Impact of Risk Management on Project Cost: An Industry Comparison

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Abstract

Project Risk Management strives to increase the frequency and effect of positive events and decrease that of negative events. Project Cost Management includes planning, estimating, budgeting, financing, funding, managing, and controlling costs to close the project within the plan. The reason for the Impact of Risk Management on Project Cost: An Industry Comparison study is to identify and detail risk management impact on cost in projects with examples from the healthcare, construction, military logistics/acquisitions, and NASA industries. We have identified an opportunity to show different points of view and guide the reader through the maze of available information regarding the state of the art in risk management planning, identification, analysis, response planning, and controlling risk; and in the ways these processes alter cost on projects. The environment that affects this opportunity limits the research by the time available leading up to the due date and the sensitivity of information specific to interviewees', survey respondents', and the co-authors' current and former employers. The study found that risk management minimizes project cost increases, limits cost, and usually reduces cost; that cost in turn drives risk management; and that research on the impact varies by industry. Further study is needed on the impact in the healthcare industry. We recommend that risk management be estimated and funded; that its impact be scaled relative to project cost; and that cost-risk analyses include the cost of managing risk; cost of issues resulting from risk; and value of issues avoided.

Keywords: Project Management, Project Cost, Risk Management, Project Management Body of Knowledge, Project Management Institute (PMI)

Introduction

The objective of this study is to identify and detail risk management impact on cost in projects. The scope of work includes the healthcare, construction, military logistics/acquisitions, and National Aeronautics and Space Administration (NASA) industries. The research was limited by the sensitivity of information specific to interviewees', survey respondents', and the co-authors' current and former employers. The methodology of the research included benchmarking an international standard on project management, U.S. Government handbooks and guides, a major reference text, and journal articles. The primary research consisted of qualitative interviews of

Project Risk Management and Project Cost Management experts, a qualitative/quantitative survey of project cost practitioners, and our professional observations.

Literature Review

This study consulted an international standard written on project management, Project Risk Management, and project cost, *A Guide to the Project Management Body of Knowledge*, as well as a Department of Defense (DoD) handbook on acquisition and a Government Accounting Office (GAO) cost estimating guide. It captured Project Risk Management best practices and lessons learned from a major reference text, two NASA handbooks, and four professional journal articles. It also drew from four qualitative interviews of Project Risk Management and Project Cost Management experts, a qualitative/quantitative survey (Appendix A) of project cost practitioners, and our professional observations. Consulting the literature, we discovered that research varies on the impact of risk management on project cost (corroborated by Interviews, Appendix B). Due to the diversity of the healthcare, construction, military logistics/acquisitions, and NASA industries and the cause-and-effect of risk and impacts, there is no one document of research on risk and cost across these industries.

For example, the effect that risk management has on the cost of projects in the healthcare industry is not well studied. According to James Byrd (2013), financial markets are not sensitive to hospital mortality rates. Although a correlation between lower mortality scores and lower interest rates was expected, Byrd found that lenders and rating agencies neither reward nor penalize hospitals for their reported quality scores. Byrd hypothesized that there are three possible explanations for this finding: that lenders and rating agencies do not perceive a variance in quality scores amongst hospitals applying for loans, that quality scores do not influence consumers' hospital selection, or that hospitals' decisions to improve quality of care are driven by the need to meet regulatory compliance instead of the potential for financial benefits. The National Health Service (NHS), Great Britain's single-payer healthcare system, has been plagued with adverse events, which cost approximately £ 2 billion per year (Emslie, Knox, & Pickstone, 2002). These adverse events include hospital readmissions, medical errors and negligence, and hospital-acquired infections. In an attempt to prevent harm and improve patient outcomes, the NHS has implemented the National Patient Safety Agenda (NPSA), which is intended to collect and analyze information from adverse events. Although the NPSA has been in effect for over ten years, there is no publicly available financial impact report, so the overall financial impact of risk management activity is not known.

Research regarding risk management and project cost in the construction industry revealed several books that define theoretical impacts of risks based on lessons learned (e.g., construction management, contract management, sureties, risk management). Preventative regulations approved by industry experts and government agencies dictate basic levels of risk evaluation (e.g., construction laws, Occupational Safety and Health Administration (OSHA), National Association of Home Builders, Associated General Contractors of America, and American Institute of Steel Construction). Legal complexities based on territorial jurisdiction provide basic understanding of the levels of liability or indemnity within contract documents (e.g., builders risk, bonds, and comprehensive general liability insurance).

Literature on risk management and project cost in military logistics/acquisitions includes textbooks, guides, and directives. As a service branch within DoD, Marine Corps risk management practitioners defer to both DoD and Marine Corps directives. The *Department of Defense Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs* applies DoD risk management processes to cost risk. Among the Department of Defense Instructions (DoDI's) most applicable to the impact of risk management on project cost is the *Operation of the Defense Acquisition System* (DoDI 5000.02). *Risk Management* (Marine Corps Order 3500.27C) applies Marine Corps risk management principles to risk factors including cost.

NASA documentation of the impact of risk management on project cost includes journal articles and a risk management guide, but the most comprehensive direction appears in a cost guide. While NASA has become one of the world's most mature organizations in terms of project management, the *NASA Risk Management Handbook* is written to apply to various risk-impacted processes and includes little application directly to the management of project cost. The *NASA Cost Estimating Handbook*, on the other hand, provides the NASA "decision maker with a clear understanding of the cost risk inherent in the project, cost of alternatives within the project, and information to make resource allocation decisions" (NASA, 2015, p. 1).

Methodology

The methodology of the secondary research included benchmarking an international standard on project management, reviewing U.S. Government handbooks and guides, a major reference text, and journal articles. The primary research consisted of qualitative interviews of Project Risk Management and Project Cost Management experts, a qualitative/quantitative survey of project cost practitioners, and the co-authors' professional observations.

Description and Analysis of Project

Project Risk Management intends to "increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project" (PMI, 2013, p. 309), including project cost. "Project Cost Management includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget" (PMI, 2013, p. 193). The following paragraphs detail risk management impact on cost in projects with examples from the healthcare, construction, military logistics/acquisitions, and NASA industries (Table 1)

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Table 1. Impact of Risk Management (RM) on Project Cost

Industry	Impact on Project Cost
Healthcare	**(RM is not yet a mature process.)**
Construction	**RM increases cost due to risk mitigation analyses and risk impacts.**
Military Logistics/Acquisitions	**RM determines if cost will allow a project to continue.**
NASA	**RM minimizes cost increases, limits cost, and usually reduces cost.**

4.1 Risk Management and Project Cost: Healthcare

Risk Management in Healthcare. During their healthcare career as a Registered Nurse, including work in Quality Management and Regulatory Compliance, one co-author of this study observed the function of hospital risk managers. Their roles vary among institutions, but in general they are involved in event and incident management, financial and legal aspects of healthcare delivery, the psychological and human factors at play, hospital insurance, and claims management (ASHRM, n.d.). Hospital risk managers can be found taking patient complaints, interacting with the hospital's legal counsel, monitoring incident reports, and applying risk mitigation for the benefit of the patients and the hospital. Project-based organizations "conduct the majority of their work as projects and/or provide project rather than functional approaches" (PMI, 2013, p. 14). As healthcare is not, historically, a projectized industry, risk managers currently do not play a direct role in project cost estimation or budget management (P. Adkins, Chief Financial Officer of XYZ Hospital, Appendix C, November 25, 2015). Hospital risk managers are perceived as helping to defray future cost, such as the cost associated with litigation, but are not perceived to significantly affect current project cost or budget. Corroborated by qualitative survey data (Appendix A), this may indicate a need for expansion of the hospital risk manager's role and education for hospital executives as to the benefit that risk management plays in other industries.

Project Cost in Healthcare. Project cost in healthcare varies greatly depending on the type of project, scope, and environment in which a hospital is operating. For-profit institutions have different methods of project financing and cost control than non-profit institutions (P. Adkins, Appendix C, November 25, 2015). Further, hospitals that are part of large corporations have different methods of project financing and cost control than independent hospitals. This makes it difficult to compare healthcare as a whole industry to other projectized industries.

Impact. As most hospitals are not mature projectized organizations, the contribution that risk managers are capable of, in terms of project cost estimation and budget management, is not recognized (P. Adkins, Appendix C, November 25, 2015). This lack of vision is unfortunate, as project management principles have clearly shown that risk management is crucial to controlling cost. As the cost of health care in the United States continues to grow, the need to involve risk managers in formal project cost estimation and budget management becomes more urgent.

Risk Management and Project Cost: Construction

***Risk Management in Construction*.** Another co-author of this study, the owner of a construction and consulting company, has recognized the construction industry as one based on evaluating how much risk the organization, sponsors, owners, financial groups, and supplementary stakeholders are willing to take. Each of these parties manages risk acceptable to their invested interest. "The risk factor is much higher in construction than it is in other industries because outside factors such as government funding, demographics, and market trends largely determine demand" (Gould & Joyce, 2003, p. 5). Project Risk Management processes are dependent on project specifics, and each project will present its unique risks. The organization undertaking construction projects must identify, analyze, and quantify identifiable uncertainties that will

directly affect the project results. The primary risks to a construction project include: delivery method, contract type, owner involvement, cost management, duration, design, quality, site conditions, material availability, complexity, regulations, insurance, and safety. "Project cost risk analysis considers the different costs associated with a project and focuses on the uncertainties and risks that may affect these costs" (Hossen, 2010, p. 1).

By identifying factors that will affect each level of the work breakdown structure, each specific risk can be aligned and cost can be matched to each risk level. By conducting a cost risk analysis, an accumulated cost can be added to compensate or mitigate impacts of these uncertainties. Uncertainties and project risk in construction can have devastating consequences for construction projects. Contingency plans based on the most likely occurrence of risk are often used. "For some risks, it is appropriate for the project team to make a response plan that will only be executed under certain predefined conditions, if it is believed that there will be sufficient warning to implement the plan" (PMI, 2013, p. 346). Although risk management in construction is conducted based solely on the unique aspects of the project, risk management is a systematic method of reviewing the project to identify potential risks that will affect project constraints. Risk responses can directly affect the scope, schedule, and/or cost baselines.

Project Cost in Construction. Project cost associated with risk assessments is identified by the cost-of-risk analysis. By conducting quantitative and qualitative risk analyses, project managers recognize the risks facing each division of a project. Cost of risk is defined as "the implicit or explicit price a company must pay to manage its risk exposures" (The Law Dictionary, n.d., para. 1). Each risk can be prioritized by cost of potential impacts. The total of these potential costs are commonly added to the total cost of the project (Appendix D). Cost risk factors include losses, damages, administrative, safety, insurance, sureties, and regulatory. There are gaps within the construction industry in how to deal with risks. This is why government regulations (e.g., OSHA, Storm Water Pollution Prevention, and Bureau of Ocean Energy Management, Regulation and Enforcement) dictate risk mitigation steps prior to execution. Each factor includes the material, equipment, and labor cost in abating risks. In the estimating phase a percentage of project cost is often applied to cover the cost of risk management.

Impact. The impact of not performing risk management in construction can be severe. The aforementioned construction risks directly impacts one or more of the project constraints. Risk management training is often lacking and left to senior managers. According to qualitative survey data (Appendix A), the strategic use of in-depth analysis tools is only partially implemented. This is common because of the "time is of essence" clauses within contractual obligations. By creating risk registers (i.e., risk logs or matrices) and prioritizing the most critical areas of uncertainty, project managers can monitor each area of concern. As construction must be conducted in stages, the priority of identified risks constantly changes. Management of risk impacts can be planned based on likelihood of occurrence and can account for expenses added by mitigation processes, and risk management can forecast the additional cost of risk impacts. Risk management increases cost due to risk mitigation analyses and risk impacts.

Risk Management and Project Cost: Military Logistics/Acquisitions

Risk Management in Military Logistics/Acquisitions. A study co-author who serves as a U.S. Marine Corps Operations Chief for a Logistics Battalion has learned that risk management in the military and overall DoD is the life blood of military logistics (maintenance of military forces). Each of the military services has used a program formerly known as Operational Risk Management (ORM). Marine Corps risk management is applied and is the responsibility of every Marine and Sailor in the Marine Corps to incorporate into their daily routine. The DoD application and guide for risk management and cost is the *Department of Defense Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs* (Cochrane, 2010).

The mission statement of the Marine Corps Order regulating the use of risk management says, "The focus of [risk management (RM)] is to identify and mitigate risk in all activities" (Paxton, 2014). The statement explains, "Successful implementation of RM increases mission effectiveness while minimizing loss of both personnel and materiel." In the military, risks incurred during garrison and combat operations are considered equal, as the service's greatest resource are its Marines. The Marine Corps treats each evolution, whether a training event, a multi-nation exercise, or combat, as a project. Risks are identified and mitigated essentially the same way as in the private sector. Risk management is considered to be one of the most effective means to eliminate the loss of life, injury, and materiel, and to minimize cost.

Project Cost in Military Logistics/Acquisitions. At all levels cost dictates the amount of risk a Commander will accept. Risks in combat are greater and more expensive than risks in garrison, as are the repercussions of those risks. Cost associated with the risk management of each project (e.g., armored vehicle, aircraft, and ship operations; nuclear propulsion systems; physical training; food preparation; and medical services) is minimized. The preservation of personnel and materiel by avoiding unnecessary risks, thus reducing mishaps and associated cost, is the intent of the risk management order. Accordingly, "Benefit or value gained by implementing the control justifies the cost in resources and time" (Paxton, 2014). This is due to the potential cost of life, limb, and materiel in combat operations. *Operation of the Defense Acquisition System* (DoDI 5000.02) requires program managers to implement effective risk management and notes, "The goal is to both mitigate risks and create opportunities for technology development outcomes that could have a positive impact on meeting performance objectives" (Department of Defense. 2015a).

Impact. The impact of risk management on the cost of military logistics and acquisitions is so closely tied to the daily routine of the overall DoD that it is the normal way of doing business. From the Secretary of Defense down to the Platoon Sergeant, risk management and the associated cost are inherent in what they do on a daily basis. It is an ingrained way of thinking, and the cost of having such a risk management program is more of a benefit than a cost with the scale and scope of operations the entire DoD participates in every day. "Integrating risk management with a program's systems engineering and program management process permits enhanced root cause analysis and consequence management, and it ensures that risks are handled at the appropriate management level" (Richey, 2009). According to Jerry Brown, Assistant Director of Logistics for Marine Corps Air Station Miramar, in an interview, "Unexpected cost overruns are addressed immediately and may determine if a project will be halted or allowed to continue depending on

associated cost" (Jerry Brown, Assistant Director of Logistics for Marine Corps Air Station Miramar, Appendix E, December 1, 2015).

Risk Management and Project Cost: NASA

Risk Management in NASA. A co-author of this study, during their career in NASA Quality Management, witnessed the evolution of NASA risk management from intuition to a disciplined process. He interviewed former Director of NASA GSFC Integration and Test (I&T) facilities, Matt Opeka. "In the early days of NASA, the 1960s, risk management was not documented much," Opeka explained. "Engineers managed risk based partly on experience and partly on logic" (Matt Opeka, Appendix F, November 25, 2015). NASA began with a qualitative process, Continuous Risk Management, which gave way to a more effective, quantitative process known as Risk-Informed Decision Making. "While there will probably always be vigorous debate over the details of what comprises the best approach to managing risk, few will disagree that effective risk management is critical to program and project success and affordability" (NASA, 2011, p. XV).

Project Cost in NASA. NASA takes a definitive approach to managing project cost due to the high cost of spaceflight and associated risks to cost, assets, and humans. Space systems are expensive, and resources are limited. Cost "estimates can be used either for the selection of proposals or the approval to proceed to the next life-cycle phase" (NASA, 2015, p. 1). Opeka explained, "We always performed a cost risk analysis, but it became more formal, sophisticated, and documented as we gained experience in risk management. Cost drives the decision on which risks you are and are not going to accept. [On manned projects] we need to bring humans safely back to Earth. Money still plays a part because there is not an infinite amount" (Matt Opeka, Appendix F, November 25, 2015).

Impact. NASA creates cost-risk analyses to manage the impact of risk on cost, which exists in all phases of the project life-cycle. According to the *NASA Cost Estimating Handbook*, NASA uses cost-risk assessments "to understand risks and help ensure that resources and plans are adequate to deliver projects on time and within budget" (NASA, 2015, pp. G-1 - G-2). An inaccurate cost estimate can mislead a project by omitting the risk of overruns. The *Handbook* continued, "At Confirmation Reviews and Authority to Proceed decision points, the cost estimate must include an appropriately chosen level of unallocated future expense (UFE)." Opeka concluded, "Risk management can impact cost in at least three ways – cost of managing risk; cost of issues resulting from risk; and value of issues avoided. Managing risk can increase cost because every labor, hardware, and/or software hour [can add cost]. Ineffective risk management can lead to issues that, if unresolved, can increase cost. Effective risk management can decrease cost at the value of issues avoided" (Matt Opeka, Appendix F, November 25, 2015). Risk management minimizes cost increases, limits cost, and usually reduces cost.

Summary

Risk Management and Project Cost: Healthcare

Healthcare is, historically, an industry that has made little use of project management principles. While most hospitals employ full-time risk managers (ASHRM, n.d.), they are not typically involved in Project Cost Management. Healthcare might benefit from expansion of the hospital risk manager's role. It might also profit from educating hospital executives about the pay-off of risk management in other industries. In an industry fraught with rising costs, healthcare has much to learn from other industries that employ strong risk managers in conjunction with project management and cost management.

Risk Management and Project Cost: Construction

Throughout the construction industry risk is a part of every activity. The goal is to limit risks to manageable levels. According to an Air Force Construction Manager interviewed, "There are usually some risks associated with any project which will eventually have to be incorporated in planning for the project and consumed during the costing phase. Knowing these variables and constraints up front will assist managers in planning for uncertainties" (Ryon Migacz**,** U.S. Air Force Construction Manager, Appendix D, December 1, 2015). Although project managers are driven to mitigate risk, construction project managers must accept certain levels that will remain with the project. An evolving risk management plan based on daily risks is crucial. This is also why safety is the number one priority on construction sites. The key is planning to continually monitor and evaluate risks associated with the current stage of execution. It is important to recognize that, although many processes are put in place to avoid risks, the construction industry will always have unforeseen risks to the project. Project managers must determine and ensure that proper steps are taken to limit future impacts of unforeseen risks.

Risk Management and Project Cost: Military Logistics/Acquisitions

Risk management in the military and DoD has evolved over the years from an order-based directive to an all-in everyday component of not only the operating services but the overall department. Due to the size, nature, and scope of the projects in which DoD is involved, the funding can seem unlimited. With a $495.6-billion-dollar budget to support the "over 1.3 million men and women on active duty, and 742,000 civilian personnel, [DoD is] the nation's largest employer. Another 826 thousand serve in the National Guard and Reserve forces. More than 2 million military retirees and their family members receive benefits" (Department of Defense, 2015b). The amount of projects and acquisitions by DOD and cost associated with the management of risk within those projects is relative to the project, whether it is a small unit function, combat, or a large-scale acquisition for a new weapon system. DoD overall, especially on the acquisitions side, has adopted its project management approach from the Project Management Institute (PMI). In so doing, DoD has implemented risk management in such a way that it has become a part of the enterprise and, at the operational levels, a way of life.

Risk Management and Project Cost: NASA

Risk management has evolved at NASA from intuition to a disciplined process. NASA takes a definitive approach to managing project cost because the cost of spaceflight is high and the risks to cost, assets, and humans can be high. NASA creates cost-risk analyses to manage the impact of risk on project cost, which can include the cost of managing risk; cost of issues resulting from risk; and value of issues avoided. This three-part lesson can be applied to most any organization or industry intending to minimize project cost through effective risk management. No project has unlimited funding. Cost drives risk decisions. Risk management minimizes cost increases, limits cost, and usually reduces cost.

Conclusions

This Impact of Risk Management on Project Cost: An Industry Comparison study detailed the effects of risk management on cost in projects. Drawing from examples in the healthcare, construction, military logistics/acquisitions, and NASA industries, the study found that risk management minimizes cost increases, limits cost, and usually reduces cost; that project cost in turn drives risk management; and that research on risk management's impact varies widely from one industry to another. Further study is needed on impact in the healthcare industry. We recommend that risk management be estimated in the planning phase and funded in the costing phase; that the impact of risk management on project cost be scaled relative to project cost; and that cost-risk analyses include the cost of managing risk; cost of issues resulting from risk; and value of issues avoided. This latter, three-part recommendation can be applied to most any organization or industry intending to minimize project cost through effective risk management.

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Appendix A
Qualitative/Quantitative Survey of Project Cost Practitioners

The Allen-Carpenter-Hutchins-Jones Team conducted the following qualitative/quantitative survey of current and former Project Cost Practitioners on November 20, 2015 through December 1, 2015. This survey focused on the topic Impact of Risk Management on Project Cost: An Industry Comparison. Limited data could be derived from the results, but there are some insightful quotes especially from respondents with recent project cost and risk management experience. The survey questions relate specifically to Impact of Risk Management on Project Cost: An Industry Comparison study subsections 4.1, 4.2, 4.3, and 4.4.

Qualitative/Quantitative Survey of Project Cost Practitioners – Parameters

- The population scope was the co-authors' current and former colleagues.
- The population size was approximately six.
- The sample size was four professional respondents.

Qualitative/Quantitative Survey of Project Cost Practitioners – Results

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Project Cost practitioners: if you could answer ANY or all of following questions, I would be grateful. Please consider all questions in the context of project cost. You need only have participated in project cost estimating, control, and/or management in some way (e.g., as a cost estimator, resource manager, or project manager). Please include only info authorized for public release as your reply implies your approval for it to be published. This survey supports my final assignment for my Project Estimation & Cost Management course at Drexel University. Replies by 11-27-15 will be most useful. Thanks! [author's name]

Project Cost and Risk Management – Survey – Qualitative Results. (Adopted from IOSH, 2011)

Strengths and Weaknesses	
What are the three best features of your risk management?	
Healthcare Respondent A	**1. Risk Assessment 2. Premium Credit Program (tying money to risk mitigation activities) 3. Event Reporting System**
Healthcare Respondent B	**1. Performance Management Decision Guide 2. Active Premium Credit Program 3. Error Prevention Tool Program**
Construction Respondent A	**1. Early identification of risks in the project life cycle 2. Full project team involvement 3. Full cost and schedule risk performed**
Construction Respondent B	**1. Very high level risk management ("big picture") ORM model used 2. Accounts for most operations 3. Saves [lives], money, time**
What are the three main areas of risk management that you need to develop?	
Healthcare Respondent A	**1. Education (understand what RM is) 2. More "on the ground" rounding for monitoring risk behavior 3. Education for RM understanding insurance policies**

Healthcare Respondent B	**1. Education for event investigation to root cause of low level events** **2. Culture of accountability that is fair and just** **3. Safety of staff**
Construction Respondent A	**1. Frequency of updates during project execution** **2. More formal close out process** **3. Quantify cost and schedule impact for new risks (after risk assessment and during project execution)**
Construction Respondent B	**1. Getting everyone in a unit to understand and practice risk [management]**

Project Cost and Risk Management – Survey – Quantitative Results. (Adopted from IOSH, 2011)

		Yes	No	Partly
	Is there a culture of risk management in your business?			
1	Risk management is a familiar issue in our business, and is understood	CC*		HH
2	We consider risk management to be useful	HCC		H
3	We have carried out individual risk management control measures	HHC		C
4	We manage risks proactively – improvements are made before problems arise	C		HHC
5	Employees have enough training in risk management	C	HHC	
6	One or more employees understand the basics of insurance and risk management	HCC		H
7	We know where to get information about risk management and which specialists to contact	HC		HC
8	Time is set aside for risk management, for example for identifying hazards	HC		HC
	How is risk management implemented?			
9	Risk management is clearly supported by management	HHCC		
10	The general principles of risk management are included in our operational policy	HHCC		
11	Risk management tasks and roles are clearly assigned	HHC	C	
12	The risk management process is outlined in instructions: who, when, what, how?	HC		HC
13	Risk management is monitored and reported as part of our normal management reporting system	HHC		C
	Are control measures used to reduce risks?			
14	Our main hazard areas have been identified	HCC		H
15	Different types of hazard are examined thoroughly	HHC		C
16	We use risk analysis methods that are recommended by specialists	HHC	C	
17	We have adequate experience of in-depth risk analysis	C		HHC
18	When analyzing significant risks, we use in-depth risk analysis methods, and our methods of working are modified to minimize the level of risk	H		HCC
19	Our risk management is regular and systematic, for example risks are always assessed at the launch of a project	CC	H	H
20	Our risk management is integrated into all our operations, for example safety instructions and rules for drawing up contracts are in place and up to date	C	H	HC
21	We use other risk management methods as appropriate, and we always consider insurance cover as an option	CC	H	H
22	We have the right insurance cover for all our operations, and we know about the limitations of insurance cover	HCC		H
	How is expertise used in your business?			
23	Employees participate in risk management activities, both inside and outside the scope of their own specific tasks	HC		HC
24	Employees have the skill to participate in the development of risk management activities	C	H	HC
25	We use the expertise of our business's network – there is co-operation between companies and knowledge is gained from assessments in other organizations	HHCC		
26	We use the expertise and information services of enforcing authorities	HHCC		
27	When needed, we use the services of consultants, insurance companies and other experts	HHCC		

*Legend: H (healthcare); C (construction); repetition (e.g., HHCC) represents multiple responses from H and C industries
**Note: this table includes British spellings.

Appendix B
Interview Results

	Healthcare	Construction	Military Logistics/Acquisitions	NASA
1. Experience?	**Hospital CFO; 8 years.**	**Negotiating cost with contractors.**	**Assistant Logistics Director; 10 years.**	**I&T Director; 53 years.**
2. RM Plan?	**Yes; based on risk assessments.**	**Yes; Operational Risk Management.**	**Yes; based on history, phases, communications, assessment.**	**Yes; at first used experience and logic.**
3. RM Plan analyzes scope, budget, duration?	**Budget, duration.**	**Scope.**	**Budget.**	**Scope, budget, duration.**
4. Cost risk analysis?	**No; projects approved by corporate office.**	**Yes; at the enterprise level.**	**Yes; in the planning phase.**	**Yes; cost drives risk decisions.**
5. Cost mitigation?	**Premium Credit (financial incentive).**	**Firm-fixed price contracts.**	**Cost forecasting and historical data.**	**Cross-utilization of personnel.**
6. RM impact on project cost?	**Prevents costs of litigation; regulations noncompliance; non-reimbursables.**	**Helps plan for uncertainties.**	**Helps structure a cost plan.**	**Incurs cost of managing risk; records cost of issues resulting from risk; earns value of issues avoided.**

Appendix C
Interview of P. Adkins (Healthcare)

The Allen-Carpenter-Hutchins-Jones Team conducted the following interview on November 25, 2015 of P. Adkins, Chief Financial Officer, XYZ Hospital. This interview focused on the topic Impact of Risk Management on Project Cost: An Industry Comparison.

Qualitative Interview Questions (Related to Impact of Risk Management on Project Cost: An Industry Comparison study subsection 4.1)

Question 1

- **Allen-Carpenter-Hutchins-Jones Team** - What has been your experience working in project cost control?
- **Adkins** - I have been a hospital CFO for eight years at several large for-profit hospital corporations. My personal area of expertise is controlling expenses and managing efficiency of labor and supplies.

Question 2

- **Allen-Carpenter-Hutchins-Jones Team** - Do you have a risk management plan?
- **Adkins** - Yes. The risk management plan involves risk assessments related to the area and scope of the project, but to be honest I am not very familiar with what the risk manager does.

Question 3

- **Allen-Carpenter-Hutchins-Jones Team** - Which of the following does the risk management plan analyze for deficiencies: scope, budget, and duration?
- **Adkins** - The risk management plan does not analyze duration, but it does analyze budget and duration. But I am not familiar with the details.

Question 4

- **Allen-Carpenter-Hutchins-Jones Team** - Does your company perform a cost risk analysis?
- **Adkins** - No. All major projects are approved and funded by the corporate office. They may perform a cost risk analysis, but I am not aware of it.

Question 5

- **Allen-Carpenter-Hutchins-Jones Team** - What types of mitigation do you effectively use to avoid additional costs?
- **Adkins** - We participate in a program called Premium Credit. It essentially applies a financial incentive to comply with risk mitigation techniques.

Question 6

- **Allen-Carpenter-Hutchins-Jones Team** - In your opinion, how does risk management affect the overall project costs?
- **Adkins** - Risk management helps prevent costs related to litigation and noncompliance with regulatory concerns. The risk management plan also addresses the prevention of hospital-acquired conditions that the hospital would not be reimbursed for.

Appendix D
Interview of Captain Ryon Migacz (Construction)

The Allen-Carpenter-Hutchins-Jones Team conducted the following an interview on December 1, 2015 of Captain Ryon Migacz, Construction Manager, U.S. Air Force. This interview focused on the topic Impact of Risk Management on Project Cost: An Industry Comparison.

Qualitative Interview Questions (Related to Impact of Risk Management on Project Cost: An Industry Comparison study subsection 4.2)

Question 1
- **Allen-Carpenter-Hutchins-Jones Team** - What has been your experience working in project cost control?
- **Migacz** - I have limited experience but I have had to negotiate a projects cost through a contracting method. For this, we used an [RSMeans construction cost-estimating] tool to generate a government cost estimate. When the contractor offered their cost estimate, we compared the two side by side and usually negotiated line items.

Question 2
- **Allen-Carpenter-Hutchins-Jones Team** - Do you have a risk management plan?
- **Migacz** - Yes, the [Air Force] typically uses Operational Risk Management (ORM) before any planning or execution.

Question 3
- **Allen-Carpenter-Hutchins-Jones Team** - Which of the following does the risk management plan analyze for deficiencies: scope, budget, and duration?
- **Migacz** - I believe scope is usually the largest part of ORM for Air Force construction management. Scope defines the scale and breadth of a project. The scope needs to be analyzed for deficiencies and this drives the budget and duration of a contract. Deficiencies identified early enough can lessen the impact on the overall project.

Question 4
- **Allen-Carpenter-Hutchins-Jones Team** - Does your company perform a cost risk analysis?
- **Migacz** - Not entirely sure, but the Air Force in capacity does this.

Question 5
- **Allen-Carpenter-Hutchins-Jones Team** - What types of mitigation do you effectively use to avoid additional costs?
- **Migacz** - See answer to #1. Firm-fixed price contracts are usually what I dealt with, so most of the cost were known upfront.

Question 6
- **Allen-Carpenter-Hutchins-Jones Team** - In your opinion, how does risk management affect the overall project costs?
- **Migacz** - There are usually some risks associated with any project which will eventually have to be incorporated into the planning for project and consumed during the costing phase. Knowing these variables and constraints upfront will assist managers in planning for uncertainties.

Qualitative Interview Questions – Secondary

Question 1
- **Allen-Carpenter-Hutchins-Jones Team** - What specific project risks can affect the initial project estimate?
- **Migacz** - Weather can affect a project's timeline and even scope. It must be incorporated into the planning for the timeline and cost estimate.

Question 2
- **Allen-Carpenter-Hutchins-Jones Team** - How do you determine impacts of risk to activities?
- **Migacz** - Past experiences, trial and error (least preferable).

Question 3
- **Allen-Carpenter-Hutchins-Jones Team** - Do risks ever affect your method of cost management? If so, when?
- **Migacz** – [No answer.]

Question 4
- **Allen-Carpenter-Hutchins-Jones Team** - Do you currently operate under a project management office?
- **Migacz** - No.

Question 5

- **Allen-Carpenter-Hutchins-Jones Team** - Do you develop and update current project estimates through the project lifecycle?
- **Migacz** - I did in my previous job.

Question 6

- **Allen-Carpenter-Hutchins-Jones Team** - What methods do you most commonly use to establish initial project estimates?
- **Migacz** - RS means (e4clicks).

Question 7

- **Allen-Carpenter-Hutchins-Jones Team** - Are you a project manager, and if so, do you have influence and control in how you adjust project cash flows? Please explain.
- **Migacz** - I was a project manager managing simplified acquisition of base engineering requirement (SABER). Not necessarily, we were awarded an indefinite quantity/indefinite delivery contract method which came with a fixed price, so there was very little room for adjustments.

Question 8

- **Allen-Carpenter-Hutchins-Jones Team** - Do changes to the project affect how you finance a project?
- **Migacz** - Not applicable for my previous job.

Question 9

- **Allen-Carpenter-Hutchins-Jones Team** - What method(s) do you use when determining the probability of uncertainties?
- **Migacz** - Not exactly sure.

Question 10

- **Allen-Carpenter-Hutchins-Jones Team** - How important is historical statistical data when used in identifying risks? In estimating project costs?
- **Migacz** - I believe it is critical because it will help the manager stay on the critical path to project completion and avoid most roadblocks.

Question 11

- **Allen-Carpenter-Hutchins-Jones Team** - Do external factors such as politics, market values, or governmental regulations affect the project costs?
- **Migacz** - Absolutely. We deal with all of this in the Air Force!

Appendix E
Interview of Jerry Brown (Military Logistics/Acquisitions)

The Allen-Carpenter-Hutchins-Jones Team conducted the following interview on November 25, 2015 of Jerry Brown, Assistant Director of Logistics, Marine Corps Air Station Miramar. This interview focused on the topic Impact of Risk Management on Project Cost: An Industry Comparison.

Interview Questions (Related to Impact of Risk Management on Project Cost: An Industry Comparison study subsection 4.3)

Question 1

- **Allen-Carpenter-Hutchins-Jones Team -** What has been your experience working in project cost control?
- **Brown -** Approximately 10 years in managing multiple projects with varying budgets and schedules for completing. Projects ranged from developing processes and procurement of equipment for streamlining aircraft part delivery systems to assisting project leaders to determine the most cost effective means for reaching departmental goals consistent with organizational financial strategies. I also have experience in contracting. Contracting requires review of proposed service contracts and projecting cost to the organization over an extended period of time.

Question 2

- **Allen-Carpenter-Hutchins-Jones Team -** Do you have a risk management plan?
- **Brown -** Yes. Initially, addressing risk on like projects can easily be handled with review of historical reports. Historical documents highlight the initial budget for the project and help to determine if budgets were exceeded and what were the contributing factors lending to the problem. Projects unique to the organization are handled in phases for addressing problems and for identifying cost overruns as one phase is nearly completed and before the next phase of a project can begin. A sturdy communications plan assists in identifying immediate risk to the project—weekly meetings with team members is a standard but members are not restricted from bringing up problems as they arise to the project leader/manager. Risk assessment is an ongoing process from start to finish of a project and is documented, addressed, reviewed, and filed for future project leader use.

Question 3

- **Allen-Carpenter-Hutchins-Jones Team -** Which of the following does the risk management plan analyze for deficiencies: scope, budget, and duration?
- **Brown -** The plan analyzes budget deficiencies for determining the likelihood of success or failure of a project. Organizational intent is to accomplish the most in structuring projects that support organizational strategies but do not require an enormous amount of organizational resources for achieving. In sum, "do the most with the least." Analysis of a project's scope and duration can be tailored to meet budget constraints, and in some cases, a project with a large goal for achieving is sometimes broken down into 2 or 3 projects to accommodate an assigned budget figure.

Question 4

- **Allen-Carpenter-Hutchins-Jones Team -** Does your company perform a cost risk analysis?
- **Brown -** Yes. Cost risk analysis is conducted at the initial phase (planning) of the project. Unexpected cost overruns are addressed immediately and may determine if a project will be halted or allowed to continue depending on associated cost.

Question 5

- **Allen-Carpenter-Hutchins-Jones Team -** What types of mitigation do you effectively use to avoid additional costs?
- **Brown -** Analyzing fiscal spreadsheets and applying cost forecasting techniques are effective means for "minimizing" additional cost. Avoiding additional cost cannot be safely guaranteed but minimizing increased risk associated with additional costs is best mitigated with analysis of historical data and review of the organization's budget at different times of the fiscal year.

Question 6

- **Allen-Carpenter-Hutchins-Jones Team -** In your opinion, how does risk management affect the overall project costs?
- **Brown -** I think it is very effective in structuring a plan for addressing a project's overall cost. Integrating risk factors that can distract from a project's momentum is important for increasing success. A project that runs out of money for completing is like a car running out of gas! In both cases—the person involved in the process is halted in reaching a goal. Therefore, mitigating risk that may affect project cost negatively is important for achieving a positive end-state.

Appendix F
Interview of Matt Opeka (NASA)

The Allen-Carpenter-Hutchins-Jones Team conducted the following interview on November 25, 2015 of Matt Opeka, a former NASA customer and current NASA contractor. Mr. Opeka has performed risk management and cost management for 53 years with NASA and contractor technical and business personnel. Now Senior Advisor at SGT, Inc. (a NASA contractor), Mr. Opeka has retired as Senior Advisor and former Program Director of the NASA Goddard Space Flight Center (GSFC) Program Analysis and Control (PAAC) Contract. Before he held those positions, he retired as Director of Integration and Test facilities at NASA GSFC, where he began his career in 1962. He has been instrumental in the success of many NASA missions whose flight hardware was processed through his facilities in the 1970s-1980s. This interview focused on the topic Impact of Risk Management on Project Cost: An Industry Comparison.

Qualitative Interview Questions (Related to Impact of Risk Management on Project Cost: An Industry Comparison study subsection 4.4)

Question 1

- **Allen-Carpenter-Hutchins-Jones Team** - What has been your experience working in project cost control?
- **Opeka** - I served at NASA Goddard Space Flight Center (GSFC) as the Director of Integration and Test (I&T) facilities. I worked for GSFC from 1962 to 1988, when I retired and became a contractor to GSFC. As the I&T Director, I managed spaceflight hardware integration and test like it was a project. This responsibility included cost management and risk management.

Question 2

- **Allen-Carpenter-Hutchins-Jones Team** - Do you have a risk management plan?
- **Opeka** - In the early days of NASA, the 1960s, risk management was not documented much, so we had no formal risk management plan. We engineers managed risk based partly on experience and partly on logic. Our experience derived largely from aircraft systems, as we were developing space systems anew. We applied logic to identify and estimate risk, but limited space systems experience limited our logic. As we gained experience, we also formalized our risk management plans.

Question 3

- **Allen-Carpenter-Hutchins-Jones Team** - Which of the following does the risk management plan analyze for deficiencies: scope, budget, and duration?
- **Opeka** - We managed risk to cost, schedule, and scope. As we got better at risk management, we identified risks; analyzed them and their potential impact; prioritized them based on potential impact and likelihood of occurring; created risk management plans to mitigate or accept the risks; tracked the risks; implemented the plans; and documented the results for future risk management plans. You must first understand the requirements and then identify the risks. There will never be enough money to launch a spacecraft with zero risks, so you must prioritize the risks. The low-cost risks are easy to resolve or mitigate. You cannot afford to fix the risks that cost a lot to resolve or mitigate, so you must decide which risks you are going to mitigate and which ones you will accept. Those you will mitigate require a plan for that process. Those you accept require a plan of action should the risk become an issue. Nothing is risk free. The risk management plan must balance risks to the factors of cost, schedule, and scope. If you buy down risk to one of these factors, you adjust the levels of one or both of the other factors. For example, you can add labor hours to a project to reduce the likelihood of slipping the schedule, but your cost will likely increase as a result. You first identify the risk and then decide if and how much you will adjust cost, schedule, and/or scope to mitigate it.

Question 4

- **Allen-Carpenter-Hutchins-Jones Team** - Does your company perform a cost risk analysis?
- **Opeka** - We always performed a cost risk analysis, but it became more formal, sophisticated, and documented as we gained experience in risk management. Cost drives the decision on which risks you are and are not going to accept. Risks on unmanned space projects are easier to decide than those on manned projects. In the latter, we need to bring humans safely back to Earth. Money still plays a part because there is not an infinite amount of money. But human life adds an element to scope that can increase cost and sometimes schedule.

Question 5

- **Allen-Carpenter-Hutchins-Jones Team** - What types of mitigation do you effectively use to avoid additional costs?
- **Opeka** - The most effective way to mitigate risk to the cost baseline is what we call cross-utilization of personnel. By that we mean getting the existing staff to collaborate more than originally planned to accommodate issues that arise and threaten to

increase cost. For example, if the customer on Project A were to add scope but require schedule to remain unchanged, then cost becomes at risk of increasing. In this case, Projects B, C, and D can lend staff to help Project A accommodate the scope increase. Perhaps the staff on Projects B, C, and D can absorb some extra work, or they may work some overtime. If they work overtime, the cost is less than it would be in hiring new or temporary staff because personnel benefits are sunk costs (i.e., already paid). Most personnel overhead cost is in the benefits (e.g., no additional vacation is accrued by overtime). In this scenario, if cost increase cannot be fully avoided, then the project manager must negotiate with the Project A customer to re-balance the cost baseline.

Question 6

- **Allen-Carpenter-Hutchins-Jones Team** - In your opinion, how does risk management affect the overall project costs?
- **Opeka** - Risk management can affect cost in at least three ways – cost of managing risk; cost of issues resulting from risk; and value of issues avoided. Managing risk can increase cost because every labor, hardware, and/or software hour expended in so doing can add cost. Ineffective risk management can lead to issues that, if unresolved, can increase cost. Effective risk management can decrease cost at the value of issues avoided.