrate a business case for SMS by analyzing the costs and benefits of SMS in safety performance of the various companies. A qualitative literature review methodology has been chosen because it encapsulates bringing together scientific facts and it will present an unbiased and wide-ranging approach to the overview of research evidence found by other scholars (Andreas, 2003). The literature review methodology also takes into account a diverse array of information from an international perspective to satisfy the specific interests of the study.

Design of the Study

This study utilized a qualitative method of research due to the open-ended nature of the research questions. A review of research findings was used to determine the costs and benefits of SMS in aviation. This research method maximized the expert opinions of scholars to develop and build a business case for SMS implementation. A preliminary Boolean keyword search for “Costs of safety,” “Benefits of Safety,” and “Safety Management System,” was carried out. The search revealed peer-reviewed articles, industry publications, specific interventions relating to SMS implementation, accident rates, and industry financial trends; these results enabled a broad and thorough search related to the specific topic of interest (Thomas, 2011).

Furthermore, major peer-reviewed journals, government databases, and industry specific databases were used. The search was limited to SMS, safety, and impact study of safety interventions; this was done ease inclusion and exclusion of the literature obtained. The following were procedures used in selecting literature included or excluded in this review:

- Time Frame: This study utilized peer-reviewed literature published in the past 37 years, thus 1978 to 2015.Therefore, studies that were done before 1978 and after 2015 were excluded from this study.
- Type of Study: Given the complex nature of the topic of study, any primary quantitative research that addressed specifically the topic of study was utilized. The study also utilized economic studies, including cost-effectiveness analysis, economic modelling, and cost-utility analysis of the public and private transportation sector where the outcome of intervention has been determined (Andreas, 2003).
- Population of Interest: The transportation industry operates in a diverse environment and as such there is a need to understand the safety policy implementation beyond borders. Fortunately, most of the transportation modes operate under a unified set of standards globally, but that does not mean differences do not exist across borders. Information was gathered from sources that have carried out research related to the topic of study in different countries. Preference for articles were made for mainly the Organization for Economic Co-operation and Development (OECD) membered states. This is because most the OECD members publish their research results related to the topic of study,

compared to the middle income countries which do not release most of their studies related to SMS implementation.

Cultural and Linguistic Difference: The transportation industry is a rather unique industry compared to other contemporary industries. This is especially true with most transportation industries operating under the guidance of international agencies and organizations. The aviation industry and marine industry are guided by ICAO and International Maritime Organization (IMO), respectively. These industries use one or more common language (s) in their official communication. This study explored only literatures reported in English, hence systematically excluded studies conducted in other languages. Studies in other cultural and linguistic ranges are excluded due to the practical difficulty of translation (Andreas, 2003).

Procedures of the Study

For the purpose of this study, the first step was to establish the sources of literature to be used as described in the design section of this study. Secondly, a complete list of sources was compiled. The Middle Tennessee State University's Walker library and governmental websites and databases were used to access most of the digital literature. A spreadsheet was developed to sort the data obtained. This enabled grouping of the literature in their respective categories, indicating whether they are related to SMS, safety, or the transport industry.

The transportation industry is highly used by the public and as such, research findings from scholars are often criticized for bias and personal opinions. Scholars in the transportation industry have adapted appraisal techniques similar to their counterparts in the health and medical fields. In Australia, scholars have used the appraisal techniques used by National Health and Medical Research Council (NHMRC). The NHMRC approach looks mainly at the scientific evidence presented by the researchers and how this evidence can be transferred to other fields. The technique looked at how nurses and physician assistants responded to work place safety and how effective the safety programs were at changing the rate of accidents among professional workers in medical institutions. Therefore, this study looked at evidences relating to the costs and benefits of implementing SMS in the transportation industry (Thomas, 2011).

Literature Search Results

A total of 109 articles were selected for literature review from various peer-reviewed and government databases. The task then shifted to identifying the articles closely related to the topic of study. Abstracts and summaries from each article were read to ascertain the possibility of them being included or excluded in the study. Preliminary screening left nearly half of the selected literature for further scrutiny. At the completion of the screening 40 articles were selected for inclusion in this study. Of all the articles selected none were specific reviews of the cost-benefit analysis of SMS implementation, but some of the studies were closely related to SMS implementation in the transportation industry. The 40 articles were selected because of their depth and direct relation to the topic of study, thus, studies that reported costs and benefits of implementing SMS were selected. Meanwhile, 69 articles were excluded from the study because the scholars of the articles did not address issues related to costs benefits and the implementation of SMS, but rather mentioned the significance of SMS as a safety program. The following sources of information will give a clear picture of the major literature search results that were used in the study.

- Airport Cooperative Research Program (2011). Federal Aviation Administration Airport Safety Management Systems Pilot Studies. The pilot studies gave an overview of what airports across United States have put in place as far as SMS implementation is concerned. It also involved responses by airport safety personnel about the costs associated with SMS implementation. This article will be used to ascertain the costs associated with implementing and maintaining SMS at airports. Each of the airports that participated in the pilot studies will be assessed on the number of SMS personnel required during and after the implementation of the program. This article also sought to ascertain whether airports that participated in the pilot studies sought services of an SMS consultant or used an internal SMS or safety personnel.
- American Pipeline Institute [API] (2015). This document summarized API Recommended Practice 1173. It is a framework designed to enable pipeline companies to implement SMS in the United States. It looked at the existing safety program and encourages operators to explore the possibilities of Pipeline SMS as a tool to identify and address safety issues in the industry.
- Andrew, W. E. (2013). This study focused mainly on the statistics and economics of railway safety in Great Britain, Japan, United States, Finland, and other European Union members. The study examined the various causes of railway accidents and how safety programs are appraised. It also highlighted how

deregulation affected railway safety performance verses a strong economic performance by the industry. Findings and recommendation from the study suggested the need for cost-benefit analysis in railway safety.

- Brian, J. & Tom, L. (2015). This peer-reviewed journal examined the effectiveness of layered security for the protection of the aviation industry against adversaries. The study further examined the effects of multiple layers of security by specifically exploring the net performance of security systems.
- Civil Aviation Safety Authority (2008). Regulation Impact Statement. This report gives an overview of the types of aviation firms that have implemented SMS. This report will be used to group all the firms based on level of income spent, size of the firm, and nature of staffing. The types of costs will be identified and business compliance cost analysis and Net Present Value calculations will be carried out.
- Civil Aviation Safety Authority [CASA] (2012). The Australian government and private sector players have been very creative with drafting and mandating SMS in the aviation industry. This article is an advisory circular to aviation operators and organizations. It highlighted an SMS case study of fictitious “Bush Air” and “Bush Maintenance.” It noted the costs associated with implementing and maintaining a safety program like SMS at company levels.
- Clinton, V.O., John, S.S., & Kurt, Z. (2013). This article reviews economic literature about aviation safety. It analyzed the commercial aviation safety record in United States and abroad. It also compared access to information among OECD member states and developing countries in an attempt to reach a reasonable

conclusion on why developing countries have poor aviation safety standards compared to developed countries.

- Damon, L., Eddie, C., Manoj, P., Rich, & Suzanne (2011). The Center for Aviation Safety Research at Saint Louis University is one of the research centers that has illustrated the need for a business case for safety programs. It specifically looked at returns on investment by examining micro and macroeconomic analysis of safety interventions in the aviation industry.
- Daniel, L.S. & David, S. (2012). The implementation of SMS in road transportation presents a tough challenge across borders. Countries across the world use different signage systems. The European, Asian, and American systems are completely different and these often confuse visiting drivers. This study highlighted the importance of a safety road network in economic growth. It also examined safety data between federal, tribal, and company authorities in United States as part of their partnership to save lives on the road.
- David, G. & William, M. (2015). This article provided an overview of economic issues related to costs, financing, pricing, and evaluation of aviation security program. This study was designed specifically to tackle the new security measures being implemented to counter dynamic threats facing the aviation industry.
- Edgar & Ingrid, (2014). This article articulates the Norwegian legislation for SMS in marine transportation, but specially to fishing fleets. Commercial fishing is considered a dangerous activity and even though there has been a reduction of the rate of loss of life at sea, the EU and Norwegian legislators have recommended

SMS as a tool to profile accident precursors in the industry. SMS legislation basically replaced risk management strategy that had been used by most EU members. This made developing cost structure for the SMS implementation extremely difficult. In the United States, the United States Coast Guard drafted the proposed Subchapter M which included Towing Safety Management System (TSMS). It estimated that the cost of implementing SMS depends on the size of the company, thus the number fleets owned by the companies. It states the small to medium size companies would incur costs of approximately $30,000 to $72,000 (Gary, 2012). This cost excludes the annual maintenance fees that the companies would incur as a result of SMS implementation.

- Edgar, M. & Ingrid, B. U. (2014). The fishing industry has had a long history of fatalities either because of weather or technical breakdown of vessels. This study looked at implementation of SMS in commercial fishing. The study looked at SMS as a tool that can be used to identify precursors to accidents. It noted that the implementation of SMS would propel positive safety performance onboard Norwegian fleets.
- El Miloudi, K. & Nathalie, D. (2006). The railway industry is one of the most intrinsic modes of transportation. It relies on interoperability among countries in the thematic network. Thus, most rail tracks have standard gauges that countries, within a block like the European Union, have to adopt. This is the same philosophy when trying to implement safety programs like SMS. This study

looked into the need for members in regional economic blocks to explore a uniform formula or directives for implementing SMS.

- Elvik, R. (2001). This study examined economic discussions on the applicability of CBA to road safety measures. It looked into the implications of some of the discussions. For example, CBA proposers argue that all economically relevant projects must be quantified. This is not always the case when implementing some safety programs for road users, due to the fact that it is extremely difficult to quantify the benefits of road safety programs.
- Elvik, R. (2003). Little research exists about CBA in road safety. This article focused on road safety in Norway and Sweden. The study revealed that the two countries established road safety programs based on CBA; thus, only safety programs whose benefits are higher than the costs are implemented. The study argued that the use of CBA ignored numerous variables required of a safety program, except for the costs and benefits that can be accrued as a result of the implementation of the program.
- Elvik, R. (2010). This study examined why setting priorities in a road safety program is essential in reducing accident rates. This article ascertained how effectively safety programs helped reduce accidents when a system of road safety pricing is used compared to when cost-benefit analysis is used. The study also found that CBA present ineffectiveness in implementing safety programs, since it eliminates expensive safety alternatives, thus cost effective safety programs are implemented regardless of their direct impact on the level of accidents.

- Ender, G. (2015). This qualitative study used responses from aviation maintenance organizations in Turkey. The aim of the study was to explore the challenges that maintenance stakeholders experienced in the implementation of safety management systems.
- European Railway Agency (2014). The significance of the railway industry in Europe can be noticed from the data on usage of the system. In fact, in Europe the railway industry is widely used for either transporting passengers or cargo. SMS has been a very instrumental tool in enhancing the safety of the railway industry among European Union (EU) members. In fact, the EU members use SMS as a proactive mechanism to identifying precursors to accidents. This article is an investigative study on railroad accidents and the impact of safety programs with specific attentions to SMS implementation among membered states.
- Ezra, H. (2011). This study on road safety illustrated that Cost-Benefit Analysis (CBA) as an economic tool lacks numerous variables. The study noted that CBA is based on estimates of statistical values of life and injuries. Secondly, CBA is based primarily on welfare economics, a rare circumstance in road safety. This means CBA seeks to identify the least cost-efficient method of improving road safety. Thus, it does not cater to the alternatives for a road safety program.
- Federal Aviation Administration (2015). The FAA has worked with Part 121 airlines on numerous extensions of the SMS mandate. This was primarily because of the lack of guiding principles and examples to follow on the implementation of SMS. In 2015, the FAA estimated the cost of implementing SMS to the airlines to

be approximately $224.3 million over a period of 10 years. The agency also estimates that the financial benefits the airlines will accrue from the investment ranges from $205 million to $472.3 million over a period of 10 years. This data will be used as an example of the feasibility of the financial benefits from SMS implementation.

- Federal Aviation Administration [FAA], (2014). This article gives an in-depth description of the major components of safety management systems. It heighted safety policy, risk management, safety assurance, and safety promotion. While this article presented a theoretical aspect of the benefits of safety structures. It is important to know each component of the safety program since any of the components may require designing separate costs structures, for example, developing software and the purchase of equipment for a safety program like SMS.
- Gary, E.E. (2012). This study gave a step-by-step breakdown of the cost of compliance. The study recognized firms in the maritime industry struggled to ensure compliance to the ISM Code mandate for implementation of SMS across the industry. This study was carried out to guide all towing vessels as part of the new regulation and requirement for certification of inspection. SMS was made part of this regulation under the ISM mandate.
- Government Accountability Office [GAO] (2014). This report to the Congressional Committees highlighted the need for SMS in commercial trucks and bus operation. The report suggests that SMS should be used to score risks in

road transportation. It is from the SMS scores that policy interventions are enacted. Although the report did not state the costs associated with implementing SMS, the impact of SMS is felt on both the business side and safety stand point. Thus, the cost of insurance, compensation, and property damages have declined due to SMS presence. On the other hand, reporting of accidents and incidents have increased subsequently, allowing policy makers to design safety programs to tackle threats or risks facing commercial trucking and bus companies.

- Government Accounting Office [GAO] (2006). This reactionary report assessed the significance of the Pipeline Safety Improvement Act of 2002. It explored the effects of integrity management system in promoting the report of threats in the pipeline industry. Reporting threats and incidents is a core part of the safety management system.
- Guy, K. & Haim, L. (2010). Behavioral economic studies have been used in major risk susceptible industries to analyze how negative sentiments affect asset pricing. This study examined the impact effect of aviation disasters on stock prices. The study further outlined the need for safety programs to avert risks to control volatility of stock markets resulting from perceived risks.
- Huan-Jyh, S. (2008). This study developed an analytic method that used data on accident and safety indicators to analyze aviation safety risks. Some of the data were gathered from flight safety management information system, a core tool used by SMS experts to audit safety programs.

- Joshua, L.V. Michael, L.L., Min, L.& Edward, J. (2013). This journal of construction study demonstrated the CBA of Construction Information Management Systems implementation (CIMSs). The study's main goal was to establish the costs and benefits of conducting a product- specific case study like safety of employees and the workplace. It also found that the use of mobile technologies increased efficiency while reducing clerical time on performing tasks. This study can easily be transferred to assess the CBA of SMS implementation in the transportation industry.
- Maritime New Zealand (2014). New Zealand has had a tough challenge coping with standards that stem from factors of geographical location and association with Australia. SMS is an operational phenomenon in Australia and as such, the ISM rules applies especially where vessels are crossing territories. Maritime New Zealand has mandated all fleet owners to implement SMS. This article breaks down the requirements for both commercial SOLAS and Non SOLAS vessels.
- Milan, J. & Fedja, N. (2008). This article reviewed research on risk and safety modelling in the civil aviation industry. The article focused on defining risk models and safety assessment among air traffic control. It used risk models and safety assessment to establish the emerging threats to the aviation industry.
- National Aeronautics and Space Administration [NASA] (2013). This investigative study carried out by the NASA safety center examined the casual factors to the North Sea Piper Alpha disaster in 1988. The study concluded that a broken chain of standard operating procedures and negligence caused this

accident. Recommendations were drawn from what the Piper Alpha company did in the aftermath of the accident. It became apparent that with SMS in place, the disaster would have been avoided.

- National Transportation Safety Board [NTSB] (2002). This accident report on a pipeline rupture in Bellingham, Washington by the NTSB broke down the sequence of events leading to the accident and established the recommendations both for federally owned and company owned pipelines. The report also broke down the cost of accidents accruing to property damages.
- Shreeve, C.M & Kelman, I. (2014). This study looked into Benefit-Cost-Ratio (BCR) as a component used while analyzing CBA in risk susceptible industries like nuclear plants, construction, oil, and the mining industry. BCR is an economic tool that helps policy makers in an attempt to demonstrate the benefits of Disaster Risk Reduction (DRR) versus the cost of implementing a safety program.
- The Occupational Safety and Health Administration [OSHA] & FAA Aviation Safety & Health Team, (2000). The FAA and OSHA have had years of conflicting approaches to enhancing safety. This article sheds light into the Memorandum of Understanding (MOU) between the FAA and OSHA to amicably solve employee-related safety issues in the aviation industry. The MOU outlined factors that fall under OSHA requirements for employees working in the aircraft without compromising aircraft or aviation safety.

- The Pipeline and Hazardous Materials Safety Administration [PHMSA] (2004). The continued occurrence of accidents across pipeline networks in the United States has prompted PHMSA to mandate all federal and private pipelines company to implement safety programs. One such program is SMS. This audit report to the Department of Transportation noted that from 1994 to 2003, fatalities from pipeline rupture was at a nearly record high. It also noted that with SMS implementation, over 20,000 integrity threats would be identified for immediate remediation. This showed the potential capability of SMS as part of the safety programs in the pipeline industry.
- Thomas, J. W., Marcus, G. W. & Dolruedee (2014). The airline industry is one of the most risk susceptible industries in transportation. Legal liabilities against airlines and aircraft have been a common part of their operation especially when disaster strikes. This article examined how these legal liabilities relating to disasters affect airline operation and financial market perspective.
- Thomas, M. J. W. (2011). This cross model research on the rail domain integrated numerous studies that focused on railway safety. The study found that SMS in the railway industry is very important since safety behaviors are influenced by the safety policy in place. It drew numerous examples from the implementation of SMS in the aviation industry.
- Thomas, M. J. W. (2011). This cross-model research also served as a report to ATSB on the effectiveness of SMS. The study reviewed other scholars' research on organizational approaches to safety structures, accountability, performance,

and procedures. The study included common identifiers like risk identification, monitoring, mitigation, and safety audit. These are common components of a successful safety management system.

- Transport Canada [TC] (2014). In 2001, the Railway Safety Act came into effect mandating all railroad companies to implement SMS as part of the effort to reduce accidents in the industry. Most railroad companies had to dedicate financial resources to meet the datelines set forth by TC. There were distinctively 28 federal railway companies and 35 local companies that were instantly affected by the regulation. The costs of implementation varied across the industry with the federal railways projected to incur about $13.8 million over a 10-year period, while local railway companies were estimated to incur about $9.9 million. These expenses stem from creating new safety positions, routine maintenance, and update of the SMS program.
- Transportation Safety Board of Canada [TSBC] (2015). This report is a highlight of the year 2014, when the Transportation Safety Board of Canada (TSBC) issued the regulations that changed the reporting of incidents in the pipeline industry. In fact, it established a live database on which operators would non-punitively report incidents. It also established that incident reporting increased significantly as accident occurrence decreased.
- Wong, S.C. & Sze, N.N. (2010). Quantifying safety programs has been the core of promoting safety in road transportation. This study revisited the effectiveness of attaching financial values to road safety among OECD membered states. The

study also evaluated quantified targets and fatalities. It basically examines the rate of accidents against the amount of money spent on implementing a road safety program.

Most of the literature selected therefore were “first cut” studies that demonstrated a CBA case in SMS implementation in the transportation industry (Thomas, 2011). The articles were further categorized as Practically Significant in SMS implementation (PSISMS) and Adapted in SMS implementation (AISMS). PSISMS articles categorized articles that support the notion of using CBA in developing a business case for and against SMS implementation. Meanwhile, AISMS categorized those articles used by industries in the completed SMS implementation. Table 3 shows the categorization of the literature of peer-reviewed and government articles that was used in this study.

Table 3 *Categorization of Literature Reviewed*

Industry	PSISMS	AISMS	Total	Percentage
Aviation	10	6	16	40
Road	3	4	7	17
Marine	3	1	4	10
Railway	2	3	5	13
Pipeline	3	3	6	15
Others	0	2	2	5
Total	21	19	40	100

The categorization of literature reviewed were graphically represented as shown in Figure 1.

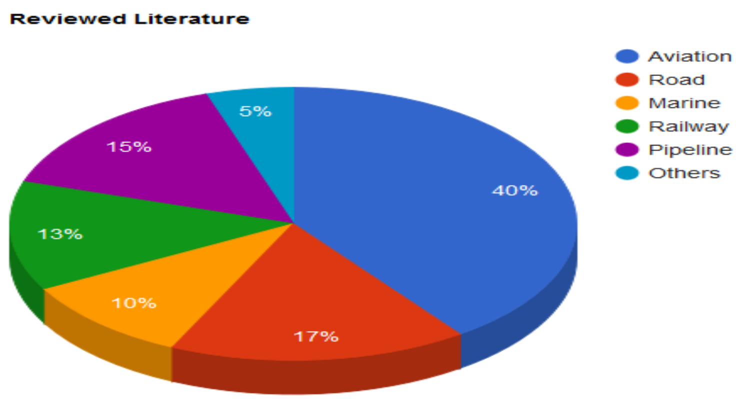

Figure 1. *A Pie Chart Representing the List of Literature Reviewed*

From Figure 1 above, it can be seen the majority of the literature analyzed in the study was from the aviation industry. Forty percent of the literature used to examine SMS implementation was from the aviation industry because the aviation industry has been at the forefront on the campaign for SMS implementation. A case-by-case evaluation of the SMS implementation articles across the transportation industry indicated SMS components were already existent in the aviation industry before regulatory agencies like FAA, CAA, TC ATSB, NTSB, and others started mandating SMS in other industries. Furthermore, there has been a proven track record of the effectiveness of the SMS implementation in the aviation industry (Thomas, 2011). Other transport industries have low reporting basically because of the absence of peer-reviewed articles on the topic of study. It is also important to note that, of the 40 pieces of literature utilized for the study, only 1 peer-reviewed article had a direct study with close relation to the topic of study.

CHAPTER III: DATA ANALYSIS

This chapter presents the results of the literature search and an analysis of the information obtained from the review of all the literature included in the study. The literature results were collected and processed in an attempt to solve the problems posed in chapter I of this thesis research project. There were two fundamental goals that propelled the search for literature and the subsequent data analysis of the information retrieved from the literature collected. These goals were developed based on the knowledge of the current demands and the regulatory mandates to implement safety management systems in the transportation industry. The goals were accomplished by reviewing scholarly articles and studies that focused on systematic analysis of the costs and benefits of implementing SMS in the transportation industry. The findings that are presented in this chapter represent the contributions of safety programs in the industry.

Literature Review and Data Analysis Strategy

The initial search yielded 109 articles. After a careful review, 40 articles which directly relate to the topic of study were selected. The assessment of each article's relevance to this study was tested based on whether some components of the study was related to the costs of SMS implementation, financial benefits, and the theoretical benefits (e.g. reduction in accident rates). Although there are numerous safety studies undertaken in the transportation industry, very few studies address the costs and benefits of implementing SMS and other safety programs as shown in Table 3. However, to better understand what this means, the various studies, based on their relevance to topic of study, are shown in Table 4 and Figure 2 below.

Table 4 *Literature Distribution*

Industry	Costs of Implementation	Financial benefits	Theoretical benefits	Related to SMS Implementation
Aviation	5	4	3	4
Road	0	1	2	4
Marine	1	0	2	1
Rail	1	1	3	0
Pipeline	0	1	3	2
Others	0	2	0	0
Total	7	9	13	11

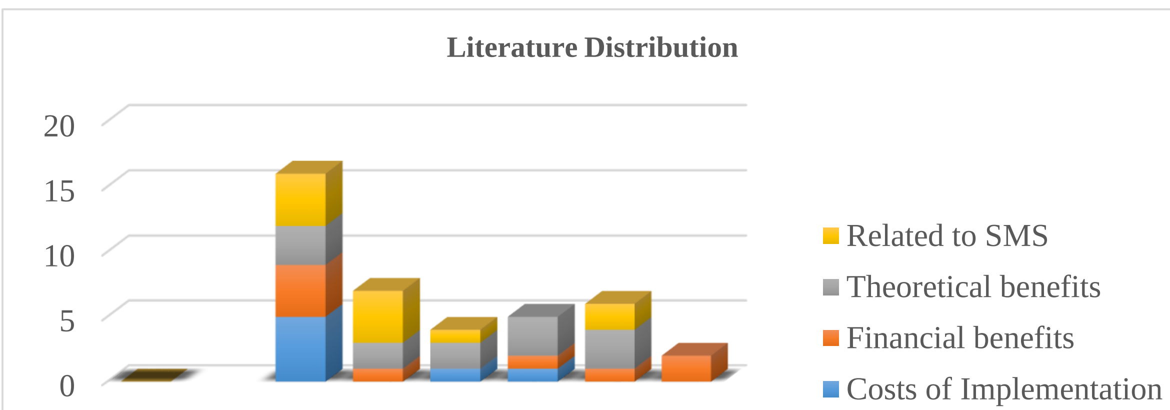

Figure 2. *Literature Distribution*

To better investigate the costs and benefits of implementing SMS in the transportation industry, all the articles used in the study are shown in Table 4. The results of the entries revealed that the aviation industry studies reported 5 studies that gave a breakdown of the costs that companies and agencies will accrue in the implementation and annual maintenance of SMS. The study of the aviation domain reported 4 articles that reflected financial benefits of SMS implementation in the aviation industry. Three of the literatures reviewed include arguments that are grouped as theoretical benefits. Four of the articles reviewed revealed some relevance to aviation safety and SMS in particular. In road transportation, zero studies of the articles reflected studies on the costs of SMS. One study showed financial benefits to implementation SMS program in the road domain. Two studies presented theoretical benefits to SMS; these mainly included reduction in accident rates and increased reporting of incidents among road users. Four studies on the road domain reflected some arguments that involved authorities performing economic analysis of safety programs in the road industry. The maritime and railway domain each had 1 study that reflected the costs of SMS. None of the studies selected addressed the Cost of SMS, financial benefits in the maritime, and railway industry respectively. The studies in the pipeline industry yielded zero studies related to the cost of SMS, with 1, 3 and 2 studies demonstrating financial, theoretical and closely related studies to SMS respectively. Other industry studies showed zero, two, zero and zero studies related to costs, financial benefits, theoretical benefits and closely related studies to SMS respectively.

Following the data entries in Table 4, the next step in data analysis involved two sections of the data entries, the costs and financial benefits. This section of the data analysis compared the costs and benefits of SMS and other safety programs shown in Table 4. The costs of SMS implementation from each transportation mode is analyzed separately. In cases where a transport mode is divided into different sectors, the costs of

SMS implementation were analyzed differently. For example, the costs of SMS implementation in the aviation industry were different across sectors like airports, airlines, and air traffic control. The estimated cost and benefit structures of SMS implementation are shown in Table 5 (Federal Aviation Administration, 2015).

The costs in the airline sector are estimated by the FAA for implementation SMS based on the study of 90 Part 121 airlines. Significant among the expenses accrued were the cost of labor, estimated to be approximately $41,925,498 over a 3-year period. The cost of research and documenting SMS was estimated to be $17,766,000. The cost for updating existing programs like ASAP is $3,854,888, with the federal government cost of web-based application tool (WBAT) estimated to be $2,600,000 annual (Federal Aviation Administration, 2015). The costs of implementing, developing and maintaining SMS at airlines presents tough financial decisions. The FAA estimated the benefits from this investment were projected to be between $104.9 and $241.9 million on a 7% discount rate. These returns on initial and maintenance cost of SMS do not reflect the returns on individual costs of implementing and developing SMS parts and components

Table 5 *The Cost of Implementing SMS in 90 Part 121 Airlines* – FAA

SMS Items	Cost of SMS Items
A) Implementation Costs	
Research, develop and Document SMS	$55,691,498
Cost of expanding existing program (ASAP, LOSA & FOQA	$3,854,888
Total Cost of SMS Implementation	$59, 546,386
B) Annual Costs	
Staffing and Promotional Material	$8,255,274
ASAPs 1-10 Years	$1,928,408
SMS Quality Manual Updates 1-10 years	$1,655,000
Estimated Total Cost per year	$11,838,682
C) Additional cost Federal Government Cost of Web Based Aviation Technology (WBAT) 1-10 years	$ 2.6. million
Total Over 10 years	$26. million
Estimated Total cost of SMS and its Burden over Time for 90 Airlines	$ 135.1. million
Estimated Benefits from SMS Implementation (Base year 2010, Discounted at 7%)	$104.9 – $241.9. million

The Australian Transportation Safety Board estimated the initial cost implementation for each small Australian aviation company to be $25,000 for development and $16,000 for maintaining the SMS program as shown in Table 6. These estimates were for small aviation companies and general aviation operators (Australian Safety Transportation Board, 2011). It did not include medium and large companies. Also, the study did not break down the cost of the individual aspect of SMS that is implemented. It therefore, relied on estimation for a small sized company.

Table 6 *SMS Implementation for Australian Aviation Companies* - ATSB

SMS ITEM	COST
Developing SMS	$25,000
Annual Maintenance	$16,000

To quantify the benefits from implementing SMS in small airlines in Australia, the ATSB estimated benefits based on the direct and indirect costs associated with accidents. Employing SMS as a safety tool, allows identification of potential precursors to accidents. When an accident occurs, the airline may lose the whole aircraft hull, or will at a minimum have to repair some parts. ATSB estimates that the cost of an engine overhaul for a small airline to be $17,500 as shown in Table 7. The company would save $17,500 for a typical accident as a result of employing SMS (Australian Safety Transportation

Board, 2011). These estimates maybe more or less depending on the size of the aircraft and airline.

Table 7 *Direct and Indirect Cost of Accidents* - Australian Transportation Safety Board

Direct Cost		Indirect Cost
Engine Strips and overhaul	$17,500	Compensation for damages, clean up, increased insurance premiums etc.
Recovery and Clean of Aircraft	$200,000	

The cost for implementing SMS in each segment of the aviation industry has also been estimated by CASA. These estimates are not the exact costs; they may be underestimated or over stated. Furthermore, the costs of SMS in each segment (Tables 8, 9 & 10) represents the costs accrued on training, CRM, human factor, documentation, and other overhead costs. It is important to note the differences in costs across the three segments; thus small and medium sized businesses experience the largest amount of expenses in the implementation process. This is due to the fact that most of the companies did not exhibit any form of SMS previously in place. Meanwhile, large businesses experienced the least amount of expenses in the formal implementation of SMS. Large businesses in Australia have been operating with SMS-related safety measures for some time, and CRM and human factors training have all been core parts of airline operation (Civil Aviation Safety Authority, 2012).

Table 8 *SMS Implementation in Small Business* - CASA

SMS Task	Hour	Amounts	Times	Persons	Amount for set-up cost	Amount for on-going cost
Project Mgt	3	$0	4	0	$16,988	$0
Gap Analysis	8	$0	1	0	$15,682	$0
SMS submission for CASA Approval	8	$0	1	0	$11,326	$0
SMS infrastructure	9	$0	12	0	$0	$93,436
Safety staffing	0	$0	12	0	$0	$0
SMS Quality Manual	0	$500	1	0	$5,500	$0
Document Mgt	0	$500	1	0	$5,500	$0
Hazard Identification	0	$500	1	0	$5,500	$0
Hazard ID	10		12	0		$103,818
Internal safety Investigation	0	$500	1	0	$5,500	$0
Internal safety investigation	5	$0	12	0	$0	$51,909
SMS Training	0	$500	0	25	$137,500	$0
HF Training	0	$400	0	55	$242,000	$0

Table 8 (Cont.)

CRM Training	0	$300	0	45	$148,500	$0
Temporary Employee Training	0	$300	0	95	$313,500	$0
SMS Audit	6	$0	4	0	$00	$20,764
Total Cost	0	$0	0	0	$445,496	$269,927
Cost Per Operator	0	$0	0	0	$24,750	$14,996

Table 9. *SMS Implementation in Medium Business* - CASA

SMS Task	Hour	Amounts	Times	Persons	Amount for set-up cost	Amount for on-going cost
Project Mgt	4	$0	4	0	$18,973	$0
Gap Analysis	8	$0	1	0	$9,486	$0
Submission to CASA	12	$0	1	0	$14,230	$0
SMS infrastructure	9	$0	12	0	$0	$73,181
Safety staffing	80	$0	12	0	$0	$960
SMS Quality Manual	0	$1000	1	0	$8,000	$0
Document Mgt	0	$1000	1	0	$8,000	$0
Hazard Identification	0	$1000	1	0	$11,000	$0

Table 9 (Cont.)

Hazard ID	30	$0	12	0	$0	$30,492
Internal safety Investigation	0	$2000	1	0	$16,000	$0
Internal safety investigation	100	$0	1	0	$0	$8,470
SMS Training	0	$600	0	25	$15,000	$0
SMS Training	0	$100	0	35		$3,500
Human Factor Training	0	$600	0	65	$39,000	$0
CRM Training	0	$600	0	25	$15,000	$0
Temporary Employee Training	0	$600	0	65	$312,000	$0
SMS Audit	6	$0	6	0		$24,394
Total Cost	0	$0	0	0	$466,489	$140,996
Cost Per Operator	0	$0	0	0	$33,335	$17,625

Table 10 *SMS Implementation in Large Business* - CASA

SMS Task	Hour	Amounts	Times	Persons	Amount for set-up cost	Amount for on-going cost
Project Mgt	4	$0	3	0	$6,534	$0
Gap Analysis	30	$0	1	0	$16,335	$0
SMS Submission for CASA Approval	24	$0	1	0	$13,068	$0
SMS infrastructure	0	$0	0	0	$0	$0
Safety staffing	0	$0	0	0	$0	$0
SMS Quality Manual	0	$5000	1	0	$5,000	$0
Document Mgt	0	$0	1	0	$0	$0
Hazard Identification	0	$0	1	0	$0	$0
Hazard ID	0	$0	0	0	$0	$0
Internal safety Investigation	0	$0	0	0	$0	$0
Internal safety investigation	0	$0	0	0	$0	$0
SMS Training	0	$600	0	0	$0	$0
SMS Training	0	$100	0	0	$0	$0

Table 10 (Cont.)

HF Training	0	$600	0	0	$0	$0
CRM Training	0	$600	0	0	$0	$0
Temporary Employee Training	0	$600	0	0	$0	$0
SMS Audit	0	$0	0	0	$0	$0
Total Cost	0	$0	0	0	$40,937	$0
Cost Per Operator	0	$0	0	0	$40,937	$0

Determining the benefits from the implementation of SMS in aviation businesses, presents a challenge due to the fact that is not easy to quantify safety programs. CASA estimated the benefits of SMS based on the amount that would have been spent on paying damages from accidents, aircraft recovery costs, workplace accident costs, and hikes in insurance. Furthermore, the effectiveness of SMS is estimated to be 50%, this stem from the fact that mandating alternative safety options other than SMS through regulations to regular public transport operators is difficult due to the fact that companies already have existing components of SMS whose reliability rates have easily been ascertained. As shown in Table 11, SMS works as a precursor to identify potential hazards that may cause accidents and incidents. As a result, when those accidents are avoided, companies save funds equal to the costs of the accident (Civil Aviation Safety Authority, 2012).

Table 11 *Benefits of Implementing SMS in Aviation Businesses* - CASA

Aircraft & Component Damage Cost	
Number of incidents involving aircraft damage (2003)	255
Number of incidents involving aircraft damage (RPT)	80
RPT Proportion in damage incidents	31.37%
Cost of servicing RPT aircraft damage	$75,000
Cost of aircraft downtime (average 4hours) $2000/hr.	$320,000
Cost of aircraft damage (prevent 40%)	$2,720,000
Annual value of benefit from reduction of aircraft damage	$,720,0000
Aircraft Recovery Cost	
Number of RPT aircraft recoveries over 10 years	4
Cost of aircraft recovery for turboprop	$200,000
Savings assuming 40% reduction	$32,000
Annual value of benefit from reduction in aircraft recoveries	$32,000
Workplace Accidents	
Number of aviation industry personnel	30,000
Average number of injuries in workplace - 2.1%	1.00%
Cost of workplace injury	$30,000
Cost of workplace accidents	$9,000,000
Annual value of benefit from reduction of workplace accidents	$3,600,000

Table 11 (Cont.)

Insurance Premiums	
Value of assets insured (million)	$35,000
Insurance premium @0.25% of asset value	$88
Savings in premium - 5%	$4
Annual value of benefit from reduction in insurance premiums	$4,380,000
Total value of benefits from adoption of SMS	$4,129,000
Effectiveness of SMS	50%
Adjusted value of benefits	$2,064,500

The implementation of SMS involves updating and reviewing safety programs, and the costs involved may include hiring a full-time SMS analyst, training of airports employees, and tenants. As an example, the implementation of SMS at North Las Vegas Airport (VGT) required designating 30 classes with 15 employees per class. Overall, the training consumed 3,600 man hours. The cost per employee attending training was $6,720 (Airport Cooperative Research Program, 2011). The pilot study did not reveal any quantified financial benefits of SMS implementation but noted that SMS is likely to detect and correct problems before they become accidents as shown in Table 12.

Table 12 *The Implementation of SMS in the Airport Sector* - ACRP

SMS ITEM	COST OF SMS IMPLEMENTATION
SMS Analyst (One full-time position)	$84,460
Annual Training of 420 employees	$57,120
Training Airport Tenants	$50,400
Total cost of labor	(84,460+57,120)-------------- $141,580

Flight Operations Quality Assurance (FOQA) has been a crucial safety instrument in the aviation industry. The GAO in its report estimated that the cost of implementing SMS is approximately the same as the cost of implementing FOQA, even though FOQA is one aspect of a functional SMS program. Therefore, implementing an SMS program would exhibit the same cost trends. For example, the number of aircraft that a company owns and the size of the company will directly impact the cost of SMS implementation. From the GAO 2014 report, it was estimated that a company with 15 aircraft would experience an annual cost of $483,500, a company with 50 aircraft would spend $759,000, and those with 100 aircraft or more would experience about $1,267,000 in expenses annually for implementing and maintaining a program like SMS (GAO, 2014).

Table 13 *FOQA and SMS Implementation* - Government Accountability Office

FOQA ITEMS	15 aircraft	50 aircraft	100 aircraft
Equipment costs	$98,500	$259,000	$492,000
Personnel costs	$385,000	$500,000	$775,000
Total annual costs	$483,500	$759,000	$$1,267,000
Cost Savings			
Fuel savings	$145,800	$486,000	$972,000
Engine savings	$300,000	$1,000,000	$2,000,000
Safety Savings	$49,500	$165,000	$330,000
Total annual savings	$495,300	$1,651,000	$3,302,000
Total Annual Savings	$495,300	$ 1,651,000	$3,302,000
Total annual costs	$483,500	$759,000	$1,267,000
Net Annual Savings	$11,800	$892,000	$2,035,000

The benefits of implementing FOQA was calculated based the number of aircraft owned, amount fuel saved, engine savings (repair), and overall safety savings. As shown in the Table 13, the net benefit is the difference between the total annual savings and total annual costs. The benefits and costs of SMS in the report to the US Congressional committee did not include other variables beyond FOQA requirements. SMS requirements may be above the costs of FOQA components. These differences may either make the costs or benefits overstated or understated, respectively.

Transport Canada has provided guidelines across the transportation industry on the implementation of SMS. The breakdown of costs in Table 14, is an example of the costs that companies will incur as a result of electing to implement SMS. Most of the cost in the railway domain came from the compliance cost, meaning the certification and updating SMS individual parts to meet the requirements set by Transport Canada (Transport Canada, 2014).

Table 14 *SMS Implementation in the Railway Domain* - Transport Canada

SMS Items for Small railway companies	Annualized Average ($ 2012)	Present Value ($ 2012)	Annualized Average ($ 2012)	Present Value ($ 2012)
Compliance costs	$48,433	$340,173	$28,754	$201,953
Administrative costs	$44	$308	$44	$308
Total costs	$48,477	$340,480	$28,797	$202,260
Average cost per small business	$8,079	$56,747	$4,800	$33,710

The cost-benefit statement in Table 15 below, reflects the initial SMS burdens that companies and federal authorities face. It is important to note that these are a one-time cost, yet they will eliminate safety problems in the future. Companies and government organizations will benefit in the long run as accidents and incidents are reduced. Therefore, the funds that would be used for repair and to settle injury and accident claims, are saved by the companies. The average industry burden was estimated to be $4,324,537. This investment has a total present value $26,803,934 based on 2015 estimates (Transport Canada, 2014).

Table 15 *Benefits of Implementing SMS in the Railway Domain* - Transport Canada

Cost-benefit statement	Base Year (2015)	2019	Final Year (2024)	Total (PV)	Annualized Cost
Federal railway companies	$2,373,390	$1,903,881	$1,906,880	$13,818,211	$1,967,402
Local railway companies on federal main track	$1,250,178	$1,434,123	$1,436,050	$9,905,494	$1,410,320
Local railway companies on federal non-main track	$700,970	$398,278	$398,278	$3,080,228	$438,555
Industry total	$4,324,537	$3,736,282	$3,741,208	$26,803,934	$3,816,277

The cost for SMS implementation in local railway companies is estimated to be $9.9 million. Using the cost-benefit statement in Table 15 and with 2015 base year values, the $9.9 million translated into an annualized value of $1.4 million. The overall industry cost for non-federal track was estimated to be $3.1 million with an annualized value of $438,000. This means the total cost over a 10-year period has a present value of $26.8 million. Because it is difficult to trace the exact monetarized benefits that can be got from the expenditure, the benefits from these expenditures are qualitative in nature (Transport Canada, 2014).

The cost of SMS implementation in marine transportation has brought some rather interesting discussions among scholars. The cost breakdown in Table 16 represents what vessel owners and companies should expect in the implementation process of SMS. The costs of SMS development were fairly low in the marine industry because companies are simply upgrading from existing sister safety programs, for example risk management systems (RMS). RMS exhibit components that are similar to SMS, and as such firms that had RMS are simply upgrading their safety programs (Gary, 2012).

Table 16 *SMS Implementation in Marine Transportation* – Gary (2012)

Cost Element	Estimated Potential Cost
SMS Development	$750 - $70,000 (one-time cost)
SMS Initial Implementation (One-time cost)	$311,000
SMS Annual Maintenance	$2.5 million
Internal Audit	$5000-$18,000 per audit
External Audit	$750 - $6000 per audit
Total	$2,817,500 - $2,905,000

Most of the assumed benefits from the implementation of SMS are derived from the fact that accidents will be reduced. The European Railway Agency, which uses SMS to identify potential threats, has seen an increase in the number of threats reported along with a decrease in accidents as shown in Table 17 below.

Table 17 *Impact of SMS in Railway Transportation* - European Railway Agency

Year of Reporting	National Safety Authority		Notification for Open Investigation
	Significant Accident	Precursor Reported	
2009	2739	9304	173
2010	2249	10339	219
2011	2187	9618	249
2012	2026	11541	233
2013	N/A	N/A	N/A

It can also be seen from the table 17, that as the number of reported precursors to potential accidents increases, the number of significant accidents were reduced. It therefore appears that the reporting of incidents as a core part of SMS has a negative relation with accident occurrence. Thus, the higher the number of incidents reported the lower the number accidents (European Railway Agency, 2014).

CHAPTER IV: DISCUSSION

The main goal of this thesis project, as established in the three research questions outlined in chapter I, was to ascertain whether there is a business case for implementation SMS in the transportation industry. After the literature categorization and data analysis, it has been determined that while many scholars exhibit opposing views about a business case for SMS implementation in the transportation industry, there is a general consensus that SMS will not only reshape the safety cultures of companies, and agencies but also improve the performance of safety programs.

In regards to the level of expenditures that companies and agencies have experienced, this study reviewed numerous studies by scholars in the transportation industry. The aviation domain has experienced a significant amount of expenses relating to SMS implementation. Most of the articles selected for this study estimated the cost of implementing and maintaining SMS based on the size of the company, number of aircraft owned and the number of employees in the company. The Civil Aviation Safety Authority (CASA) study estimated that small, medium, and large businesses would encounter annual cost of approximately $445,496, $466,489, and $40,937 respectively. Small to medium sized companies are estimated to bare the heaviest burdens of SMS implementation. This is due to the fact that most of the small and medium companies lack existing safety programs related to SMS that large companies already have in place.

The cost of maintaining SMS also varies significantly depending on the size of the business. Small and medium companies are projected to accrue an annual cost of $269,927 and $140,996 respectively. Large businesses are estimated to experience zero annual maintenance costs as shown in Table 10. This is because unlike in small and medium sized businesses, large businesses will integrate SMS as part of safety programs that are already being run by fully staffed safety departments. Furthermore, the Federal Aviation Administration (FAA) estimated that 90 airlines across the United States would experience approximately $135,100,000 over 10 years, this also represents about $1,501,111 per airline in implementation costs of SMS. The Australian Transportation Safety Board, on the other hand, noted in a case study on small aviation companies, that a company spent about $25,000 on SMS development and $16,000 on maintaining the program.

In the railway domain, the implementation of SMS continues to receive significant studies about the cost associated with the SMS program. Transport Canada, in a regulatory statement to railway companies, noted that the initial implementation of SMS would cost $2,373,390 for federal railway companies and $48,477 for small private companies. In the marine industry, the United States Coast Guard, through the Coast Guard and Maritime Transportation Act of 2004, estimated that depending on the number of fleets, vessel owners and companies would incur costs ranging between $2,817,500 and $2,905,000 as shown in Table 17.

The first research question asked “What level of expenditures has been experienced by companies or agencies that have implemented SMS?” Based on the reviews of various studies, there is a lack of clarity in the cost of implementing SMS. Most of the articles selected for this study revealed costs and expenditures based on estimates. Furthermore, the articles did not represent the entire transportation industry.

Only 5 aviation articles, 1 railway article, and 1 marine transportation article actually revealed estimated expenditures for SMS. In as much as transportation companies will likely incur some expenses in undertaking the SMS venture, this study cannot conclude what those estimated expenses are from the few studies currently available.

The next research question asked “What cost savings have been experienced by firms or agencies that have implemented SMS?” Several articles from scholars were used to answer this question. Most of the scholars seem to agree that SMS will not just improve the safety performance of transportation companies, but also reduce unnecessary expenses resulting from potential accidents. Most of the discussions are centered on the idea that SMS will serve as an identifier to precursors of potential accidents. It is estimated that the transportation industry will be able save money that would otherwise be used to repair engines, clean up accident scenes, and meet legal compensation claims after accidents.

A review of studies across the transportation industry did not reveal a direct cost savings that can be traced to SMS implementation. Therefore, in regards to the research question, it was determined that there is no direct cost saving related to SMS implementation. In fact, the cost savings that scholars argue about has been used to motivate the implementation of SMS, and for the sale of various components of SMS. This mean none of the studies justified SMS as a direct cost saving device. However, a close examination of the cost of accidents among U.S airlines between 1970 and 1984 has shown that on average about $363,000 was received in compensation for an air crash involving many passengers. It is also estimated that U.S airlines paid about $72,000 in legal fees and expenses. These expenses excluded the cost of hulling aircraft parts like engines and cleaning accident scenes. It is from these expenses that a functional SMS program would help in identifying potential causes of accidents, thus the cost savings are realized when accidents are avoided (CASA, 2012).

The final research asked, “From a financial standpoint, are the returns from SMS expenditures adequate to justify the investment?” The study revealed that it is difficult to quantify direct returns from the implementation of SMS in the transportation industry. In fact, both the FAA and CASA used net present value, an economic tool that creates value for investments, but net present value requires guesswork about the cost of a company’s capital. This guesswork may not reflect the actual cost of implementing a program like SMS. A synthesis of the results of this study would suggest that the financial returns from SMS implementation may not lie in the specific components and parts of SMS implemented, but rather in hidden sophistication and economic estimations based on accidents avoided due to enhanced safety procedures. In fact, the estimation of the cost of accidents by Boeing company has shown that the cost of repairing an aircraft after an accident exceeded the cost of a new aircraft in production by 50%. When the cost of compensation and other claims are added to regular company expenditures, it pushes the companies towards bankruptcy (Boeing, 2014). Therefore, even though the investment on SMS implementation may not directly yield financial benefits, companies and agencies benefit significantly when SMS as safety tool is used to identify precursors to potentially costly accidents. In regards to the research question, even though there have been no direct financial returns experienced by companies in the transportation industry to make the investment justifiable, the cost-savings from accidents related to repairing the aircraft, legal expenses, and compensation makes SMS exhibit some business related benefits.

Overall, the study found that there is lack of clarity in associating the costs of implementing SMS to the direct benefits resulting from the implementation of SMS in the transportation industry. Very few studies could speak directly to the costs and benefits of implementing SMS in the transportation industry. Most of the cost saving arguments were used to motivate policymakers and companies top management employees to adhere to the new compliance of SMS. Therefore, this made it very difficult to determine the potential for a business case for SMS implementation. However, when companies weigh the cost of SMS implementation compared to cost of accidents and related claims, it is clear that SMS can help companies identify potential safety glitches.

Recommendations

While the findings of this study may shed a little light on a business case for SMS implementation, most regulatory frameworks related to SMS implementation in the transportation industry are in line with internationally recommended best practices. Even though the implementation of safety management systems in the transportation industry is receiving a high level of success and is mandated, each individual transportation industry is still struggling to ascertain whether there is a business case for the implementation of SMS. Numerous studies have used estimates to assign costs to the implementation of SMS in the various transportation sectors. For this reason it is recommended that policymakers and companies clearly define the cost of each component and part of SMS implemented. Furthermore, companies and agencies should also trace the returns on expenses spent on implementing components or parts of SMS in the transport sector. This will help in eliminating the doubt that the estimated costs and benefits are being used to motivate company and agency authorities to positively respond to SMS implementation.

Limitations

It is imperative to note that companies and agencies will experience some costs and some potential benefits SMS. This study is concluding that there is not a strong business case for SMS implementation in the transportation industry, but rather, the implementation of SMS is just an accumulation of a wide range of safety interventions that will see some level of costs with the potential benefit of accident prevention. And while this study is non-conclusive, it focused mainly on qualitative studies that looked at the costs and benefits of implementing SMS in the transportation industry. This posed a limitation when trying to ascertained quantified financial benefits of SMS.

While the reliance on purely qualitative studies and evidences give a direct look at what the transportation industry is doing in terms of SMS implementation, it has been criticized by scholars for generating and adopting a highly opinionated approach to research. To strengthen the research on SMS implementation, both qualitative and quantitative research needs to be carried out to determine the possibility of a business case for SMS implementation. Therefore, the limited access to direct and exact costs and benefits of implementing SMS in the transportation industry limited making a conclusion on whether there is or there is not a business case for SMS across the transportation industry.

Another limitation of the research was the use of the transportation industry as whole. It became clear that the transportation industry as whole is too broad to be assessed in a single study. Furthermore, the complex operating environment across the transportation industry does not require generalization and assumptions. Each transport sector exhibits intrinsic approaches to implementing safety programs. This study treated all the transport sectors as homogenous, and this limited the ability to obtain specific costs and benefits for specific SMS components peculiar to a particular transport sector.

Lastly, this study used the methodology of reviewing literature from other studies. The problem with this approach in a study like the cost-benefit analysis of SMS implementation is that the literature is limited to support this kind of study. This is primarily because SMS is a new concept and not much research has been done on it. Furthermore, study was limited to peer-reviewed and agency authored articles. Unfortunately, most of the articles reviewed did not include financial reports from transport companies. This lack of financial reports subsequently eliminated data regarding company's exact expenses, savings, and profits from the implementation of SMS in the transportation.

Future Studies

This study has opened up the potential for numerous future studies and investigations into the subject matter. The costs and benefits of implementing a SMS is not only a process of proving a business case for the safety program, but also a step toward encouraging companies to look at the safety mandates not as extensions of regulatory measures but as a business opportunity. A future study on the same topic should explore using financial reports since those are an accurate reflection of expenditures and benefits that companies experience. Another related study should consider limiting the scope of the study to only a specific sector of the transportation industry, for example the aviation, railway, or even the pipeline industry. It would be interesting to look at the costs and benefits from each transportation sector standpoint rather than industry wide approach.

Conclusion

In conclusion, this research not only provide support for the FAA's definition of SMS, but also opened up opportunities for further discussions about the potential of establishing a business case for SMS and other safety programs. The scholarly articles reviewed provided some benchmarks as far as the costs and benefits of SMS are concerned. In most cases, scholars and agencies were able to establish the costs of implementing and maintaining SMS in the transportation industry. Even though the costs were easily established, it became apparent that the benefits of SMS were not easily quantified as the scholarly articles noted that companies and agencies will experience benefits in the form of money saved from the cost of accident. Thus, when an accident occurs the company has to clean the accident scene, repair damaged equipment, and claims from customers and passengers for injuries and goods damaged during an accident. The lack of actual financial reports from companies made it really difficult to reach a substantive conclusion on whether there is a business case for SMS implementation in the transportation industry. This study also generalized the transportation industry. This ignored the complex characteristics of each transportation sector. The results of findings from this study suggest that a sector specific analysis would be able to capture the direct costs and benefits associated with the implementation of SMS and any other safety program.

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