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An Assessment of the Effectiveness of Air Force Risk Management Practices in Program Acquisition Using Survey Instrument Analysis

Michael J. Maroney Jr.

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Abstract

Air Force acquisition programs invest a large amount of resources to develop and field systems. Many of these resources go to risk management in order to help ensure those programs finish successfully with respect to cost, schedule, and technical performance goals. The question arises as to whether this is a sound investment. Although risk management has been shown to be effective in industry, scant empirical evidence exists for its effectiveness within the Air Force. Correlation and regression analysis of survey data show that a positive relationship does exist between specific risk practices and project success. Furthermore, the analysis suggests that organizational behavior practices may reinforce that positive relationship in addition to the structured risk management steps prescribed by organizations such as the Department of Defense and the Project Management Institute.

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AN ASSESSMENT OF THE EFFECTIVENESS OF AIR FORCE RISK MANAGEMENT PRACTICES IN PROGRAM ACQUISITION USING SURVEY INSTRUMENT ANALYSIS

I. Introduction

General Issue

The measure of success for managing nearly any project or program is whether it meets the given targets for cost, schedule, and performance (Kerzner, 2013:8; Mantel and Meredith, 2012:3; PMI, 2013:35). Since projects are most often executed under conditions of uncertainty, risk management aids the project team in delivering a successful project. Numerous frameworks exist for project management in general and most of those frameworks also include significant portions on risk management (DoD, 2013; DoD, 2006; PMI, 2013, INCOSE, 2011; NASA, 2011). More applicable to an Air Force audience, Department of Defense (DoD) Instruction 5000.02 (DoD, 2013), the overarching guide for defense acquisition, contains numerous references to cost, schedule, performance and risk (DoD, 2013). What remains largely unknown is the effectiveness and efficiency of those risk management efforts.

Problem Statement

The DoD, Project Management Institute (PMI), International Council on Systems Engineering (INCOSE) and many other organizations provide detailed methods for how to approach risk management and handle identified risks (e.g., DoD, 2013; DoD, 2006; PMI, 2013, INCOSE, 2011; NASA, 2011). While these methods might provide direction on *how* to implement a risk management effort, they don't offer a *means to evaluate* the effectiveness or of that risk management effort. As measured by the number of and page count of its policies, the Air Force invests a lot of resources in risk management but the question remains whether it's effective.

Research Objective

The purpose of this study is to evaluate the effectiveness of risk management efforts within the Air Force acquisition community. By collecting survey information from Air Force acquisition professionals regarding whether and how risk management is actually practiced, a more accurate view of Air Force risk management efforts may be gained. Ultimately, this information could be used to determine not only the effectiveness of risk management but also provide insight into how to better manage Air Force projects.

Investigative Questions

Before exploring any additional questions, this study must first find if a relationship exists between risk management efforts as a whole and the project's outcomes with respect to cost, schedule, and performance. In the event there is no relationship, the rest of the questions are unanswerable.

Q1. Does a relationship exist between risk management and an Air Force project meeting its cost, schedule, and performance goals?

Additionally, the study will identify how effective is risk management when applied to Air Force projects. Considering the importance placed on risk management by various project management and system engineering frameworks, it would seem practicing risk management in accordance with those prescriptions would be effective. Does the presence of a risk management effort lead to better project outcomes with respect to cost, schedule, and performance?

Q2. How effective is the Air Force risk management effort in aiding its projects to meet their given cost, schedule and performance targets?

The third research question will compare industry practices with Air Force practices. Risk management is applied in both areas and follow similar policies or frameworks. The expectation, then, is that the practices in use should be similar. In the event they aren't, these practices could be shared to improve the success rates of projects executed by both groups.

Q3. Are there differences between the effective risk management practices used in industry and those used by the Air Force?

Hypotheses

To better answer the research questions, three hypotheses will be tested. The first hypothesis deals with the relationship that risk management has with Air Force project outcomes. The second question is to determine if risk management is effective in guiding Air Force projects to meet their cost, schedule, and performance goals. Finally, the third hypothesis focuses on whether or not a difference exists between practices related to cost, schedule, and performance from an industry sample are the same as those from an Air Force sample. These questions explore the effectiveness of risk management, in general, as well as specific risk management practices as they relate to Air Force projects and how this effectiveness compare to an industry sample.

Risk management expert Edmund Conrow states that the DoD Risk Management guide is “quite simply the best introductory document on risk management” (Conrow, 2003: xx). Conrow’s suggestion might lead one to believe the DoD performs risk management well. Additionally, the basic principles of risk management have been in practice for centuries. It seems unlikely, though not impossible, that people would continue to invest efforts into a set of practices that failed to provide some benefit. However, the DoD seems to have trouble implementing risk management well (GAO, 2012). GAO’s criticism might suggest that opportunity for improvement exists. For these reasons, one might expect there to be a weak but positive correlation between the presence of a risk management effort and a project successfully meeting its cost, schedule and performance goals.

H1. There exists a statistically significant correlation between risk management practices and Air Force project success relative to cost, schedule or performance goals.

There are many prescribed practices for performing risk management. Logic dictates that at least some of those practices might be more successful than others. Knowing which practices offer the greatest impact could be useful to the program office and the Air Force to better prioritize activities. Project success is often determined by a variety of influences, some known to the project office in advance and some not. Since projects are unique and multi-determined, it seems unlikely that all practices will prove to significantly affect project success. Still, one might expect at least some of them to show a relationship.

H2. At least one risk management practice will be shown to significantly affect Air Force project success relative to cost, schedule or performance goals.

Based on a review of the literature, it seems there's a great deal of similarity between the risk management frameworks in use within the DoD and those in use in the private sector. Specifically, the government frameworks from the DoD, the Air Force and NASA will be shown to be similar to those offered by PMI and INCOSE. Additionally, a GAO study revealed that, as of 2006, 86,181 of the 1,857,004 employees who left the DoD since 2001 work for defense contractors (GAO, 2008:10). This includes 2,435 senior acquisition officials (ibid). It could be expected that defense contractors might adopt the risk practices of their customer either explicitly or implicitly. They might adopt them explicitly to mirror the customer to give that customer peace of mind that they understand what is being asked of them. They might also implicitly borrow some of those same practices because they share employees with similar backgrounds and experiences. Recent survey work by Dr. Josef Oehmen was conducted to see how industry organizations practice risk management (Oehmen, et al., 2014).

H3. A difference does not exist between the effective risk management practices used in industry and those used by the Air Force.

Methodology

The focus for this effort is the influence of risk management on Air Force acquisition programs as seen through the eyes of mid-career, active duty and civilian acquisition professionals. These individuals will be contacted through a course offered by the Air Force Institute of Technology's (AFIT's) School of Systems and Logistics. The course is targeted at acquisition program managers but is also attended, albeit in lower numbers, by professionals from other career fields like engineering, logistics and contracting. The study relies on these individuals to provide insight into the broader Air Force acquisition system.

A survey method will be employed to characterize how the student population practices risk management. Survey respondents will be asked to provide answers on a wide range of activities involved with project risk management. The survey will also allow respondents to provide comments regarding their experiences.

Survey respondents will be asked to identify which risk management practices were in use on their project and what level of success that project achieved relative to its original cost, schedule and performance goals. Since risk management is as much about behavior as quantitative results, a survey should provide better insight into the project to better compare risk practices, or behaviors, with project outcomes. Results from these survey responses will be analyzed to determine descriptive statistics of those questions as well as potential relationships between answers provided.

Tests of correlation and linear regression will be used to answer the first research question on the effectiveness of risk management. These same tools will also be used to answer the second research question regarding which specific practices influence Air Force project success. The third research question will be answered by comparing the correlation of individual practices from two different survey sets; one for industry respondents and one from Air Force respondents.

Assumptions/Limitations

There are a number of assumptions required for this study. One of the key assumptions is that survey respondents will answer honestly. This study relies on self-reported information so, in addition to honesty, the respondents must also be accurately informed about the practices in use on their project as well as the project's status. Since these responses are also made at a point in time rather than at the end of the project, final project success is assumed to be the same as the information reported at that moment in time. These are necessary assumptions are necessary but impossible to guarantee.

This study is limited by a number of factors. As this research will rely on a self-reported, voluntary survey instrument, the data and results are subject to the typical limitations that accompany this type of effort. Specifically, to gain access to the survey, individuals will first have self-selected to attend a two-week course on project management and, further, agreed to complete the survey. This necessarily introduces some degree of bias—the extent and impact of which cannot be known.

A smaller than expected sample size could also be a limitation to generalizing the results. Surveys often have a low response rate. Compounding that challenge are Air Force policies that inhibit a wider dissemination of the survey. Even if the results prove interesting, the sample size will be critical for interpretation and generalization.

The reach of this survey is also limited by policies dealing with the use of and dissemination of surveys in the Air Force. These limitations might prevent the wider dissemination of the survey needed to more accurately and completely characterize the population of DoD acquisition professionals as a whole.

Implications

Insight from this study could lead to a number of different outcomes. If risk management efforts are highly correlated with project success, then better training and more stringent policy on risk management could lead to improved likelihood of acquisition success. If it turns out that only a handful of specific risk practices are correlated with project success, then those practices could be emphasized. Similarly, less valuable practices might be given less attention or omitted altogether. Also, these results could provide additional insight relative to risk management practices in the defense industry vis-à-vis the private sector. Where there is a critical difference, the Air Force might implement changes to better match successful industry practices.

All of the previous implications assume the results show risk management to be effective at all. The results from the study may show risk management to have no or little impact on project success. If that's the case, resources previously assigned to risk efforts might be redirected elsewhere for efficient use.

II. Literature Review

Chapter Overview

This research effort seeks to build on the existing body of knowledge of risk management. A better understanding of existing risk-related research might better shape the focus and evaluation of current practices. Both risk management and the underlying influences of organizational behavior are multi-dimensional and often involve other disciplines. Consequently, the review will also be wide ranging, but will better set the foundation for the current assessment of DoD practices. This chapter will review current structured risk management definitions and approaches. Additionally, a review of current risk management practices and research will be presented. Finally, a review of risk management effectiveness will be provided.

Risk Management Definition and Overview

Understanding risk management requires understanding a few definitions. In this section, we will define “risk,” “uncertainty,” “risk management,” and provide a review of five risk management frameworks. This background will provide the basis for answering the study’s research questions.

The first definition we’ll explore is “risk.” The Project Management Institute (PMI) defines a risk as “an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality” (PMI, 2013:309). The DoD defines risk as “a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints” (DoD, 2006:1). Similarly, the United States Air Force (USAF) defines a risk as “a future event that, if it occurs, may cause a negative outcome or an execution failure in a program within defined performance, schedule, and cost constraints” (USAF, 2014:83). NASA defines risk as:

> *The potential for performance shortfalls, which may be realized in the future, with respect to achieving explicitly established and stated performance requirements. The performance shortfalls may be related to institutional support for mission execution or related to any one or more of the following mission execution domains: safety, technical, cost, schedule.* (NASA, 2008:7-8).

INCOSE borrows its definition from E.H. Conrow in writing that risk:

> *“has been defined as the likelihood of an event occurring coupled with a negative consequence of the event occurring. In other words, a risk is a potential problem – something to be avoided if possible, or its likelihood and/or consequences reduced if not”* (INCOSE, 2011:216).

Table 1, below, summarizes the definitions of risk as given by the reviewed frameworks. As noted above, the definitions share the notion that risk is a future event of unknown likelihood with some impact on project objectives.

What should be noted is that all of these definitions of risk share a few key attributes. One is that risk is in the future. These documents all offer additional details beyond that provided in the table. Another shared attribute from those documents is that the risk has some root cause which may or may not lead to the risk becoming realized. Finally, the risk, if realized, will have some impact on project success. These basic concepts are shared by all the reviewed frameworks.

However, there are some differences between these frameworks. Many of these documents distinguish between a not-yet realized risk and an issue--something that has already or will certainly happen (USAF, 2014; DoD, 2006). This emphasis does not exist with the others. Additionally, only one of these guides suggests that the impact must be

Table 1. Definitions of Risk

Source	Definition of Risk
DoD	"a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints" (DoD, 2006:1)
INCOSE	"has been defined as the likelihood of an event occurring coupled with a negative consequence of the event occurring. In other words, a risk is a potential problem – something to be avoided if possible, or its likelihood and/or consequences reduced if not" (INCOSE, 2011:216)
NASA	"The potential for performance shortfalls, which may be realized in the future, …related to any one or more of the following mission execution domains: safety, technical, cost, schedule." (NASA, 2008:7-8)
PMI	"an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality" (PMI, 2013:309)
USAF	"a future event that, if it occurs, may cause a negative outcome or an execution failure in a program within defined performance, schedule, and cost constraints" (USAF, 2014:83)

negative (USAF, 2014). Interestingly, PMI believes that a risk could lead to a positive impact (PMI, 2013). Some, including INCOSE, use the word "opportunity" to refer to a risk with a positive impact to project objectives (e.g., INCOSE, 2011:227). Recently, the DoD issued an interim update to its Risk Management Guide for Defense Acquisition. In this version, the DoD has also adopted the use of "opportunity" as uncertain events "that have the potential for improving the program" (DoD, 2014).

A concept similar to risk is "uncertainty." Much of risk management might be traced to a doctoral dissertation written by Frank H. Knight and published as his book, Risk, Uncertainty, and Profit. In this book, Knight provides definitions of "risk" and "risk proper." Here, Knight provides some insight into the distinction between risk and uncertainty:

> *The essential fact is that "risk" means in some cases a quantity susceptible of measurement, while at other times, it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearing of the phenomenon depending on which of the two is really present and operating. There are other ambiguities in the term "risk" as well, which will be pointed out; but this is the most important. It will appear that a measureable uncertainty, or "risk" proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all. We shall accordingly restrict the term "uncertainty" to cases of the non- quantitative type.* (Knight, 2006:19-20).

This distinction by Knight is seminal to risk management and little has changed since its original publication in 1921.

While the difference between risk and uncertainty was clear to Knight, some difference exist on these topics among the frameworks reviewed. The DoD Risk Management Guide seems to make no distinction between risk and uncertainty while the Air Force does. The USAF describes uncertainty as "the indefiniteness about the outcome of a situation" (USAF, 2014:95). Additionally, the USAF seems to use the word "concern" nearly synonymously with "uncertainty." Their provided definition for "concern" is a "potential future event for which the cross-functional [Life Cycle Risk Management] team does not have sufficient information to quantify a likelihood or consequence" (USAF, 2014:84). The definition provided by PMI echoes Knight in suggesting that risks are known and refers to uncertainty as an "unknown risk" (PMI, 2013:309). While there are some similarities between risk and uncertainty, the key difference is how one deals with the two concepts. PMI suggests that risks can be handled with a risk reserve where the budget might be assigned based on, for example, a mathematical expectancy of the risk (PMI, 2013). Conversely, uncertainty would be handled with management reserve which might be simply a percentage of the total budget since no information is available at the beginning of the project (ibid).

With the definitions of risk and uncertainty explored, the review will now focus on the definition the reviewed frameworks provide for "risk management." Table 2, below, provides a comparison of definitions for "risk management."

Table 2. Risk Management Definitions

Source	Definition of Risk Management
DoD	"the overarching process that encompasses identification, analysis, mitigation planning, mitigation plan implementation, and tracking" (DoD, 2006:1)
INCOSE	"continuous process for systematically addressing risk throughout the life cycle of a system, product or service" (INCOSE, 2011:215)
NASA	"set of activities aimed at achieving success by proactively risk-informing the selection of decision alternatives and then managing the implementation risks associated with the selected alternative" (NASA, 2008:1)
PMI	"processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project" (PMI, 2013:309)
USAF	"the proactive management of future uncertainties to ensure that program cost, schedule, and performance objectives are achieved in every phase of the life cycle" (USAF, 2014: p. 83)

In addition to the similarity these frameworks share with respect to the definition of risk, Table 2, above, also highlights a great deal similarity with respect to the definition of risk management.

Despite the similarities on definitions, these various sources provide for slightly different structured approaches for risk management. A few models start first with risk management planning to decide at the project level how risk management will be carried out with respect to risk identification, analysis and implementation. Then, all the models offer a series of steps to identify, analyze and respond to the risk. NASA, however, uses slightly different terms to perform the same basic actions.

While the approaches differ somewhat, all of them then offer some steps for identifying, analyzing and responding to risks to reduce their likelihood and/or impact. Each framework offers a matrix that plots likelihood against impact to arrive at a composite number that provides some notion of total risk to the project's objectives. Most of the frameworks offer a five by five matrix where there are five levels of likelihood of event occurrence and five levels to denote severity of impact. PMI offers no pre-defined matrix, instead leaving it to the implementing organization to define the scales for likelihood and impact.

Another interesting note is found with the two industry frameworks; INCOSE and PMI. INCOSE is focused on systems engineering where PMI's focus is on project management. While these represent two different views of executing projects, they both share risk management as a key part of that execution and hold similar views on risk and risk management.

The next step is to implement some plan to reduce the likelihood of the risk, the impact of the risk, or both. All of the frameworks discussed provide a step for tracking the identified risks and their responses. These feedback loops create an iterative process for risk management that should be ongoing throughout the life of the project. However, no firm prescription is given on exactly which practice to implement or the effectiveness of those practices or the effectiveness of the risk management effort as a whole.

Table 3 below provides a comparison of the step-by-step approach prescribed by each of these organizations.

Table 3. Risk Management Framework Comparison

	DoD	INCOSE	NASA	PMI	USAF
Risk Management Planning	-	√	-	√	√
Risk Identification	√	√	√	√	√
Risk Analysis	√	√	√	√	√
Risk Mitigation	√	√	√	√	√
Risk Tracking	√	√	√	√	√

(DoD, 2006:4; INCOSE, 2011:218-219; NASA, 2008:15; PMI, 2013:309; USAF, 2014:90)

What should be noted from the comparison is the great deal of similarity among the review frameworks. Two of the frameworks, the DoD and NASA, do not have an explicit step for risk management planning; although, it could be argued that the risk management planning called for in the other frameworks is still implied by the two frameworks that do not. Both the DoD and NASA have a number of other required policies that could be argued to take the place of the missing planning step (DoD, 2013; NASA, 2010).

In terms of options for dealing with risk, the consensus is that one can *accept*, *avoid*, *mitigate* (sometimes referred to as control) or *transfer* the risk (DoD, 2006:18; ISO, 2011:225; PMI, 2013:344). Risk *acceptance* is merely accepting the likelihood and consequence as is. This could make sense for when the cost of the risk response is greater than the risk impact or when the likelihood and/or impact is deemed to be negligible. *Avoidance* describes a situation where the project team may make a decision such that the risk is no longer a factor. *Mitigation* (i.e., control) can be used when the project team takes some action to reduce likelihood and/or impact associated with a given risk. For example, wearing of a camouflage vest with armored plate could be expected to reduce the likelihood of being shot and reduce the consequence. *Transference* refers to a situation where the project team seeks to insulate itself from the risk impact through another party. Insurance policies are a classic example of risk transfer where the cost of the impact has been shifted to the insurance company.

The USAF offers those exact four management strategies plus the option of "monitoring" as a risk response (USAF, 2014:102). The Air Force's inclusion of "monitor" describes a situation of short-term acceptance but leaving open the opportunity to take some action later. Note that this is a distinct strategy as opposed to simply tracking the risk. These options provide categories of ways to reduce the likelihood or impact of a given risk (with the exception of acceptance) but they don't provide a measure of effectiveness.

One interesting omission from these frameworks is that none has a means of tracking the effectiveness of the risk management effort. Many have steps to track the implementation of a given risk response, but that fails to fully address the implementation of risk management on the whole or provide some insight in advance as to which practice might be most likely to improve the project's chance of success. INCOSE calls for the project team to "evaluate the risk management process" but this is focused at the level of a given risk much like how the other frameworks call for "tracking." None of the frameworks offer that empirical insight to practitioners to better manage their projects.

With a working set of definitions of "risk" and "risk management" in hand, the study will now provide a review of risk management practices. The focus will now turn to a review of risk management practices in an effort to provide the groundwork for answering the research questions for this study. Recall that the first question asks if risk management practices have a relationship with project success relative to cost, schedule, and technical performance and the second research question asks, assuming a relationship exists, if risk management if effective. A review of relevant research is provided to explore these questions.

Risk Management Practices

Some of the risk responses discussed above could be considered practices in risk management, but there are many others. Oehmen et al. recently structured a survey asking 95 questions (of a survey total of 173) on specific risk management practices (Oehmen et al., 2014). In that survey, Oehmen, et al., documented six categories of risk management practices, or categories of practices, and mapped them to risk management process steps. The categories resulted from the author's use of a factor analysis to reduce the number of practices. Those basic steps are based on their analysis of risk management frameworks reviewed above with the addition of the ISO 31000 standard on risk management. Table 4, below, is reproduced from that article (Oehmen, et al., 2014:447) with permission from the authors:

The first category deals with the skills and resources required to perform risk management activities. The second category is aimed at developing a risk management approach tailored to the unique needs of the given project. Neither of these map directly

Table 4. Risk Categories

Risk Management Categories	Risk Ident.	Risk Analysis	Risk Eval.	Risk Treat.	Monitor and Review	Other
1. Develop risk management skills and resources						X
2. Tailor risk management to and integrate it with new product development						X
3. Quantify the impact of risks on your main objectives		X				
4. Support all critical decisions with risk management results			X	X		
5. Monitor and review your risks, risk mitigation actions, and risk management process					X	X
6. Create transparency regarding new product development risks	X					

(Oehmen, et al., 2014:447)

to a risk management step in the frameworks reviewed but, at least in the opinion of PMI, are taken as given prior to the beginning of a project (PMI, 2013). Additionally, the DoD also assumes that the requisite resources are in place to manage the project successfully (DoD, 2013).

The third category deals with how well the risks are analyzed. In the previous frameworks, the organizations implementing the project will have identified the likelihood and impact of the given risks. Organizations can evaluate the risk with respect to cost, schedule, performance or a variety of other factors. For instance, some organizations might consider the ability to commercialize the product to be a key factor for evaluation. Some organizations will evaluate risks by rank ordering (e.g., 1 to 10) or, in the case of more rigorous approaches, the risks can be evaluated more probabilistically using distributions for likelihood and impact. Statistical methods like Monte Carlo can more comprehensively evaluate the cost and schedule risk to the project and provide more insight that evaluation approaches that provide a single number for likelihood and a single number for impact. Where cost and schedule are a function of each other, this might give a more complete picture of the project's risk.

The fourth risk management category has to do with how well the risks are evaluated and how they are treated to make the best trade-off decisions within the project. Risk evaluation could influence the requirements of the project as well as resource allocation within the project. Trade-off studies or decisions made by weighing costs and benefits could be other forms of evaluation. The second set of practices within this category has to do with how risks are treated to reduce likelihood and/or impact. This is where most of the practices identified by Oehmen, et al. are located.

Broadly, Oehmen, et al. consider that risk mitigation may be carried out to improve organizational efficiency, project management efficiency, improve requirements selection, or reduce technological risk (Oehmen, et al, 2014). They consider the use of financial or schedule reserves to improve organizational efficiency. To make use of a risk reserve, the organization would set aside an additional amount of money or time to deal with the unexpected. These are sometimes referred to as management or risk reserves.

The selection of contract type is another way they have identified to improve organizational efficiency. Selection of contract type can be an important consideration in allocating risk between customer and developer. A fixed-price contract is expected to shield the customer from cost overruns and place more of the development risk on the provider. Conversely, a cost-reimbursable contract makes the customer responsible for cost overruns and largely shields the developer from risk. This is a common decision within the DoD that has implications for how the contractor is incentivized to perform the requested service or product development. With a fixed-price contract, the contractor is required to deliver what was promised in the contract and is held financially responsible for cost overruns. Under a cost-reimbursable contract, the contractor is obliged only to deliver "best effort," and cost overruns are paid for by the customer.

Project management efficiency practices seek to improve the standardization and quality of process in use by the project team. These would include additional cost, schedule and performance studies as well as process monitoring and training programs. The original set of requirements will begin to dictate the risk profile for the project; the more ambitious the requirement, the greater risk of complications. Within the DoD, Technology Readiness Levels (TRLs) are one method of measuring how ready a given technology is to be put into use for a given project. Selecting only ready or nearly ready technology is expected to reduce the project's risk.

The fifth category has to do with how the risks are monitored and reviewed. All of the frameworks discussed include a loop to re-evaluate the already identified risks as well as continuously look for new ones. Organizations can choose to do this at given intervals (e.g., daily, weekly, monthly) or in response to specific events like significant milestones or prior to key decision points. Organizations can also choose the depth of risk review. For example, some organizations might choose to review only the top ten risks or only those they consider critical.

The sixth and final category includes methods to ensure transparency of reporting with respect to risk management. Where the goal of risk management is to reduce likelihood and/or impact of risks, more transparency should aid in good decision making.

While there are some differences between the frameworks, this study will use a common set of steps and terms. Borrowing from the most expansive frameworks, this study will acknowledge the following risk management steps: risk management planning, risk identification, risk analysis, risk mitigation and implementation, and risk tracking. Additionally, while most of the frameworks agree that risk may be positive or negative, this study will use "risk" when referring to a potential negative outcome and "opportunity" when referring to a positive outcome. This should add clarity for the reader.

Effectiveness

There appears to be a great deal of similarity in the risk management approaches surveyed above. However, these details still fail to answer the second research question; that is, whether risk management is effective at improving project success. A significant challenge exists in providing empirical evidence of risk management effectiveness; every project is unique. Indeed, a recent study notes, "the literature does not document any empirical investigations of how risk management activities can be effectively and efficiently implemented" (Oehmen et al., 2014:443). This project uniqueness makes developing a valid control group difficult if not impossible.

Still, some studies have provided some insight into the effectiveness of risk management. One recent study that evaluated the effectiveness of risk management was completed by Elm in 2012 as part of a larger effect to ascertain the overall effectiveness of Systems Engineering (Elm, J.P. and Goldnerson, D.R., 2012). This study was performed as a collaboration between the National Defense Industrial Association System Engineering division (NDIA-SED), the Institute of Electrical and Electronic Engineers Aerospace and Electronic Systems Society (IEEE-AESS), and Carnegie Mellon's Software Engineering Institute (SEI). Elm's study looked at a number of systems engineering practices including risk management.

Looking at the broad implementation of risk management, this study delivered a Goodman-Kruskal's Gamma of +0.21, suggesting a moderately positive correlation between the implementation of risk management and project performance (ibid: p. xii). In this study, project performance was measured by degree of adherence to assigned cost, schedule and technical performance goals. Systems engineering implementation was measured by surveying respondents' views on the implementation of work products prescribed by the Capability Maturity Model – Integrated (CMMI). More specifically, the study looked at the impact on "lower challenge" and "higher challenge" projects and found gamma values of +0.18 and +0.24 respectively (ibid:76). This has a number of possible explanations. It could suggest that risk management becomes more effective as project challenge increases. It could also suggest, as noted in another study (DoD, 2014), that project practices change based on the amount of risk; that is, more effort may be placed on higher risk projects.

The DoD routinely reviews acquisition performance, which includes some measure of risk management practice effectiveness. These reviews are documented in GAO reports, Select Acquisition Reports and a various other means. Fixed-price contracts are largely regarded as a method to protect the buyer from cost overruns where cost reimbursable contracts shift the cost risk from the seller to the buyer. For this reason, recent DoD policy has stated a preference for use of fixed-price contracts (DoD, 2013), but the 2014 annual report on the Performance of the Defense Acquisition System found "no statistical correlation in either development or early production between performance (cost or schedule growth) and broad contract type (fixed-price and cost-plus)" (DoD, 2014:87). This analysis covers 433 major defense acquisition programs (MDAPs) from 1970 to 2011 (ibid). However, the report also discusses the difference in contract type and cost performance and that this distinction between contract types is "*not the divide on effectiveness*" [emphasis in the original] (DoD, 2014:101). Instead, the difference is that fixed-price contracts should be used in low technical risk situations and cost reimbursable contracts are most appropriate in higher technical risk circumstances. This also highlights again the difficulty in establishing a true control group for measuring risk management effectiveness since it would be unreasonable to assign different contract types to projects of the same risk level.

The survey used by Oehmen, et al (hereafter simply referred to as the Oehmen study) looked to identify specific practices that improved either project or product success. The survey from that research effort discovered a total of 30 specific risk management practices that were positively associated with program outcomes (Oehmen, et al., 2014). There were five practices noted for each of the first three categories in

Table 4 above; three for category 4; nine for category 5; and three for category 6. These specific practices were also tested for Goodman-Kruskal Gamma associations between these practices and a number of outcomes including project and product success (ibid). What's interesting about these findings is that they validate many of the risk management frameworks above. Many of the practices are already encouraged by those frameworks. The ten practices found to be successful, but not called for explicitly by the frameworks, are categorized in Table 4 above under "other" and deal primarily with organizational behavior and other management factors.

The Oehmen study used four outcome variables which were mapped to two success parameters. How well the project met its cost target and how well the project met its schedule target were two of the outcome variables, each of which was mapped to *project* success. The two other outcome variables, technical performance success and customer satisfaction success, were considered by Oehmen, et al. to represent *product* success.

Their survey found ten practices to be positively correlated with success, eight for product success and two for project success. Table 5 lists the variables Oehmen, et al. found to be statistically significantly correlated with outcome variables that, based on the research questions for this study, are most likely to be relevant. Each of the variables has a Kruskal Goodman Gamma that ranges from 0.41 to 0.52 which represents a moderate to strong relationship between these independent variables and the two dependent variables (schedule success and customer satisfaction success).

Table 5. Significant Schedule and Customer Satisfaction Correlations

Variable	Schedule Success (Kruskal-Goodman Gamma)	Customer Satisfaction Success (Kruskal-Goodman Gamma)
1.1 Our employees are motivated to perform/implement risk management(RM)	-	0.43
1.5 Our RM takes human and cultural factors into account	-	0.41
2.5 The RM process is effectively integrated…	-	0.46
3.1 The impacts of risk are quantified using cost as a dimension	0.41	-
3.2 The impacts of risk are quantified using technical performance…as a dimension	0.49	-
4.1 Resources are allocated to reduce largest risks as early as possible	-	0.42
5.8 Our RM is dynamic, iterative and responsive to change	-	0.40
5.9 Our RM is systematic, structured and timely	-	0.42
6.2 Our RM is transparent and inclusive towards all stakeholders	-	0.51
6.3 Our RM explicitly addresses uncertainty	-	0.42

(Oehmen, et. al., 2014)

Of the eight practices associated with product success, two were considered to be a part of the “skills and resources” category from the Oehmen study. Those two measured the motivation of employees to perform risk management and whether the risk management effort considers human or cultural factors. Risk management process integration and resource allocation to reduce risk were also found to be positively correlated with product success. The final four practices measured how responsive and structured the risk effort was and how transparent the effort was as well as how well the risk effort addressed uncertainty. All eight of these variables were reported having a Goodman-Kruskal Gamma of between 0.40 and 0.51, indicating a good correlation between these practices and their associated outcomes. These findings suggest not only that risk management may be correlated with product success, but also that specific practices might be related to project success.

The Oehmen study also considered additional outcome categories (quality decision making, high program stability, and a proactive and open organization) but were not considered relevant for this study's research questions since they do not relate to the definitions of project success as defined by the reviewed frameworks.

None of their variables were found to be correlated in a statistically significant manner with either cost success or technical performance success. However, the variables reported do offer a moderate covariance with the outcomes. This offers some indication that risk management is at least correlated with some measures of project success.

Air Force and Industry Risk Management Approaches

The third research question asks if there are difference between practices in use in industry and practices in use on Air Force projects. Based on the information contained in Table 1 and Table 3, it appears that DoD and Air Force guidance is quite similar in policy to the prescriptions provided by leading industry groups such as PMI or INCOSE. Assuming the DoD policy is implemented as written, one could reasonably expect the RM approaches used in both the Air Force and the private sector to be quite similar. What remains to be seen, however, is whether the approaches, or practices in use, are similar. A comparison of risk management practices in use in the Air Force is explored next.

Risk Management in Practice within the Air Force

A comprehensive review of all AF programs is beyond the scope of this study but two programs may make for a useful comparison. Both of these implemented, or failed to implemented, some of the practices discussed previously. They are the F-16 and F-35 fighter programs.

The F-16 was born out of the Lightweight Fighter Program (LFP). This effort began in earnest in 1972 and sought a small, inexpensive, and maneuverable fighter that would be less expensive to develop and provide the “low” part of the high-low fighter mix the Air Force was seeking (Aronstein & Piccirillo, 1996). The “high” role would be filled by the F-15; already in development and production at the time.

The AF selected two aircraft for test demonstration: the YF-16, developed by General Dynamics, and the YF-17, developed by Northrop. The aircraft were selected not based on their expected performance but on their dissimilarity. There was no expectation to purchase either aircraft. Instead, the design features were expected to be combined in some future aircraft. Selection of two designs for the same purpose is sometimes referred to as competitive prototyping. This is expected to reduce production risk by spending more money in development. Two designs offer a greater opportunity of finding at least one desirable aircraft and the presence of competition might be expected to create downward price pressure for the next phase.

The contract used for this development was a Cost Plus Fixed-Fee (CPFF). With this contract type, the contractor is paid a fixed fee and the customer (government) assumes the risk for any cost overruns. Additionally, the developer is only obliged to deliver their "best effort." In this case, the technical or performance risk is borne. Because of that, the developer may be willing to accept more technical risk which, while it might lead to a poor outcome, may also lead to a higher performance aircraft. The developer in this instance, General Dynamics, felt comfortable pursuing the technical risk associated with a fly-by-wire flight control system in the YF-16. This flight control, while revolutionary at the time, would allow the aircraft to be more maneuverable but would also require more computer control of the flight control surfaces. Despite the contract type, Northrop still did not feel comfortable with a fly-by-wire flight control for the YF-17.

There was also no scheduled delivery date. Instead, the Air Force wanted the contractor's very best effort. Former Air Force Systems Command commander General Alton Slay suggested that the individual aircraft testing will take place whenever they're delivered. This freedom to deliver should allow the contractor to take more design risk which might be expected to lead to greater performance if one were willing to pay for the added cost and schedule impacts should they occur. This again highlights the interdependence between cost, schedule and performance.

The request for proposal for the LFP was quite restrained coming in at only twenty-five pages (Ward, 2009). Relative to the F-15, the LFP sought a restrained technical solution well within the state of the art for the time (ibid). This reinforces the

DoD preference for more proven technology (as measured by TRLs) for use in acquisition programs.

Another interesting feature of the F-16 is its longevity and the number of successful modifications and upgrades. Originally, however, there was no immediate plan to upgrade the aircraft. Recent, though not current, DoD policy called for evolutionary development where the product would be planned for an initial production run with planned increments for improvement (DoD, 2008). While it's unclear why this preference was not included in current policies, this preference was expected to field capability sooner and less expensively than the alternate approach, i.e., single-step to maturity. In this case, the product is kept in development until the product meets 100% of all desired requirements. In hindsight, the F-16 appears to employ evolutionary development.

Only during test did a confluence of events take place where the Air Force selected the YF-16 as the "winner." Eighteen months later, the F-16 was in production. While not immediately selected, the YF-17 was the basis for what became the F-18, a more than capable aircraft. In this instance, the application of these risk practices made for a highly successful effort for both tested aircraft.

In contrast, the more recent F-35 development has proved to be a different program. Rather than a small, inexpensive, and limited design, the F-35 is actually three different aircraft (F-35A, F-35B, and F-35C) with substantially different features. While they are similar from the outside, the Air Force model (F-35A) is different from the Navy version (F-35C). In addition to other features, the F-35C has a larger wing area and different landing gear. The model developed for the Marines (F-35B) is the most dissimilar in that it features a completely different engine that allows it to perform take-offs from short runways and to land vertically. This feature is also referred to as Short Take-Off and Vertical Landing. Clearly, the program is not developing one aircraft but rather three distinct and different aircraft. This is a much greater technical challenge than the more limited requirements provided for the F-16.

Contrary to the F-16's appearance of evolutionary acquisition, the F-35 program's approach seems to use the opposite paradigm: single-step to maturity. Previously, the single-step to maturity approach was expected to keep the system in development longer, resulting in greater costs and greater delay in delivering the product or service to the end user.

The approach to engineering development is also different between the F-16 and F-35. Starting the in the 1950's, the DoD began pursuing concurrent development of individual sub-systems. That is, designers would develop an aircraft's airframe at the same time as they developed the engine at the same time they would develop other sub-systems. This is in contrast to the previous approach where individual items were developed sequentially. While this took more time, it reduced the risk of integration. This is the time in the program where sub-systems are matched together. Concurrent development sometimes resulted in re-work to address conflicts from concurrent development.

With the F-35 program, the DoD has decided to pursue not the concurrent development of individual sub-systems but rather they have opted to overlap whole phases of the defense acquisition system. DoD policy calls for technology development to mature risk to an acceptable level. Notionally, this technical risk is measured by

Technology Readiness Levels (TRLs) where a given technology should be at TRL 6 prior to entering the Engineering and Development Phase (EMD) (DoD, 2011). Then, engineering development can be performed to design and develop a production-ready system. Finally, the system is produced and operated. The F-35 program has opted to perform technology development at the same time as engineering development at the same time as production. This leads to production items which are already obsolete before they leave the production line. This practice also defeats the cost efficiency gains available from producing the same item multiple times. In effect, each aircraft is unique. The military should have learned its lessons from previous acquisition failures brought about by concurrent development (Converse, 2012) but, if it did, those lessons were not applied to the F-35.

This study seeks to evaluate the effectiveness of risk management. However, it's plain that the F-35 has deviated from what many of the previous frameworks define as best practices in risk management. Interestingly, the F-35 seems to have violated notional DoD policy that suggests a design should include proven technology and be proven through testing before going into production (DoD, 2013). The F-35 has called into question not just the effectiveness of risk management but rather the effectiveness of acquisition management as a whole. In light of the decisions leading to the current state of the F-35, it seems to make little sense to evaluate the effectiveness of risk management policies if the policies themselves aren't followed.

Survey Design

Since a survey will be used to partially answer the research questions, some review of that literature is warranted here. However, more details of the survey will be presented in the chapter on methodology.

One consideration that governs survey use is determination of sample size. Cohen (1992) has provided some meaningful insight on sample needs based on the size of the effect and the statistical test used. This article provides a number of considerations for sample size including the desired alpha (α) (or risk of incorrectly rejecting the null hypothesis) as well as type of test, and effect size.

One of the settings for the level of significance for the test, or alpha (α), is 0.05 which allows for a 5% chance of falsely rejecting the null hypothesis and accepting an effect exists when it does not (a Type I error). A 0.01 level of significance is sometimes used but appears too stringent for a survey asking respondents about behavior. The 0.10 level of significance is also used at times but increases the chance of a Type I error. Oehmen used a 0.01 level of significance (Oehmen, et al., 2014) but, given a smaller expected sample size, using a 0.05 level of significance seems to make sense here. This difference in significance presents some challenge but based on the expected sample size discussed below would be unavoidable. Since no attempt will be made to show one sample as being more or less significant, this difference should be a minor one.

The other two considerations are the type of test and effect size. Commonly, measures of correlation are used to show how two variables move together. Regression models can be used to determine the size of the influence in addition to correlation. Primarily, this research will look for correlations and, if warranted, characterize the correlations via a regression model. Oehmen reported Goodman-Kruskal Gamma values (correlation) of between 0.40 and 0.51. Cohen would consider this to be a medium to large effect for correlation and large for regression (Cohen, 1992). Cohen describes a medium effect size as one that would "represent an effect likely to be visible to the naked eye of a careful observer" (Cohen, 1992:156).

Based on the tests of correlation and a medium to large effect size, Cohen suggests a sample size of twenty-eight for a large effect and 85 for a medium effect given a 5% level of significance (Cohen, 1992:158). Since a regression model will also be used, Cohen suggests a sample size of 42 for a large effect and a sample of 91 for a medium effect (ibid).

Summary

The chapter has reviewed a number of factors useful for the remainder of the study. Definitions of "risk" and "risk management" were explored to provide a common set of terms. Additionally, five different risk management frameworks were explored to determine what prescriptions exist for practicing risk management. Additionally, a review of different studies were reviewed to determine if risk management might be expected to relate to project performance relative to cost, schedule, or performance success. Those studies also indicated that the practices provided are also effective in aiding projects to meet their cost, schedule, and technical performance success targets. Finally, a literature relevant to survey research was provided to provide a basis for reviewing the methodology in use for this study.

III. Methodology

Chapter Overview

This chapter will detail the research methodology for this effort. This research study's three research questions will be answered through the collection and analysis of survey data. Details will be provided covering the population of interest as well as the expected respondents. Additionally, information on the survey design, collection efforts, sample size, and analysis will be discussed.

Evaluating the effectiveness of risk management requires an analysis of the project team's behavior with respect to the type and extent of risk management practices that were used. While objective, quantitative data can be collected on some facets of project performance, this alone is insufficient because it would fail to capture the actual steps taken to reduce risk. With that in mind, a survey will be used to evaluate the risk practices that are employed by project teams. This survey work should provide more insight into the inner workings of the project than other purely objective methods such as merely reviewing cost and schedule performance. Those other methods would fail to capture the actual practices in use in the project office.

Since the goals of a project are to meet cost, schedule and technical performance targets, these will be the dependent variables for this study. Additionally, a measure of customer satisfaction will be used as another measure of project success. The independent variables will be individual risk practices that the reviewed frameworks prescribe to improve the likelihood of project success. These variables will be will be implemented by a survey instrument asking respondents about the practices in use on a project of their choosing and the success of that project as measured by achievement of success for the dependent variables.

Information provided from the survey will also be used to record the performance of the dependent variables. While potentially biased, this information can be better matched to the risk management practice information reported by the respondents. Since many defense projects/programs extend over many years, these respondents have more insight into the project during the same specific window in time during which the practices were in use. Longer term studies might be better for matching ultimate project performance and risk management practices but the necessity of baseline changes during a program that stretches years might be even more difficult to employ accurately than this methodology.

Population of Interest

The population of interest for this effort is U.S. Air Force (USAF) acquisition personnel. However, challenges exist to surveying this population. For example, Air Force policies strictly prohibit the use of surveys except in limited circumstances. Instead, a reasonable subset of that population will become the sample population of interest. The sample population of interest will be those who have completed AFIT's Intermediate Project Management Skills Course (IPM) 301 course. All of the personnel who might complete the survey will be from the Program Management or Engineering career fields since they represent those in the best position to consider cost, schedule, and technical success as well as the actual risk management practices in use on that project. However, other career fields such as Logistics, Cost Estimating, Financial Management and others might be interested in answering the survey. Any of these respondents comprise the sample under study and have similar backgrounds and expertise with respect to risk management practices on their assigned projects.

Survey Collection

An anonymous survey will be administered over a period of several months to collect data. The survey will be provided electronically via the Air Force Institute of Technology's (AFIT's) WebSIRS platform based on a design from the previous work of Dr. Josef Oehmen. That survey was previously used (Oehmen, et al., 2014) and forms the basis of this study.

The sample for this survey will be students attending classes at AFIT. The intent of this survey collection is to limit survey responses to those within the intended population (USAF acquisition personnel). Students will be solicited to complete the survey during time provided by their training event. Potential respondents will be advised of the voluntary nature of their involvement and other human subject rights such as the ability to exit the survey at any time without penalty. Given the limitations of performing survey work within the Air Force, no attempt is made to broadcast the availability of the survey by any means other than these class settings.

The primary means of collecting survey data, IPM 301, provides access what should be a representative sample of the target population. This course, offered by AFIT's School of Systems and Logistics (AFIT/LS), is an Air Force fulfillment of the requirement for two of the Defense Acquisition University (DAU) Program Management Tools (PMT) courses, PMT 251 and PMT 257. Those courses focus on program management tools and are required for the DoD Acquisition Professional Development Program (APDP) Level II Program Management Certification. Because of that fulfillment, the course is in high demand and is expected to draw a large number of students from the desired population.

Participants in this class typically range in rank from 1st Lieutenant (O-2) to Major (O-4) for the active duty students, although more senior members do attend periodically. Civilian participants of the course are typically between GS-09 and GS-13, although, more senior civilian members may attend on occasion as well. The active duty students typically have between two and twelve years of government acquisition experience. The civilians present a much wider range of experience where some are retired military personnel and others joined the civil service after some time in civilian industry. In short, this class provides a wide range of background and experience to inform the students' responses to the survey.

Achieving the desired sample size is critical for survey research. Based on this guidance from Cohen, a minimum desired sample size is 42 (in the event a large effect is expected) and a sample size of 91 (in the event a small effect is expected) (Cohen, 1992). The Oehmen study noted in their effect what Cohen might consider a large effect. The actual sample size needed will be dictated by the effect noted in this study but a sample size between 42 and 91 should be expected to meet the needs of the analysis planned.

Survey Details

The survey for this study will be kept as similar to the Oehmen study in all ways possible. Since that survey was designed for use in industry, the survey for this research was adapted to make it more meaningful for a government audience. The original survey questions are provided as Appendix A. In order to aid in comparing results, every effort was made to keep the questions and response options as consistent as possible. In most cases, the questions remained identical in wording and answer type. However, some questions simply were not applicable to the government so changes were made. For example, the original industry-focused survey asked about the use of cost reimbursable contracts which, from industry's perspective, serves to place risk on the government. This survey instead used fixed price contracts in lieu of cost reimbursable contracts for this question since, in this case, their use would put that same risk on to the private contractor. Finally, two demographic questions were added. One asked the respondent if they were a military member, civilian or contractor and the other asked how many years of acquisition experience the respondent has. Other than these changes, the survey for this study and the Oehmen study's survey will be the same in questions, pagination and grouping, or the "binning", of constructs.

The survey is comprised of four question categories. First, respondents are asked for basic demographic data concerning professional experience and career field background. Additionally, they are instructed to answer all of the questions using the same project as a reference point. Second, respondents are asked about a variety of organizational factors. These organizational factors include budget, development approaches/methodologies and specifically which risk management models are in use. This information will potentially be used for exploratory analysis to look for other factors related to risk management performance. The third set of questions deal specifically with risk management processes. Risk management process areas include planning, risks and risk analysis, risk mitigation, and risk monitoring. Finally, in the fourth set of questions, respondents are asked to provide information on risk management performance where they have the opportunity to provide insight on how effective efforts are at improving project or program success.

In total, the survey in use for this study comprises 173 questions and it's expected to take approximately 30 minutes to complete. This includes ten demographic questions and twenty additional questions pertaining to a project in which the subject was involved. Within the 173 questions, are an additional seventeen questions on risk management planning. Most of the questions to this point in the survey are on a five-point Likert scale (i.e., "strongly disagree" to "strongly agree"). There are a few open-ended questions to allow for free entry of text as well as three questions which allow for the selection of more than one response.

Table 6, below, provides a summary of the questions on the survey.

A few of the survey questions will not be considered for this study. Questions 1 through 30 had more to do with demographics of the respondent. These will be reviewed for demographic information but will not be part of the statistical analysis. Additionally, Questions 48 through 77 asked the respondents about the impact of risks that had happened. The binary and free text questions were included as qualitative questions for exploratory reasons. These questions were posed for use with a different methodology. They are not useful for the current research questions and methodology, however, and thus will not be included in the statistical analysis.

Table 6. Survey Questions and Answer Types

Question Category	Answer Type	Number of Questions
Demographics – Organization/Individual	Mixed (drop down, binary, free text)	10
Demographics – Project/Program	Mixed (drop down, Likert, binary, free text)	9
Project/Program – Challenges Experienced	Five-point Likert (“very low” to “very high”) with one free text	11
Risk Management - Planning	Five-point Likert (“strongly disagree” to “strongly agree”) with one binary and one free text	17
Risk Management – Risks and Impacts	Six-point Likert (“not occurred” to “ very high impact”) with five free text	30
Risk Management – Analysis and Quantification	Five-point Likert (“never” to “always used”) with one binary and one free text	7
Risk Management – Risk Evaluation	Five-point Likert (“never” to “always used”) with one free text	9
Risk Management – Risk Mitigation	Six-point Likert (“not used” to “very high risk reduction achieved”) with one binary and five free text	38
Risk Management – Monitoring and Review	Five-point Likert (“completely disagree” to “completely agree”)	5
Risk Management – Formal Review	Nine-point Likert (“daily” to “only after specific events”) with two binary and one free text	9
Risk Management - Performance	Five-point Likert (“strongly disagree” to “strongly agree”)	22
Overall Project Success	Five-point Likert (“complete failure to meet target by more than 30%” to “Strongly exceeded target by 30%”)	6

Questions 153, 155, 162, and 166 asked the respondent about the outcome of risk management (i.e., organization is satisfied with RM performance, the ROI of RM is positive, etc.). Since this study is using the cost, schedule, technical performance, and customer satisfaction success variables as outcome variables, these questions did not add any additional insight and were ignored. These were kept in the original survey to match the original survey as much as possible. However, the recently published Oehmen article did not center on these questions so they will not be used for this study either. This reduced the number of useful questions for correlation and statistical analysis from 173 to 95 for this study.

The dependent variables for this survey map to questions 168 – 171 and correspond to, respectively, cost success, schedule success, technical performance success, and customer satisfaction. All four questions are answerable with a five-point Likert scale ranging from "complete failure to meet target (by more than 30%)" to "Strongly exceeded our target (by more than 30%)." The answers for cost and schedule may be fairly simple. Both can be measured on a numeric scale of some kind--cost in currency and time in days, weeks, etc. The technical performance measure is a little more difficult. Few large systems have a single dimension of technical performance so the respondent may be forced to make broad generalization from their view of the project which could be limited to their technical area of expertise.

The measure for customer satisfaction presents some challenge. For one, since most of the frameworks above agree that the three goals of a project are cost, schedule, and scope/performance, customer satisfaction would presumably be a function of the other three variables. Additionally, the satisfaction score is reported by someone in the developing organization, not someone from the client's or customer's organization. While interesting as an outcome variable, this one presents the most challenge for drawing inferences.

However, the information collected from this variable could still represent useful information. Notionally, a customer's satisfaction would be a function of cost, schedule and performance. However, military users might be different. Since the user of the delivered service or product is likely not paying directly for the product, they may be disinterested in the cost of item unless is directly and immediately influences the quantity available for purchase. Even then, it might not be immediately known. While the user might like the deliverable sooner, some have argued that the military user is most interested in technical performance and most flexible on cost (e.g., Wirthlin, 2009). With these thoughts in mind, this dependent variable will still be explored since it provides a useful measure different from the other three dependent variables.

Survey Data Analysis

The survey data will be analysis through a variety of steps. Once the surveys are collected, the raw data will be processed to remove blank or incomplete entries. Since questions may be skipped, some missing data may exist but will be left in the data set provided the respondent made it far enough into the survey to begin answering questions on risk practices. All of the data statistical analysis will be performed using SPSS.

Prior to survey analysis, a few questions will be adjusted. The response scale for questions 137 through 140 will be reverse coded. Originally, these response options were ranked high to low where most of the other Likert options in the survey ranged low to high. Additionally, Questions 156 through 160 will be reverse coded for the same reason. Initially, the questions ranked most to least frequent with respect to reviewing the risk management effort. After these changes, all of the survey responses can be matched against each other in a consistent manner on the same ordinal scale.

The research questions and their methodologies are summarized in Table 7 below.

Table 7. Research Questions and Methodologies

Question	Hypothesis	Methodology
Q1. Does a relationship exist between risk management and an Air Force project meeting its cost, schedule, and performance goals?	H1. There exists a statistically significant correlation between risk management practices and Air Force project success relative to cost, schedule or performance goals.	Survey correlation analysis
Q2. How effective is the Air Force risk management effort in aiding its projects to meet their given cost, schedule and performance targets?	H2. At least one risk management practice will be shown to significantly affect Air Force project success relative to cost, schedule or performance goals.	Survey correlation analysis combined with factor/regression analysis
Q3. Are there differences between the effective risk management practices used in industry and those used by the Air Force?	H3. A difference does not exist between the effective industry practices shown to relate to affect Air Force project success relative to cost, schedule or performance goals.	Survey correlation analysis comparing these results with the Oehmen study results

Table 7 above will be helpful for following the structure of the methodologies described in this chapter as well as the analysis performed in the subsequent chapter.

Research Question 1 Methodology

This research question will be answered by performing a correlation analysis comparing individual questions with the four dependent variables. To ease both understanding and clarity in answering the research questions, the individual survey questions will be analyzed here in bins that match the risk framework steps for this study. This framework will make clear any relationship risk management has with project success outcomes. This correlation analysis will be performed using Pearson's correlation coefficient and examine if individual questions have a relationship with the four dependent outcome variables. This question can be answered by looking for statistically significant correlations between the individual questions and the outcome variables.

The null hypothesis for this question is that no relationship exists between risk management and project success with respect to cost, schedule, technical performance, and customer satisfaction. If the null hypothesis cannot be rejected, the study will conclude that no relationship exists for this sample population.

Research Question 2 Methodology

The previous correlation analysis will also be used to partly answer the second research question. Since this question asks about the effectiveness of risk management, the magnitude and direction of the correlation will also be reviewed. Finally, that correlation analysis will be used as the basis for answering the third research question through the use of a factor analysis followed by a multiple linear ordinary least squares regression.

This study will attempt to preserve the same basic analytical model as the Oehmen study and make use of the same factors. If possible, this study will attempt to construct and test the same factors used in the Oehmen study. These factors are the same as those provided in Table 4 where they were mapped to the individual risk framework steps. Each dependent factor variable will be tested for its relationship to all six independent variables. It is hypothesized that all six independent variables are positively related to the dependent variables. The planned independent and dependent variables are displayed in Table 8 below.

Table 8. Oehmen Survey's Independent and Dependent Variables

Independent Factors	Dependent Variables
IV1. Risk Management Skills and Resources	DV1. Project Cost Success
IV2. Risk Management Tailoring	DV2. Project Schedule Success
IV3. Risk Impact Quantification	DV3. Product Technical Success
IV4. Risk Based Decision Making	DV4. Customer Satisfaction
IV5. Risk Monitoring and Review	
IV6. Transparency	

(Oehmen, et al., 2014)

These independent factors describe a number of constructs. The first independent factor described above describes how well skills and resources are provided to deal with risk management. Since all projects are unique, the second factor describes how well the risk effort was tailored to deal with the specific project under analysis. The third factor, risk quantification, describes how well the identified risks were quantified as part of the analysis step. The fourth factor describes how well the risk analysis was included in decision making for the project and organization. The fifth factor, risk monitoring and review, focuses on how well risks were tracked during project execution. Finally, transparency measures how well risks were communicated though-out the organization(s) involved in the project.

In the event the constructs cannot be recreated, questions with a statistically significant correlation will be used in an exploratory factor analysis to construct factors that can be used in a multiple linear regression model. The exploratory factor analysis will be performed to examine the dimensionality of the constructs involved. This factor analysis will seek to identify the underlying relationships between measured variables and provide support for the latent constructs in the survey.

Reliability analysis will be performed on the individual questions using Chronbach's Alpha as the test statistic (George and Mallery, 2003; Kline, 1999). An Alpha of 0.700 or greater will be used as support to aggregate the individual questions into an overall latent variable for each of the six independent variables listed above. Aggregated factors will be calculated by averaging the score of the individual questions within those factors/variables.

A review of the descriptive statistics will be performed on the factors. This will assess normality of the data. Additional statistical analysis may be required in the event the data fails this test of normality. Aggregated factor means, standard deviations as well as kurtosis and skewness will be reviewed to ensure the measures are sound for additional analysis.

Assuming normality with the individual factor averages, a correlation table using Pearson's correlation coefficient will be examined. This correlation table will be used to assess the relationship the constructed factors have with the four dependent variables. This relationship will be reviewed for both significance as well as the strength and direction of the relationship (positive or negative).

Finally, four multiple linear regressions will be performed to model the relationship between the independent factors and each of the four dependent variables (cost, schedule, technical performance, and customer satisfaction). The models will be examined to determine what significance and relationship the individual factors have with each of the four dependent variables.

The null hypothesis for this question is that risk management is not effective in aiding the project in meeting its success target with respect to cost, schedule, technical performance, and customer satisfaction. If the null hypothesis cannot be rejected, the study will conclude that risk management is not effective.

Research Question 3 Methodology

Since the Oehmen study did not perform any regression analysis, any comparison to that study will be limited to comparing correlation tables only. This research question will be answered by using the correlation results used to answer the first two research questions and comparing those to the results published for the Oehmen study. Significant questions from the two studies will be compared to determine if they are the same questions and to evaluate the direction of the relationship (positive or negative). This study uses Pearson's correlation coefficient where the Oehmen study uses Kruskal-Goodman's Gamma. Since they are different measures of correlation, no determination can be made about a given question being more or less correlated but the two can still be compared for significance and direction of impact.

The null hypothesis for this question is that a difference does exist between the effective risk management practices used in industry and those used in the Air Force. If the null hypothesis cannot be rejected, the study will conclude that a difference does exist between the industry practices and the Air Force practices..

Summary

This chapter details the method for answering the three research questions. A survey will be administered to Air Force acquisition personnel who represent the sample population of interest. Data from this survey instrument will be used to perform a correlation analysis to answer the first two research questions. Finally, a factor analysis and regression analysis will be performed to answer the third research question.

IV. Analysis and Results

Chapter Overview

A number of analysis steps are performed to answer the research questions. First, some preliminary survey data analysis is performed to evaluate the demographics of the respondents. A correlation analysis is performed to answer the first research question. Those results are used along with a factor analysis to perform regression models for each of the four dependent variables to answer the second research question. Finally, results from this survey are compared to the survey performed by Oehmen, et al. to determine what, if any, difference exists between those two samples.

Survey Collection

Survey responses were collected from 6 June 2013 to 12 March 2015. Surveys were expected to come from three different training class sources but, in the end, all or nearly all of the responses came from AFIT's IPM 301 course. Historically, the course is attended almost exclusively by acquisition program managers with the exception of the occasional engineer or logistician. The actual student demographics for this course match those expectations detailed in Chapter 2, but the total number of responses was less than expected. In total, 190 students started the survey, with only 127 of them completing enough of the survey for it to be of analytical value in this study. Depending on the variable in question, the number of useful responses was less than 80. Based on Cohen's recommendations regarding, this is well above the lower number required, and close to the higher number, so this should be sufficient depending on the strength of impact found from the data analysis.

In addition to the challenges encountered in collecting surveys from the two partner organizations (DAU and AFLCMC), even the AFIT students had difficulty completing the survey. The survey was hosted on AFIT's WEBSirs electronic survey platform. On numerous occasions, students experienced system outages when attempting to access the survey. In some cases, the electronic survey was restored in time for those students to complete the survey prior to the end of their course. However, in a few of cases, students completed their two week course without being able to access the survey. These problems also contributed to a lower number of survey responses than expected.

Respondents were asked a number of demographic questions. One of those questions asked about their amount of acquisition experience. This is summarized in Table 9 and Figure 1 below.

Table 9. Survey Respondent's Years of Acquisition Experience

	Frequency	Percent	Valid Percent	Cumulative Percent
Missing	1	.8	.8	.8
0-5 years	80	64.5	64.5	65.3
6-10 years	21	16.9	16.9	82.2
11-15 years	7	5.6	5.6	87.8
16-20 years	6	4.8	4.8	92.6
20+ years	9	7.3	7.3	100.0
Total	124	100.0	100.0	

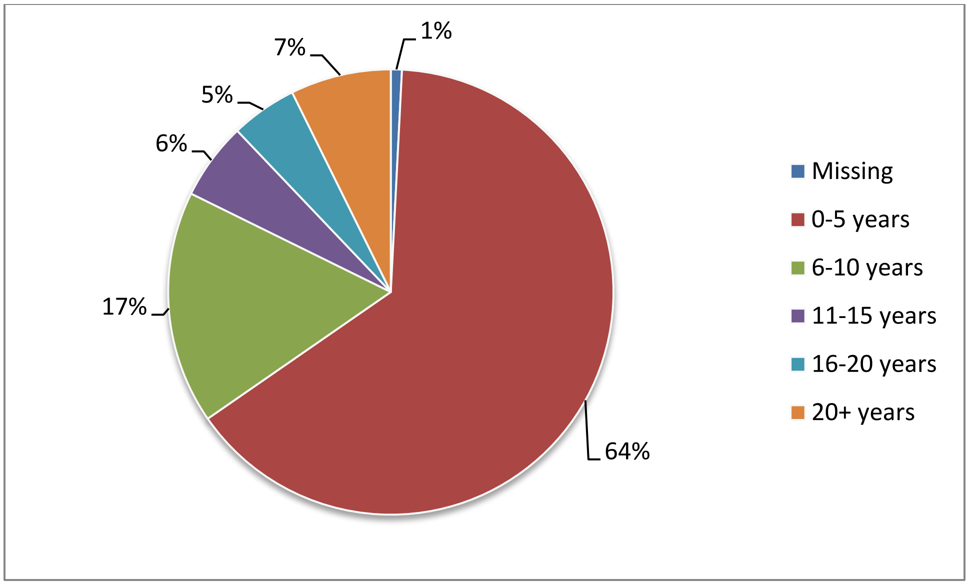

Figure 1. Survey Respondent's Years of Acquisition Experience

Since the course is targeted at students with three years of acquisition experience, the larger number of less experienced respondents is expected. However, as shown in the table above, the course also draws more experienced personnel. This is likely due to the course's status as a fulfillment of certification requirements for their job positions.

Respondents were also asked about their employment status at the time they filled out the survey. These results are summarized in Table 10 and Figure 2 below.

Table 10. Survey Respondent's Employment Status

	Frequency	Percent	Valid Percent	Cumulative Percent
Active Duty	63	50.8	50.8	50.8
Civilian	60	48.4	48.4	99.2
Contractor	1	.8	.8	100.0
Total	124	100.0	100.0	

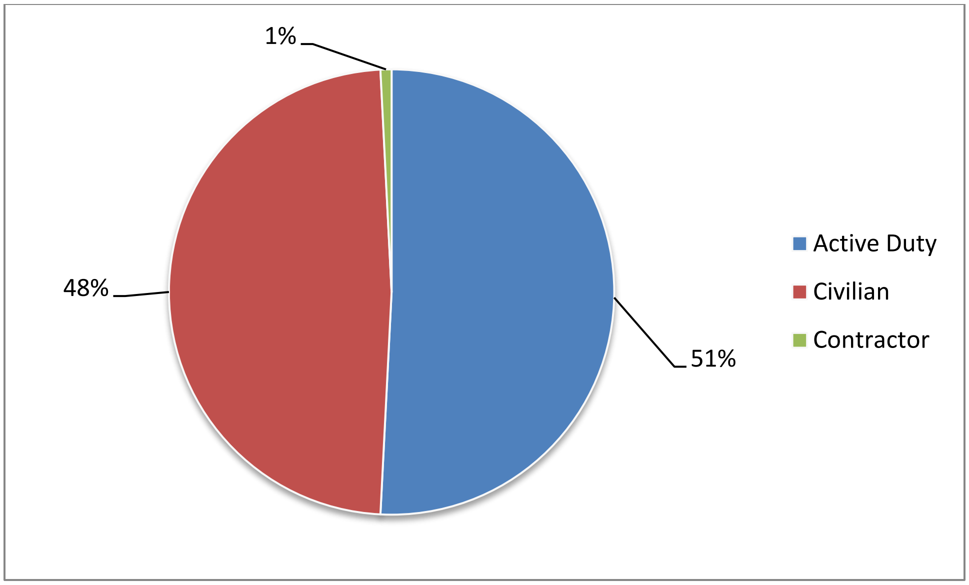

Figure 2. Survey Respondent's Employment Status

One respondent identified him or herself as being a contractor working directly in a government program office. While contractors may have work that is different from direct Air Force employees, a contractor working in a direct support position in the government program office might be expected to have similar work history and views as the direct employees and so these responses were deemed to be valid for inclusion in this study.

Survey Data Analysis

To match the original Oehmen study, this sample was reviewed for correlations comparing the relationship between the independent questions and the final four dependent questions on outcome success (cost, schedule, technical performance, and customer satisfaction). Using Pearson’s correlation coefficient (r), a number of variables were found to be statistically significant in their covariance with the four outcome (dependent) variables. Some of these questions match those discovered by the Oehmen article, while some did not. Additionally, an exploratory factor analysis is presented and multiple regression models show the relationships those factors have with the dependent variables.

The methodology for answering the three research questions will now be discussed.

Research Question 1: Correlation Analysis

The first research question asks if a relationship exists between risk management and the Air Force project meeting its cost, schedule, and performance success targets. The following section will analyze the survey data in an effort to answer that question by examining the correlations of each risk management step.

This study found a much larger list of variables to be significantly correlated with the four outcome variables than what Oehmen found. However, this may be due to the difference in the selected level of significance. Recall that Oehmen selected the 0.01 level of significance whereas this study uses the 0.05 level of significance.

This study finds a total of 48 of the 109 questions in use to be significantly correlated (as measured by the Pearson correlation coefficient) with the four selected outcome variables. Thirty of these questions are related to risk management practices associated with planning and preparation to reduce risk. The additional eighteen questions were found to be significant correlations between specific risk handling plans and are described later. All of the significant variables had sample sizes between 74 and 82.

The statistically significant correlations are provided in a series of tables below (along with their p-values in parentheses) based on the risk management frameworks discussed in Chap 2. This will improve clarity as well as provide additional support for the frameworks themselves. Note that some of the names of the dependent variables in the columns have been shortened from schedule success, technical performance success, and customer satisfaction success to "Sched. Success," "Tech. Perf. Success," and "Cust. Sat. Success," respectively.

Risk Management Planning

Recall that the first risk management step for use in this study is risk management planning. These actions are taken by the organization to focus the risk management on the specific project at hand. The correlation results for the significant risk management planning questions are provided in Table 11 below. The top number in each data cell is the correlation coefficient with the corresponding p-value shown in parentheses below.

Table 11. Significantly Correlated Planning Variables

Risk Planning Variables	Cost Success	Sched. Success	Tech. Perf. Success	Cust. Sat. Success
Q31. Our employees are motivated to perform/implement risk management	-	-	-	0.295 (0.008)
Q35. RM is systematic, structured and timely	-	-	-	0.238 (0.032)
Q45. RM teams are cross-functional and cross-organizational	-	0.236 (0.033)	-	0.268 (0.015)

Table 11 shows that project performance was significantly correlated with three instances (of the fifteen questions used) pertaining to the risk planning phase. Schedule and customer satisfaction outcomes are correlated with three questions but no questions were found to relate to either cost or technical project performance.

Interestingly, having employees motivated to perform risk management is found to be highly significantly correlated with customer satisfaction success (p-value: 0.008). While none of the reviewed frameworks discuss motivation explicitly, it seems to make logical sense that personnel will perform better with greater motivation.

These three risk planning variables provide some evidence for a relationship between risk management and project outcomes.

Risk Identification

Recall that the second step in the risk management framework for this study is risk identification. None of the questions corresponded with risk identification so no results are presented here.

Risk Analysis

The following step is risk analysis. Those questions found to have significant correlations are summarized in Table 12 below.

Table 12 shows that project performance significantly correlates with nine instances (of the thirteen questions used) pertaining to the risk analysis phase. At least one of the questions correlates with at least one of three dependent variables: schedule, technical performance, and customer satisfaction outcomes were all correlated with three questions. None of the questions correlate with cost success.

Table 12. Significantly Correlated Risk Analysis Questions

Risk Analysis Variables	Cost Success	Sched. Success	Tech. Perf. Success	Cust. Sat. Success
Q80. Assessment of risks on scales	-	-	0.235 (0.035)	-
Q83. Monte Carlo simulations to aggregate different types of risk estimates	-	-	0.253 (0.025)	
Q85. Make go/no go decisions based on risk assessment	-	-	0.284 (0.010)	-
Q86. Resources are allocated to reduce target risks as early as possible	-	-	-	0.230 (0.040)
Q87. Risk assessments are used to set more 'realistic' or 'achievable' objectives	-	0.231 (0.037)	-	-
Q89. The results of the risk analysis are considered in making technical, schedule and/or cost trade-offs	-	-	0.272 (0.013)	-
Q90. Decisions are made based on risk-benefit trade-offs	-	0.241 (0.030)	0.281 (0.011)	0.306 (0.006)
Q91. Risk-benefit trade-offs are used systematically to favor 'low-risk, high-benefit' options and eliminate 'high-risk, low-reward' options	-	0.271 (0.014)	0.259 (0.019)	0.234 (0.036)
Q92. Contracts are derived from detailed cost risk assessments	-	0.230 (0.039)	0.237 (0.033)	0.251 (0.025)

Seven questions are significantly correlated with technical performance success. The three questions regarding trade-off studies and contract type are also found in this group. The additional questions also deal with trade-off decision making with the final two questions dealing with how the analysis was performed. The practice of assessing risks on scales and the performance of simulations were also significantly and positively correlated with technical performance success.

Four of the questions related to Risk Analysis are significantly correlated with schedule success and four are found to correlate significantly with customer satisfaction. These two outcome variables share three of the questions (regarding trade-off decisions and contract type). All of the questions here are positively correlated and provide some non-negative support for the guidance provided by the reviewed frameworks.

These twelve risk planning variables provide some evidence for a relationship between risk management and project outcomes.

Risk Mitigation

A number of questions asked respondents about risk reductions achieved through the implementation of specific practices. This set is analogous to the risk mitigation and implementation step in use for this study. They also provide some insight into specific practices found to correlate with the cost, schedule, technical performance, and customer satisfaction outcomes. As reviewed above, risk mitigation plays an important part of the risk management frameworks analyzed. The significant correlations are provided in Table 13.

Table 13 shows that project performance was significantly correlated with eighteen instances (of the thirty-two questions used) pertaining to the risk mitigation phase. This set might provide the best support for risk management in that these questions ask about the *amount* of risk reduction achieved. In other words, these questions provide some insight into the types of risk mitigation pursued to achieve the

Table 13. Achieved Risk Mitigation Actions Significantly Correlated with Outcomes

Risk Mitigation Variables	Cost Success	Sched. Success	Tech. Perf. Success	Cust. Sat. Success
Q96. Contractor/Government integration	-	0.284 (0.011)	0.344 (0.002)	0.323 (0.004)
Q97. Organization-internal integration	-	-	0.316 (0.005)	0.312 (0.005)
Q99. Schedule reserves	-	-	0.261 (0.020)	-
Q100. Contractual sharing of cost overruns with contractor(s)	-	0.337 (0.003)	-	-
Q101. Contractual sharing of cost overruns with other organizations	-	0.292 (0.010)	-	-
Q106. Detailed cost, schedule, and performance simulations and trade-off studies	-	-	0.327 (0.003)	0.316 (0.004)
Q108. More detailed design reviews	-	0.247 (0.027)	0.379 (0.000)	0.305 (0.006)
Q109. Training program or special career path to increase skill level	-	0.245 (0.032)	-	-
Q110. Define 'standard work' or 'standard processes' to increase process reliability	-	-	-	0.285 (0.011)
Q113. Active internal lobbying toward top management to promote project	-	0.250 (0.028)	0.243 (0.032)	-
Q117. Management of requirements	-	0.264 (0.021)	-	-
Q118. Active lobbying with key stakeholders outside of direct customer/contractor relationship	-	0.320 (0.006)	0.291 (0.011)	-
Q122. Increased testing and prototyping activities	-	-	0.222 (0.048)	-
Q124. Develop flexible product architecture	-	-	0.243 (0.031)	-
Q125. Strict configuration control	-	-	0.348 (0.002)	-
Q126. Engineering with redundancy or safety margins	-	-	0.290 (0.010)	-
Q127. Pursue several engineering solutions in parallel	-	-	0.249 (0.026)	-
Q128. Focus on design for manufacturing or design for service	-	-	0.254 (0.026)	-

cost, schedule, technical performance, and customer satisfaction outcome success noted by the respondents. Still, these measures look only at correlation and not causation, so a clear a line between these results and risk management effectiveness remains elusive.

Interestingly, none of the Risk Mitigation questions correlate significantly with the cost success outcome variable. While these variables continue to provide evidence that some positive relationship exists between a long list of example risk mitigation options, this lack of influence on cost success remains interesting and unexplained directly by the data.

This group also includes seven questions that are highly significantly correlated with at least one of the dependent variables. These include the integration of risk management within the organization as well as between the customer and developer (government/contractor). Interestingly, contractual sharing of cost overruns had no relationship with cost but does positively relate to schedule success. Engineering and considerations such as trade-offs, design reviews, and configuration control were also found to be highly significantly correlated with technical performance and/or customer satisfaction success. The final significantly correlated questions covers lobbying with key stakeholders outside of the customer/contractor relationship.

These eighteen risk mitigation variables provide some evidence for a relationship between risk management and project outcomes.

Risk Tracking

The next set of correlations deals with Risk Tracking. This step follows the implementation of the selected risk responses to reduce risk likelihood and/or impact and is sometimes referred to as risk monitoring and review. In total, five questions are found to significantly correlate with the outcome variables. These results are summarized in Table 14 below.

Table 14. Significantly Correlated Monitoring and Review questions

Risk Tracking Variables	Cost Success	Sched. Success	Tech. Perf. Success	Cust. Sat. Success
Q132. Risks were escalated to senior management according to guidelines	-	0.236 (0.035)	0.279 (0.012)	0.234 (0.036)
Q133. Risks were regularly re-assessed according to guidelines	-	-	0.315 (0.004)	-
Q134. The RM process was regularly reviewed and improved	-	0.248 (0.029)	0.251 (0.027)	-

Table 14 shows that project performance was significantly correlated with three instances (of the eleven questions used) pertaining to the risk monitoring phase. Once again, the questions correlate with schedule, technical performance, and customer satisfaction but none for cost success.

One question, escalating risks to senior management, was found to correlate significantly and positively with the other three outcome variables. This seems reasonable in that senior management likely has more resources available to allocate to risk reduction. This would also seem to influence costs success as well. However, it may not appear here for a few reasons. For one, the government respondents may have contracted the developed on an FFP contract and would likely be blind to the cost status of the project. Alternately, perhaps the risk reduction efforts to achieve the schedule, technical performance, and customer satisfaction success consumed additional financial resources that, while it improved three of the four outcome variables, may have harmed the cost success of the project in some manner.

Two additional questions correlated significantly and positively with technical performance success. One of the questions, how risks were re-assessed, correlates highly significantly with only technical performance success where the other, that RM processes were reviewed, correlates with both schedule and technical performance success. This finding is expected based on the frameworks reviewed and a logical interpretation of the questions.

These five risk tracking variables provide some evidence for a relationship between risk management and project outcomes.

Risk Management Performance

The final set of reviewed correlations provides insight to the organization's view of risk management and its perceived value. Table 15 summarizes these findings below.

Only three questions correlate significantly with cost success. Those three and an additional question correlate significantly with schedule success. These questions all provide some limited non-negative support for the effectiveness of risk management.

However, twelve questions are correlated positively and significantly with technical performance or customer satisfaction success. Ten of these questions correlate positively and significantly with both outcome variables. In short, these questions all provide non-negative support for open communication within the project. They also provide non-negative support for the notion that an organization that perceives value in risk management will also reap its benefits.

Table 15 also shows that project performance is significantly correlated with thirteen instances (of the twenty-two questions used) pertaining to risk management performance. All of these questions correlate positively with at least one of the outcome variables and ten of them correlate at the 0.01 level. There continue to be relatively few questions that correlate significantly with the cost success variable; only three.

Table 15. Significantly Correlated Performance Variables

Risk Management Performance Variables	Cost Success	Sched. Success	Tech. Perf. Success	Cust. Sat. Success
Q146. PMs support RM activities	0.221 (0.046)	0.225 (0.042)	0.249 (0.024)	0.299 (0.007)
Q147. RM results play an important part in the decision making of senior managers	-	0.252 (0.022)	0.320 (0.003)	0.372 (0.001)
Q148. RM results influence trade-off decisions	-	-	0.266 (0.016)	0.243 (0.029)
Q150. RM processes are primary mechanism to determine management reserves	0.229 (0.039)	0.208 (0.060)	-	-
Q151. Findings from the RM processes translate into action	-	-	-	0.293 (0.008)
Q154. Budgeting for risks is an incentive against identifying new risks	-	-	0.264 (0.019)	0.335 (0.003)
Q156. RM creates and protects value	-	-	0.460 (0.000)	0.393 (0.000)
Q158. RM is a central part of decision making	-	-	0.349 (0.001)	0.399 (0.000)
Q159. RM facilitates continuous improvement in the organization	-	-	0.301 (0.006)	0.458 (0.000)
Q160. RM has a positive influence on program success	-	-	0.352 (0.001)	0.448 (0.000)
Q161. Project management took a proactive stance in addressing risks and issues	-	-	0.337 (0.002)	-
Q164. Concerns were heard and addressed	0.250 (0.023)	0.256 (0.020)	0.235 (0.033)	0.316 (0.004)
Q165. It was OK to report 'bad news' and concerns	-	-	0.310 (0.005)	0.333 (0.002)

Additionally, four of the variables were found to correlate significantly with schedule success, eleven with technical performance success, and eleven were significantly correlated with customer satisfaction success. Two of the questions correlate with all four dependent variables.

These thirteen risk performance variables provide some evidence for a relationship between risk management and project outcomes.

Research Question 2: Factor Analysis, and Multiple Linear Regression

The previous correlation analysis used for Research Question 1 will be used for answering this research question as well. The correlation analysis is used to provide a list of significant questions for further analysis. That analysis will be followed by a factor analysis and multiple linear regression to fully answer this research question.

Factor Analysis

Since correlation doesn't provide a great picture of relative impact, additional statistical analysis was performed to see which variables had the greatest influence on the outcome variables. This was performed with linear regression. However, additional question analysis was required prior to performing those regressions.

Recall that the survey was originally used by the Oehmen study to analyze a population of various companies. The questions were kept the same to perform a comparison of one-to-one correlations between dependent and independent variables among the two samples but, for more detailed statistical analysis for the Air Force, not all questions were useful. Additionally, the initial factor analysis was performed using principal component analysis as the extraction method with varimax orthogonal rotation. Orthogonal rotation is selected when the variables are expected to be uncorrelated (Field, 2009). That attempt failed to find the same grouping as used by Oehmen. Next, the factor analysis was performed again using the oblimin oblique rotation which is selected when the variables are expected to be correlated (Field, 2009). In neither case, did the principal component analysis extraction find the same groupings as the Oehmen study. Therefore, additional review was required.

The questions were reexamined for both face and content validity. The Oehmen study had a large number of questions that were deemed to be exploratory in nature and were removed from further statistical analysis. Given the small sample size, the questions were reviewed to further limit the dependent variables and questions to fewer than what was expected at the beginning of this study. The review for face validity sought to ensure the questions were sound and met a basic test of reason. The following content validity sought to ensure that the questions met with the expectation provided by the leading risk management framework reviewed in Chapter 2. This review reduced the survey question variables from 173 questions to just twenty.

This additional review produced six dependent variables each with a number of subset questions. Table 16, below, provides the six variables and the questions associated with each.

Table 16. Independent Factors and Contents

Independent Variable Factor	Content of Variable
RiskPlanning	Questions 31, 35, and 45
RiskEvaluation	Questions 85 – 87, 89 - 92
RiskMonitor	Questions 132, 133, and 146
RiskInfluence	Questions 148,150, and 151
RiskPerception	Questions 156, 158, 159, and 160

Since the same factors used by Oehmen could not be constructed, the variables were changed. While some of the same questions are used in both this study and

Oehmen's, there isn't enough overlap to compare the factors directly. Additional detail on the comparison can be found in the results for the third research question found toward the end of this chapter during the discussion for the third research question comparing industry and Air Force practices. From here on, only the new independent variable names will be used for clarity.

The first variable is RiskPlanning. The three questions that comprise this factor ask about employee motivation to perform risk management (Q31), if the risk management is systematic and structured (Q35), and if risk management is effectively integrated with other PM processes (Q45). The questions that form this factor are presented in the section of the survey on risk management planning. If project team members are more motivated to carry out risk management and the RM processes are better integrated with the rest of the process, one might expect better formulated and implemented risk management plans.

The second variable is RiskEvaluation. This factor includes seven questions that all appear in the survey section on evaluating and making use of the risk analysis. The questions ask respondents about how well risk is included in making decisions. For example, students are asked in this section if go/no-go decisions based on risk assessments and are the results of the risk analysis used in making cost/schedule/technical trade-offs. One might expect that decisions made with the inclusion of risk analysis and assessments should lead to project performance that more closely matches the expectations.

The third independent variable is RiskMonitor. The three questions that comprise this factor ask respondents about their project's risk monitoring and review process. For example, respondents were asked if risk were escalated to senior management and if the risks were regularly reviewed. One might expect that risks reviewed and discussed with senior managers more often would lead to increased project success.

The fourth factor is RiskInfluence. These three questions ask respondents how much influence risk management has in their organizations. For example, these questions ask respondents if risk management processes are the primary mechanism to determine project reserves and whether the findings from the risk management processes translate into action. One might reason that the more favorably that risk management is perceived, the more risk management principles might be considered in making decisions and allocating resources.

The fifth and final independent factor is RiskPerception. These four questions ask respondents about how risk management is perceived in their organization. For example, respondents are asked if they believe risk management creates/protects value and if risk management has a positive influence on program success. One might expect that organizations that have a more positive perception of risk management might be expected to internalize the recommendations of the frameworks reviewed.

The resulting factor analysis was performed using principal component analysis extraction with varimax orthogonal rotation. Table 17 below shows the variance explained by the factors created. The five aggregated factors that resulted from this analysis are presented in the five component columns (one through five) with the individual questions in the column on the left. The individual question numbers appear on the left side of the variable name (e.g., 31) and the mapping to the original Oehmen study is provided on the right side (e.g., 1.1). The communality of these individual questions will be shown to be similar by measuring and looking for components with eigenvalues greater than 1.000.

Table 17, below, displays five components with eigenvalues greater than 1.000.

Table 17. Factor Analysis Explained Variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.894	44.468	44.468	8.894	44.468	44.468	4.799	23.993	23.993
2	2.491	12.454	56.922	2.491	12.454	56.922	3.430	17.148	41.141
3	1.542	7.712	64.634	1.542	7.712	64.634	2.488	12.439	53.580
4	1.163	5.813	70.447	1.163	5.813	70.447	2.379	11.894	65.474
5	1.127	5.633	76.081	1.127	5.633	76.081	2.121	10.607	76.081
6	.614	3.069	79.149						
7	.570	2.850	81.999						
8	.527	2.633	84.633						
9	.468	2.338	86.970						
10	.418	2.090	89.060						
11	.389	1.943	91.003						
12	.318	1.588	92.591						
13	.284	1.421	94.012						
14	.265	1.324	95.336						
15	.218	1.090	96.426						
16	.193	.965	97.391						
17	.178	.888	98.278						
18	.127	.633	98.912						
19	.120	.602	99.514						
20	.097	.486	100.000						

Extraction Method: Principal Component Analysis.

The communality between the questions that comprise each factor is summarized in Table 18 below.

Table 18. Rotated Component Matrix

Question/Variable Name	Component				
	1	2	3	4	5
31 Risk execution 1.1				.776	
35 Risk execution 5.9				.763	
45 Risk Process Application 2.5				.812	
85 Decision Making	.697				
86 Decision Making 4.1	.689				
87 Decision Making	.758				
89 Decision Making 4.3	.677				
90 Decision Making	.840				
91 Decision Making	.828				
92 Decision Making	.861				
132 RM monitor and review 5.1	.415		.795		
133 RM monitor and review 5.2			.782		
146 Risk management performance			.662		
148 Risk management performance					.702
150 Risk management performance					.856
151 Risk management performance					.620
156 Influence of risk management		.858			
158 Influence of risk management		.815			
159 Influence of risk management		.797			
160 Influence of risk management		.882			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Note: Rotation converged in 7 iterations.

This analysis produced neatly grouped elements into five components. These groupings confirmed the communality of the content questions used in the factors described above. There were a few that fit into more than one factor, however. Question 132 shows communality with both the first and the third factor but will be placed on the third factor for further analysis because it shows greater communality with that factor.

Next, a reliability analysis was performed to confirm that the questions/variables extracted above meet a standard test for reliability. In this sense, reliability refers to the repeatability of the survey. In other words, if one were to take and retake the same survey, a reliable survey will return consistent answers. Measured as Cronbach's Alpha, a few authors suggest that an Alpha greater than 0.7 indicates an acceptable result (George and Mallery, 2003; Kline, 1999). In this case, SPSS returns a Cronbach's Alpha of 0.936; well above the 0.7 standard recommended as "acceptable." Based on this, one could accept that the variables extracted meet the test of reliability.

Table 19. Reliability Analysis (Cronbach's Alpha)

Cronbach's Alpha	N of Items
.936	21

With a favorable reliability analysis result, the factors were aggregated using an average of their component question scores. Since all the questions within each factor were answered on the same scale, no additional adjustment was required. Next, the descriptive statistics of each aggregated factor were reviewed to ensure normality. This was performed by examining the skewness and kurtosis of each factor. The descriptive statistics are presented in Table 20 below. One heuristic suggests that one test for normality would be a skewness and kurtosis statistic between -1 and 1. In this case, all factors appear to meet this standard of normality, although Technical Performance Success, RiskInfluence, RiskMonitor, and RiskPerception do have slightly elevated statistics for skewness and/or kurtosis, which may indicate non-normality of the data in use.

Table 20. Aggregated Factors and Dependent Variables Descriptive Statistics[1]

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Cost Success	82	1	5	2.98	.875	-.066	.266	.737	.526
Schedule Success	82	1	5	2.93	1.016	.149	.266	-.254	.526
Technical Perf. Success	82	1	5	3.06	.654	-.062	.266	2.868	.526
Customer Sat. Success	81	1	5	3.04	.782	-.065	.267	1.248	.529
RiskPlanning	118	1.00	5.00	3.3305	.90319	-.437	.223	.196	.442
RiskEvaluation	92	1.00	5.00	3.0140	.89529	-.374	.251	.016	.498
RiskMonitor	88	1.00	5.00	3.7765	.83003	-1.113	.257	1.345	.508
RiskInfluence	90	1.00	5.00	3.2519	.87881	-.590	.254	.472	.503
RiskPerception	90	1.00	5.00	3.6722	.85101	-.844	.254	1.061	.503
Valid N (listwise)	76								

Next, a correlation table is presented displaying the covariance between the five independent, aggregated factor variables and the four dependent, outcome variables. Table 21 summarizes these correlations below.

These correlations provide some insight to answering the second and third research questions. All five of the factors are positively correlated with the outcome variables and all are significantly correlated with at least one outcome variable. All four dependent

[1] The statistics for skewness and kurtosis indicate the data in use may violate the assumption of normality required for the use of ordinary least squares (OLS) regression. The same regressions presented later were also performed using ordinal regression which doesn't require the assumption of normality. No material change was found between the two different regression types so the OLS regressions are presented alone for clarity.

variables exhibited statistically significant correlations. From a practical standpoint, all four of these variables are also highly correlated. These relationships suggest that there really is a strong interdependence between cost, schedule, performance, and in this case, customer satisfaction.

Table 21. Independent and Dependent Variable Correlations

		Risk Planning	Risk Eval.	Risk Monitor	Risk Influence	Risk Percept.	Cost Succ.	Sched Succ.	Tech. Perf. Succ	Cust. Sat. Succ
Risk Planning	Pearson Corr.	1	**.511**	**.517**	**.450**	**.397**	.044	.149	.153	**.284**
	Sig. (2-tailed)		**.000**	**.000**	**.000**	**.000**	.694	.183	.170	**.010**
	N	118	**92**	**88**	**90**	**90**	82	82	82	**81**
Risk Eval.	Pearson Corr.	**.511**	1	**.616**	**.485**	**.424**	.117	.263	**.309**	**.294**
	Sig. (2-tailed)	**.000**		**.000**	**.000**	**.000**	.306	.019	**.006**	**.009**
	N	**92**	92	**85**	**85**	**86**	79	79	**79**	**78**
Risk Monitor	Pearson Corr.	**.517**	**.616**	1	**.463**	**.398**	.137	**.223**	**.323**	**.271**
	Sig. (2-tailed)	**.000**	**.000**		**.000**	**.000**	.227	**.048**	**.004**	**.016**
	N	**88**	**85**	88	**86**	**87**	79	**79**	**79**	**79**
Risk Influence	Pearson Corr.	**.450**	**.485**	**.463**	1	**.549**	.143	.165	.212	**.244**
	Sig. (2-tailed)	**.000**	**.000**	**.000**		**.000**	.199	.139	.056	**.028**
	N	**90**	**85**	**86**	90	**89**	82	82	82	**81**
Risk Percept.	Pearson Corr.	**.397**	**.424**	**.398**	**.549**	1	.038	.190	**.404**	**.471**
	Sig. (2-tailed)	**.000**	**.000**	**.000**	**.000**		.734	.087	**.000**	**.000**
	N	**90**	**86**	**87**	**89**	90	82	82	**82**	**81**

Note: Significant correlation at the 0.05 level (2-tailed) is noted in bold face.

None of the aggregated factors correlate with the cost success variable. This finding matches the Oehmen study which also found no questions that significantly correlated with cost success. Since these factors are compromised of the same individual questions, this is of little surprise.

Two of the factors correlate with schedule success. They are RiskEvaluation and RiskMonitor. Recall that these two variables capture how well risk analysis is incorporated into decision making and how the risks are monitored and reviewed. This finding provides support for the conclusion that a relationship does exist between risk management and project success outcomes.

Three factors correlate positively with project performance success. RiskEvaluation, RiskMonitor, and RiskPerception are all shown to have a relationship with this outcome variable. The first two factors were discussed previously with their relationship to schedule success. RiskPerception attempts to capture how the organization perceives the value of risk management. These findings also suggest that a relationship exists between these risk management practices and project success.

Finally, all five independent factors are shown to have a significant relationship with customer satisfaction. It's interesting that all five variables are shown to relate to this outcome variable as compared to the other three outcome variables. This finding lends support that a relationship exists between risk management and project success.

Regression Models

Correlation is interesting is not as powerful as more rigorous methods such as regression. Four multiple linear regression models examine more deeply the relationship between these five independent factors and the four dependent variables. A multiple linear regression was performed for each outcome with all five independent factors included. The results of each multiple linear regression are provided below.

Cost Success Regression

The cost outcome was analyzed first. The model summary is provided in Table 22 below.

Table 22. Cost Regression R-Square Values

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.232	.054	-.013	.878

With an R-square of 0.054, this model does not appear to offer a great deal of insight into what controls cost. Based on the correlation results presented in Table 21 above, this result is unsurprising. That table revealed no independent factors to correlate with cost success.

In addition to not providing much insight into the variance of cost success, it also fails to provide a statistically significant model as shown by the 0.548 significance in Table 23 below.

Table 23. Cost Regression ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.112	5	.622	.808	.548
	Residual	54.680	71	.770		
	Total	57.792	76			

Finally, the multiple linear regression model for cost success is shown below in Table 24.

Table 24. Linear Regression Cost Success Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.479	.544		4.558	.000
	RiskPlanning	-.062	.140	-.063	-.446	.657
	RiskEvaluation	.059	.146	.062	.406	.686
	RiskMonitor	.076	.160	.073	.473	.637
	RiskInfluence	.231	.150	.233	1.541	.128
	RiskPerception	-.148	.148	-.150	-1.000	.321

As expected, no variables appear as significant influences to cost success. The variable closest to significance, RiskInfluence, has a moderate parameter estimate but wouldn't even be significant at the 0.10 level.

Schedule Success Regression

Next, the impact of risk management on schedule success was analyzed. This model seeks to explain the influence that risk management has on a given project meeting its schedule success criteria.

Table 25, below, shows the schedule model's summary.

Table 25. Schedule Regression R-Square Values

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.280	.078	.013	1.009

The R-Square value of 0.078 for the schedule model indicates the model explains only slightly more of the variance of schedule success than it does for cost success. This also indicates that the additional influences for schedule success remain unexplained.

Table 26, below, shows the ANOVA table for the schedule success model.

Table 26. Schedule Regression ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.126	5	1.225	1.204	.316
	Residual	72.238	71	1.017		
	Total	78.364	76			

As indicated, the model shows no significance. In combination with the R-Square above, this model may not have much explanatory insight for describing any relationship between risk management and schedule success.

Below in Table 27 is the linear regression model for schedule success.

Table 27. Linear Regression Schedule Success Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.675	.624		2.684	.009
	RiskPlanning	-.028	.162	-.024	-.175	.862
	RiskEvaluation	.201	.167	.183	1.202	.233
	RiskMonitor	.082	.183	.069	.451	.654
	RiskInfluence	.066	.173	.057	.383	.702
	RiskPerception	.053	.170	.046	.314	.755

In this case, none of the independent variables are statistically significant.

Technical Performance Success Regression

The third linear regression model seeks to explain how the risk management model influences the project meeting its technical performance success measures. First, the model summary for the linear regression model predicting technical performance is detailed in Table 28 below.

Table 28. Technical Performance R-Square Value

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.453	.205	.149	.615

With an R-square of 0.205, this model offers a bit more insight into the technical performance success than it did for the cost and schedule success models. Again, though, the majority of the variance here still remains unexplained.

Next, the ANOVA results are provided in Table 29 below.

Table 29. Technical Performance Regression ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.929	5	1.386	3.663	.005
	Residual	26.863	71	.378		
	Total	33.792	76			

Unlike the previous models, this model is significant with a p-value of 0.005.

Finally, the multiple linear regression model for technical performance success is provided in Table 30 below.

Table 30. Linear Regression Technical Performance Success Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.715	.381		4.499	.000
	RiskPlanning	-.095	.098	-.125	-.969	.336
	RiskEvaluation	.094	.102	.129	.916	.363
	RiskMonitor	.143	.112	.180	1.273	.207
	RiskInfluence	-.044	.105	-.058	-.415	.679
	RiskPerception	.266	.103	.352	2.568	.012

This model does feature a significant variable. RiskPerception is found to be significant with a p-value of 0.012. This suggests that the organization's perception of the value of risk management has a significant and moderately positive influence on project technical performance success. This provides support for the existence of a relationship between an element of risk management and an element of project success.

Customer Satisfaction Success Regression

The final model seeks to explain the influence the risk management model has on the final dependent variable, customer satisfaction. The model summary for customer satisfaction success is presented in Table 31 below.

Table 31. Customer Satisfaction Regression R-Square Value

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.491	.241	.187	.685

This model seems to provide more insight into explaining the variance of customer satisfaction than it did for the other outcome variables. In this case, the model explains almost 25% of the variance of customer satisfaction success.

Next, the ANOVA results are presented in Table 32 below.

Table 32. Customer Satisfaction Regression ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.586	5	2.117	4.506	.001
	Residual	33.362	71	.470		
	Total	43.948	76			

The ANOVA results provided indicate that the model is highly significant with a p-value of 0.001.

Table 33, below, provides the table for the customer satisfaction success linear regression.

Table 33. Linear Regression Customer Satisfaction Model

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.326	.425		3.121	.003
	RiskPlanning	.062	.109	.072	.570	.570
	RiskEvaluation	.054	.114	.066	.477	.635
	RiskMonitor	.022	.125	.024	.173	.863
	RiskInfluence	-.032	.117	-.036	-.269	.788
	RiskPerception	.369	.115	.430	3.204	.002

Once again, RiskPerception is found to be a significant variable in explaining a project success outcome. In this model, RiskPerception is highly significant and moderately impactful. This provides additional information to support the notion that risk management does have a relationship with customer satisfaction and is effective at aiding the project in meeting its outcome goals.

In summary, the models provide some insight into explaining risk management effectiveness and its impact on project performance. However, based on the R-Square values and few significant variables, much remains unexplained. It does appear that RiskPerception has a positive and significant influence on two of the four outcome variables. However, the model tested provides little insight into the relationship or effectiveness of risk management with respect to cost and schedule success.

Research Question 3: Correlation Analysis Comparison

The third research question asks if a difference exists between the findings for this study and the findings for Oehmen study. Recall that there are some challenges in making a direct comparison here. Recall, also, that the Oehmen study selected an additional nine outcome variables that were considered as intermediate steps, not outcome variables, for this study. These two studies use different measures of correlations and different levels of significance. Still, this comparison could be insightful.

Table 34, below, duplicates a previous table and provides the questions that the Oehmen study found to correlate significantly with schedule or customer satisfaction success. Recall that the Oehmen study found no questions that correlated significantly with either cost or technical performance success.

Table 34. Oehmen Significant Variables

Variable	Schedule Success (Kruskal-Goodman Gamma)	Customer Satisfaction Success (Kruskal-Goodman Gamma)
Q31 Our employees are motivated to perform/implement risk management(RM)	-	0.43
Q34 Our RM explicitly addresses uncertainty	-	0.42
Q35 Our RM is systematic, structured and timely	-	0.42
Q38 Our RM takes human and cultural factors into account	-	0.41
Q39 Our RM is transparent and inclusive towards all stakeholders	-	0.51
Q40 Our RM is dynamic, iterative and responsive to change	-	0.40
Q45 The RM process is effectively integrated…	-	0.46
Q78a The impacts of risk are quantified using cost as a dimension[2]	0.41	-
Q78b The impacts of risk are quantified using technical performance…as a dimension[2]	0.49	-
Q86 Resources are allocated to reduce largest risks as early as possible	-	0.42

(Oehmen, et.al, 2014)

The previous correlation analysis for Research Question 1 finds 52 questions that correlate with the four dependent variables. This contrasts with a list of only eight from the Oehmen study that correlate with the four dependent variables from this study. Of those questions, the two studies find four questions in common. Table 35, below, summarizes these similar findings.

[2] This question is one of the qualitative questions not used for this study.

Table 35. Shared Significant Questions

Common Variable	Air Force Sample (Pearson)			Oehmen Study (K-G Gamma)	
	Cost Success	Schedule Success	Customer Satisfaction	Technical Performance	Customer Satisfaction
Q31 Our employees are motivated to perform/implement risk management(RM)	-	-	0.295 (0.008)	-	0.43
Q35. RM is systematic, structured and timely	-	-	0.238 (0.032)	-	0.42
Q45. RM teams are cross-functional and cross-organizational	-	0.236 (0.033)	0.268 (0.015)	-	0.46

There are a number of interesting findings from these results. The RM activities associated with questions 31, 35, and 45 are found to correlate significantly with customer satisfaction in both studies. Question 45 is also found to correlate with schedule success by this study.

While this study and the Oehmen study found different factors, there were still some similarities. A comparison is provided in Table 36 below. As the table notes, there is not a great deal of overlap between the two studies with respect to factors. Two of the factors (RiskEvaluation and RiskMonitor) are similar enough to factors used by the Oehmen study that they might be considered reasonably similar. The remaining three constructed factors for this study share little with the other Oehmen factors. RiskInfluence and RiskPerception share one question each from the Oehmen factors while RiskPlanning share three questions but from three different Oehmen factors. In short, no conclusion can be drawn from this factor analysis.

Table 36. Independent Variable Comparison

New Independent Variable Factor	Similar Oehmen Independent Variable	Shared Questions
IV1. RiskPlanning	-	Shares Questions 31, 35, and 45 (Oehmen's 1.1, 5.9, and 2.5)
IV2. RiskEvaluation	4. Support all Critical Decisions with Risk Management Results	Shares Questions 86 and 89 (Oehmen's 4.1 and 4.3)
IV3. RiskMonitor	5. Monitor and Review Your Risks, Risk Mitigation Actions, and RM Process	Shares Questions 132, 133, and 146 (Oehmen's 5.1, 5.2, and C.4.)
IV4. RiskInfluence	-	Shares Question 148 (Oehmen's A.2.)
IV5. RiskPerception	-	Shares Questions 158 (Oehmen's A.1.)

Investigative Questions Answered

This study looks at the relationship between risk management and project success. It additionally seeks to determine if the risk management efforts are effective and if specific practices that relate to project success can be isolated. The research questions and their associated hypotheses are presented in Table 37 below.

Research Question 1

The first research question asks if a relationship exists between risk management and project success outcomes. A number of correlation tables were reviewed containing results from individual questions and their relationship with the four dependent outcome variables. Those questions were mapped to the risk management frameworks reviewed.

Table 37. Research Questions and Hypotheses

Question	Hypothesis
Q1. Does a relationship exist between risk management and an Air Force project meeting its cost, schedule, and performance goals?	H1. There exists a statistically significant correlation between risk management practices and Air Force project success relative to cost, schedule or performance goals.
Q2. How effective is the Air Force risk management effort in aiding its projects to meet their given cost, schedule and performance targets?	H2. At least one risk management practice will be shown to significantly affect Air Force project success relative to cost, schedule or performance goals.
Q3. Are there differences between the effective risk management practices used in industry and those used by the Air Force?	H3. A difference does not exist between the effective risk management practices used in industry and those used by the Air Force.

Questions from areas pertaining to risk planning, risk analysis, risk monitoring and review, risk performance, and risk mitigation were reviewed. In total, 46 questions are found to correlate significantly.

Not all of the outcome variables showed the same number of correlated questions. The cost success dependent variable has no correlated questions. The schedule success variables had a few more significantly correlated variables but some of those, too, had a negative relationship. The other two dependent variables, technical performance success and customer satisfaction success, showed the greatest number of questions with a significant correlation.

Additionally, some of the questions asked about risk reduction achieved. These questions measure impact of the risk mitigation(s) employed rather than the planning and analysis done to prior to the risk occurring. In this section, respondents indicated there were eighteen questions that positively and significantly correlated with project success outcomes. While none correlated with cost success, these questions also show a relationship between risk management and project cost, schedule, and technical performance success.

H1. Answer: Reject the null hypothesis and conclude that a statistically significant correlation does exist between risk management practices and Air Force project success relative to cost, schedule or performance goals.

Research Question 2

Now that a relationship has been shown to exist between risk management and project success outcomes, the second research question asks how effective it is. Of the 46 questions found to have a relationship with one or more of the four outcome variables, all but eight were found to have a positive relationship with those outcome variables. Additionally, the factor analysis that was performed also found all five constructed factors to be significantly and positively correlated with at least one dependent variable. Finally, the regression models developed and tested found two of the models to be significant but the RiskPerception factor is the only factor found to have a significant relationship with any of the dependent variables. RiskPerception is found to have a positive and significant relationship with technical performance and customer satisfaction success.

H2. Answer: Reject the null hypothesis in favor of the alternate hypothesis and accept that one or more risk management practices are found to relate significantly and positively with project success.

Research Question 3

The third research question seeks to determine if the effective risk practices in use by industry match those in use by the Air Force. A comparison between the industry study performed by Oehmen, et al. and this survey study found a number of common practices. The Oehmen study found only ten specific questions to correlate significantly with cost, schedule, technical performance, or customer satisfaction success; two with schedule success and eight with customer satisfaction. The Air Force sample for this study found three of those ten to also correlate significantly and in the same direction (positive) as the industry sample.

Answering this research question is not as clear as answering the previous two. There is some overlap but not a significant amount of overlap. Increasing the confidence level of the AF study would reduce the number of significant questions from 46 to 26. However, it would also reduce the number of shared questions from three to one. The differences in results and methodologies between the two studies prevent a conclusive finding to this research question. This study fails to provide conclusive results to warrant rejection of the null hypothesis. While the findings here are less conclusive, the methodology for this question was to accept the null if it could not be rejected.

H3. Answer: Accept the null hypothesis and conclude a difference exists between the industry sample and the Air Force sample.

Summary

This chapter summarizes the analysis results for this study. A correlation analysis compared the individual survey questions with the four dependent variables and found a relationship does exist between risk management practices in use by the Air Force acquisition personnel surveyed. That correlation analysis also shows a great deal of overlap between the practices in use from an industry survey and the practices in use by that Air Force sample. Additionally, a factor analysis is used to assemble four multiple linear regression models comparing the five developed factors and their relationship with cost, schedule, technical performance, and customer satisfaction success. Those models also confirmed that a relationship exists between the risk management models and one of the constructed factors with project success.

V. Conclusions and Recommendations

Chapter Overview

This chapter summarizes the findings of this study and provides additional insight and recommendations for future efforts. The conclusions reached by the study are that a relationship does exist between risk management and project success. Furthermore, that relationship is a positive one where risk management may be effective at aiding the project to reach its cost, schedule, technical performance, and customer satisfaction targets. These findings provide support to a variety of risk management frameworks and their prescriptions.

While the findings are interesting, there are still some limitations to this study. The small sample size prevents this study being declared as much more than a glimpse into the relationship between risk management and project success. In addition to the small sample size, the respondents were more homogenous than what would be desired to allow these finding to be generalized more broadly than the small population the surveys were drawn from. However, despite the small sample size, the findings do support recommendations for action and future research.

However, additional steps remain to fully describe the relationship between risk management and project success. There appears to be a relationship, but it needs to be more clearly defined beyond mere correlation. In order to better define this relationship, risk management needs to be more clearly separated from the other practices within project management and systems engineering.

In the meantime, additional recommendations can be made. The risk management frameworks in use and their prescriptions for a number of specific practices do appear to have a positive relationship. What is also interesting is the organizational behavior aspect of risk management that appears to have a significant and positive relationship with project success; specifically, customer satisfaction. Policy makers and educators of risk management should consider this effect.

Conclusions of Research

Before reviewing the conclusions, a number of assumptions and limitations should be reviewed to temper any conclusions from this study. For one, all of the survey responses are self-reported including the outcome or dependent variables. Additionally, all of this data is provided by those serving in acquisition assignments and not in the roles of the customer themselves. Because those in the acquisition position may have better insight into project performance for a window in time, this self-reported information is still useful. Additionally, since the sample is likely comprised entirely of acquisition program managers who are, by DoD policy, most responsible for risk management, the results here may provide an insight into risk management across the Air Force acquisition system.

As described in the conclusions from Chapter 4, risk management appears to have a positive relationship with project performance at least within the minds of the respondents. 46 specific practices from the four tested steps in a notional risk management framework are found to be significantly correlated with project success. This may confirm that a relationship exists for this sample but any generalization beyond this group requires the assumption that this sample is representative of all Air Force acquisition personnel -- an assumption that cannot be tested and proven.

In addition to confirming the presence of a relationship, this study showed that risk management may be effective at aiding projects in meeting their cost, schedule, technical performance, and customer satisfaction goals. While correlation does not prove causation, it's still worth noting that all 46 of the correlated questions have a positive relationship with risk management.

There are a number of potential explanations for this lack of questions that correlated with cost success. The contract type in use could be one example. Because the DoD currently has a preference for using fixed-price contracts in many cases, this sample's respondents might all be working with their contractor via a fixed price contract. In this case, any cost savings or reductions would accrue to the developer and not to the government. One other possible explanation is the priorities in place in DoD acquisition and, likely, the AF as well. In a number of cases, the DoD seems more willing to tolerate cost overruns while less willing to tolerate schedule and technical performance problems. This finding could be the result of the intentional trade of cost for performance or time.

The correlation analysis also provides some support to the risk management frameworks in use in a variety of organizations. Specific risk management practices were found to positively and significantly influence all four of the tested risk management framework steps (no attempt was made to analyze risk identification). This provides some validation to the basic risk management model.

There are plenty of examples here that offer some support for the inclusion of risk analysis in the project's decision making process. The trade-offs and interdependence between cost, schedule, and performance has been noted. This list provides numerous examples of significantly correlated questions that indicate that considering risk is positively covariant with a successful project. Since risk analysis comprises a major portion of the risk frameworks reviewed, this also offers some support for the continued inclusion of risk management analysis in project decision making.

What's also interesting is the covariance revealed between organizational behavior issues and project success. None of the frameworks explicitly call for a free and open exchange of information within the project team; though, at least a few of them imply that it should take place (DoD, 2013; PMI, 2013). Oehmen also notes this important part of risk management (Oehmen, et al., 2014). This finding suggests that there could be more to effective risk management than merely completing the steps prescribed within a given framework.

The correlation results from Chapter 4 show that a relationship does appear to exist between risk management and the four project success variables. Numerous questions from the four risk management steps tested (risk planning, risk analysis, risk mitigation and implementation, and risk tracking) proved to have a significant relationship. This provides support that, not only does the relationship exists, but that it can be extended to at least the individual risk management step.

The factor analysis and multiple linear regressions also provide valuable feedback on risk management. The factor analysis identified five broad factors that are tested for their relationship with the four dependent outcome variables. While these factors proved to be different than the Oehmen study factors, they still provided some support for those factors since they shared a number of individual questions.

Though two of the three research questions could be conclusively answered, there are still some limits to the findings of this study. Since this study relied heavily on correlation, there are limits to the conclusions that can be drawn from it. The factor analysis and multiple linear regressions also provide some insight but that insight is limited by the survey response size and homogeneity noted above. Most seriously, perhaps, all of the results are the opinion of the respondent. It's entirely possible that the individuals who think more highly about risk management responded more positively about its impact. Recall that the only factor that was found to be significant in any of the models was the factor that represented the value the respondent placed on risk management (RiskPerception). It's entirely possible that those with a high opinion of risk management simply responded that it was effective because they have a high opinion of it. Note that the two regression models that featured RiskPerception as a significant factor were the two most that are most subjectively measured. In sum, all that can be conclusively shown is that certain types of risk management, specifically those related to Risk Perception, are associated in the minds of the survey respondents with more favorable technical performance outcomes.

Additionally, despite the interesting findings, the methodology employed still makes it difficult to fully conclude the results are due solely to risk management. Project management and systems engineering influences may also play a role in project success. Since risk management is included in both of those sets, the results here may be conflated with those two other broader sets of tools and practices. Additionally, correlation results only prove a relationship between the two constructs. This insight may obscure as much as it reveals.

Significance of Research

Any discussion of the significance of this study must start with acknowledging the small sample size. The low number of survey responses combined with the homogenous pool of respondents will obviously limit how far these results can be generalized. Even though the findings are interesting these factors prevent this study from providing truly significant insight.

Another limiting factor to declaring this study significant is the methods employed. The use of a survey for this effort had the promise of providing more insight into the actual practices in use. However, the low number of survey responses prevented the use of more rigorous methods. Correlation is useful for providing insight into a relationship between two constructs exists but it fails to prove causation. Recall, also, that the correlation methods used in combination with the low sample size may have produced spurious results for the binary questions asked. Additionally, the use of correlation may allow for the possibility that the results obtained are actually from a confounding variable that exist between the two constructs involved.

Since the survey responses are self-reported without validation, additional limitations remain. For one, the individuals responding may not have complete or accurate information. Additionally, the dependent project success outcomes were not only self-reported but self-reported by acquisition personnel that may be closer to the developer than to the user or customer. This is especially true for the customer satisfaction success variable.

It's important to repeat the point made earlier that all of this is transpiring within the minds of the respondents. There is no tie to objective measures for either the use of the risk practices or to the project success outcomes (cost, schedule, technical performance, and customer satisfaction). In some cases, this lack of an objective tie may improve accuracy in that program baselines often change over time making it difficult to tie a specific practice to a particular outcome. However, this lack of objective validation poses an obvious limitation to the significance of the findings.

Still, with all of these limitations, this study does provide some interesting findings. It finds some evidence to support for the broad practice of risk management as well as for individual practices. It also provides some support for a variety of policies and prescriptions dedicated to risk management and project success. These findings provide an answer to the over-arching question that motivated this study; that a great deal of time and money are spent on risk management when, previously, its relationship and effectiveness were largely unknown. In short, this study provides interesting and useful insight that can aid policy makers, project management practitioners, and educators of risk management.

Recommendations for Action

Given the findings of this study, a number of recommendations can be made. For one, policy makers have some added insight to the positive relationship risk management has with project success. This information will also be useful to project management practitioners and acquisition personnel. Finally, educators of risk management can include these findings in their treatment of risk management.

This study provides some useful feedback for risk management policy makers. The findings provide useful feedback that the existing policies have some value. Some of the findings indicate that having personnel committed to risk management makes it more effective. While this may seem obvious, much of the current project, systems engineering, and acquisition policy focuses more on the risk management steps themselves than on the effort behind the steps. If policy makers were to provide this feedback to the practitioners, it may help them see the value which might lead to the desired impact: more successful project.

The results from this study might also better inform practitioners. Since individual practices have been found to have a significant and positive relationship with project success, they might be more likely to make use of those practices. While there's no clear finding of causation between these findings and project success, the finding of the regression models indicate that an organization's belief in the effectiveness of risk management may lead to the desired project success.

Finally, these findings may aid educators of risk management. So much of risk management education relies on teaching the individual risk management steps (i.e., identification, analysis, mitigation, etc.). The findings of this study provide some validation for that approach but also highlight the importance of influence of perception. Educators of risk management should also relay the motivational and organizational behavior aspect of risk management. The steps themselves may be necessary, but they are insufficient. The students should understand and believe the value of what they're being taught.

Recommendations for Future Research

There clearly appears to be value in performing risk management in an effort to guide projects to meeting their success targets. However, more work is required to fully define this relationship. This study showed a conclusive relationship between risk management and project success. However, future studies should move past correlation to better define this relationship.

This study provides some insight but suffers from limitations. Primarily, this study provided some validation for a similar survey delivered to industry participants. Since both studies found similar results, it certainly appears that there is some relationship worth exploring here. A future study might seek to perform a similar analysis but use more objective and quantitative data to evaluate the relationship risk management has with project success and its effectiveness.

Risk management plays a significant role in the prescriptions of both PMI and INCOSE. This indicates that risk management is an important role in both project management and systems engineering. This study made no attempt to hold constant for the other PM and SE practices. Future work must hold constant for these practices as well to ensure that the risk management findings for this study have not been conflated with those other two sets of tools to aid project success.

A specific area of further research would be to expand on the relationship between organizational behavior and risk management. Many of the significant questions and the findings from the regression models indicate that organizational behavior factor influence risk management. This is an area that appears to be largely ignored by the frameworks reviewed yet is seems it may play a critical factor in achieving project success.

With the correlation findings from this study, future research should be free to pursue more rigorous methods to define this relationship. Originally, this study was to rely much more heavily on regression models to define the risk management – project success relationship. Low survey responses prevented the use of more rigorous methods in this study. Future studies might be better served by avoiding survey methods and employ more objective methods that rely less on survey work.

Risk management certainly appears to have a relationship with project success with respect to cost, schedule, technical performance, and customer satisfaction outcomes for this sample population. Numerous, specific risk management practices are found to correlate significantly with these project success measures. However, its exact relationship and its effectiveness remain less clear. This study finds some support for a number of risk management frameworks and specific risk practices but more work remains to be able to generalize these findings to a broader population.

Appendix A: Survey

DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

SCN: 2013-05

Privacy Notice

The following information is provided as required by the Privacy Act of 1974:

Purpose: The goal of the survey is to understand better what the current state of practice in industry and government services is regarding the management of risk in development programs and projects. Results from this survey will be used to indentify areas for improvement in the areas of policy and education/training. The survey was developed by MIT's Lean Advancement Initiative (LAI) in collaboration with the Air Force Institute of Technology and Futron.

Participation: Participation is strictly VOLUNTARY. You are not required to participate in this survey.

Confidentiality: We would greatly appreciate your participation. ALL ANSWERS WILL BE KEPT STRICTLY CONFIDENTIAL.

Instructions

During this survey, we will ask questions regarding risks, risk management practices and the success of risk management in projects and programs.

For the purpose of this survey, we follow the definitions and guidance of the ISO 31000 standard. Risk is defined as the effect of uncertainties on objectives; risk management is defined as coordinated activities to direct and control an organization with regard to risk. When you answer the questions, we ask you to observe the following rules:

- Please pick one program or project to use as a reference when answering the questions.
- Always use this one program/project as a reference for all questions.
- Please choose a program/project with a focus on development (not only production).
- Please choose the development program/project that was finished most recently, if possible within the last 6 months.

The survey will ask questions based on the following structure

1. General Questions - Organization
2. General Questions - Program/Project
3. Risk Management Processes
4. Risk Management Performance

The Risk Management Processes section will be further decomposed by:

1. Planning and Preparation
2. Risks and their Impact
3. Risk Analysis
4. Risk Evaluation
5. Risk Mitigation
6. Risk Monitoring

If you cannot or wish not to answer a question, please leave that answer blank.

The survey should take 25-30 minutes.

DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

General Questions on Your Organization

Please provide some information about your organization and yourself.

1.	What type of organization do you work for?	
2.	What is the yearly budget of your company or government equivalent (for government employees, consider the budget of your PEO)	
3.	What describes your role best during the program or project?	

		Yes 1	No 2
4.	Did you spend a significant portion of your time (more than 20% or at least one day a week) on risk management related activities?	○	○

		Yes 1	No 2
5.	Did your project allocate a significant portion (at least 10% of yearly budget) to conduct risk management activities?	○	
6.	If government, which service do you work for?		
7.	If you selected 'other' above, please specify here		

		Active Duty 1	Civilian 2	Contractor (working directly in a government program office) 3
8.	If government, are you active duty or civilian?	○		
9.	How many years of acquisition experience do you have?			

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below:

10.		

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DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

General Questions on Your Program/Project (1/2)

Please provide some general information on the program/project you chose as the example for this survey

		Less than $500k	$500k-$1m	$1m-$5m	$5m-$10m	$10m-$50m	$50m-$100m	$100m - $500m	$500m -$1bn	more than $1bn	do not know
		1	2	3	4	5	6	7	8	9	10
11.	Development budget for all contractors/suppliers for the program/project										
12.	Development budget within your organization for program/project										

13. What types of industry sector does the program fit best?

14. If you selected 'other' above, please specify here

15. What was the main type of product of the program/project?

16. What risk management models were relevant for the design of your risk management process?

- Department of Defense Risk Management Guide for DoD Acquisition
- Air Force Life Cycle Risk Management Process
- Project Management Institute (PMI) project risk management process (part of the Project Management Body of Knowledge
- Risk management process of PRINCE2 project management framework
- NASA Risk-Informed Decision Making (RIDM) or Continuous Risk Management (CRM) process
- INCOSE risk management process from the Systems Engineering Handbook
- ISO 31000 standard "Risk management- principles and guidelines"
- Do not know
- Other

17. What development approaches or philosophiesplayed a significant role in your project/program?

- Waterfall (e.g. Stage Gate, V-Model, DoD 5000)
- Spriral development
- Agile development
- Design for Six Sigma
- Lean Product Development
- Do not know
- Other

		Program Level (Coordination of entire development effort between customer. contractors and suppliers))	Integrator (Organization mainly reponsible for the customer or contractor side)	System supplier/teir -1 supplier (Main supplier of a high-level system, integrator of that system)	Component supplier/tier -2 supplier (Supplier for key components for a specific system or assembly)	Lower-tier supplier/tier-3 or lower (Supplier that delivers parts for system components)	Other
		1	2	3	4	5	6
18.	At what level of the program/project enterprise are you working?						

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below:

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DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

General Questions on Your Program/Project (2/2)

The following questions will ask you to generally characterize the project/program posed in the 5 areas of

- Technology
- Customer
- Company
- Supplier
- Market

Regarding

- novelty and
- complexity

Please rate the challenge that the program/project posed for your organization regarding technology:

		Very low 1	Low 2	Average 3	High 4	Very high 5
20.	Technology experience: Familiarity of your organization with key technologies.	○	○	○	○	○
21.	Technology Complexity: Size and level of integration of the technical system (mechanical, electronics and software)	○	○	○	○	○

Please rate the challenge that the program/project posed for your organization regarding the customer:

		Very low 1	Low 2	Average 3	High 4	Very high 5
22.	Experience with customer or stakeholders: Familitarity of your organization with key customers and stakeholders.	○				
23.	Customer or stakeholder complexity: Number and diversity of customers or stakeholders.	○				

Please rate the challenge that the program/project posed for your organization regarding the internal processes and skills:

		Very low 1	Low 2	Average 3	High 4	Very high 5
24.	Experience with relevant processes and skills: Familiarity of your organization with the relevant processes and skills needed to execute the project/program.	○				
25.	Complexity of relevant processes and skills: Number, difficulty and variety of processes and skills needed in your organization to execute the project/program.	○				

Please rate the challenge that the program/project posed for your organization regarding the supply chain:

		Very low 1	Low 2	Average 3	High 4	Very high 5
26.	Experience with supply chain: Familiarity of your organization with the supply chain needed to execute the project/program.	○				
27.	Complexity of supply chain: Size, diversity and level of integration of the project's or program's supply chain.	○				

Please rate the challenge that the program/project posed for your organization regarding external factors:

		Very low 1	Low 2	Average 3	High 4	Very high 5
28.	Experience with external factors: Familiarity of your organization with the external factors (e.g. other organizations, legal and regulatory environment).	○				
29.	Complexity of external factors: Number and diversity of external factors (e.g. other organizations, legal and regulatory environment).	○				

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

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DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

Risk Management Process - Planning and Preparation

Integration of stakeholders in communication and consultation of risk management activities. Choosing the right processes, tools and methods for risk management.

Please indicate your assessment of the way risk management was executed.

		Strongly Disagree 1	Disagree 2	Neither Agree or Disagree 3	Agree 4	Strongly Agree 5
31.	Our employees are motivated to perform/implement risk management.	○	○	○	○	○
32.	Our risk management has available, qualified experts to help implement the processes.	○	○	○	○	○
33.	There are available resources or manpower to conduct risk management.	○	○	○	○	○
34.	Our risk management explicitly addresses uncertainty.	○	○	○	○	○
35.	Our risk management is systematic, structured and timely.	○	○	○	○	○
36.	Our risk management is based on the best available information.	○	○	○	○	○
37.	Our risk management is tailored to specific program/project needs.	○	○	○	○	○
38.	Our risk management takes human and cultural factors into account.	○	○	○	○	○
39.	Our risk management is transparent and inclusive towards all stakeholders.	○	○	○	○	○
40.	Our risk management is dynamic, iterative and responsive to change.	○	○	○	○	○

Please indicate which of the following statements regarding stakeholder communication and consultation apply to your risk management.

41.

- ☐ There is a formal document (e.g. risk management plan) that defines when, how and by whom the risk management process is executed
- ☐ There is a board that oversees risk management activities of the program/project
- ☐ Risks and risk management activities are communicated to stakeholders (including management)
- ☐ Risks are communicated as consolidated reports (e.g. PDF files are email attachments)
- Risks are communicated via managed risk register/database

Please indicate if the following statements apply to the risk management process step in your project/program.

		Strongly Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Strongly Agree 5
42.	We tailor the risk management process and the methods to the specific program/project.	○				
43.	We coordinate and integrate risk management activities of different functions and across the hierarchy.	○				
44.	Risk management is integrated with higher-level risk management processes, e.g. portfolio-level risk management or enterprise-level risk management.	○				
45.	The risk management process is effectively integrated with other project/program management processes.	○				
46.	Risk management teams are cross functional and cross-organizational.	○				

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

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CONTINUE

DoD Risk Management Practices

Risk Management Process - Types of risk and their impact

In the following, a list of risks is presented. Please indicate below the impact that these risks did have on your program/project. The impact can be on and program or project target, e.g. cost, schedule or performance.

Please rate in the following questions the overall risk impact in the project:

- Not occurred: The described risk did not play a significant role in the program/project.
- Very low impact: The risk occurred, but could be dealt with in the routine workflow.
- Medium impact: The risk required special attention and resource allocation to overcome.
- Very high impact: The risk significantly threatened the overall program/project success.

If you don't know the answer, please leave the question blank.

Risks regarding organizational efficiency.

		Not occurred 1	Very low impact 2	Low impact 3	Medium impact 4	High impact 5	Very high impact 6
48.	Lack of cross-functional integration and communication within the organization.						
49.	Lack of cross-organizational integration and communication with suppliers.						
50.	Lack of cross-organizational integration and communication with customers/government.						
51.	Resources are re-allocated or become unavailable.						
52.	Activities of other organizations disrupt program/project execution (e.g. new technology introduction)						
53.	Other						
54.	If you selected 'other' above, please specify here						

Risks regarding general project/program management efficiency.

		Not occurred 1	Very low impact 2	Low impact 3	Medium impact 4	High impact 5	Very high impact 6
55.	Progress monitoring and management (e.g. Earned Value Management) insufficient.						
56.	Supplier failure causing development delays, cost overruns or quality problems.						
57.	Insufficient skills or intellectual capital leading to problems in executing the program/project plan.						
58.	Insufficient change management or improvement process (e.g. Lean management, Six Sigma).						
59.	Other.						
60.	If you selected 'other' above, please specify here						

Risks regarding requirements, contracting and compliance:

		Not occurred 1	Very low impact 2	Low impact 3	Medium impact 4	High impact 5	Very high impact 6
61.	Customer/stakeholder requirements are poorly understood.						
62.	Customers/stakeholders change or extend requirements or their priority.						
63.	Unrealistic objectives regarding cost, schedule or performance set.						
64.	Misalignment of incentives between customer and contractor.						
65.	Insufficient management of compliance leads to issues with regulatory policies.						
66.	Other.						
67.	If you selected 'other' above, please specify here						

Risks regarding Technology, Product Design and Engineering:

		Not occurred 1	Very low impact 2	Low impact 3	Medium impact 4	High impact 5	Very high impact 6
68.	Technology readiness level (component-level) too low to meet objectives.						
69.	System-level integration readiness level too low to meet objectives.						
70.	Production readiness level for the entire system too low to meet delivery objectives.						
71.	Service readiness level for the system too low to effectively support operations and maintenance.						
72.	Product development/systems engineering processes ineffective.						
73.	Management and development process was unstable; time was wasted by frequent deviations from changing process standard.						
74.	Test plan schedule (component and system level) incomplete or lacking dependencies.						
75.	Other.						
76.	If you selected 'other' above, please specify here						

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

77.		

Risk Management Process - Risk Analysis and Quantification

Clarification of risks with sufficient accuracy

78.	Please indicate what dimensions were used to quantify the impact of risks:	☐ Cost ☐ Technical performance or quality ☐ Human health, environmental, systems safety or reliability ☐ Schedule ☐ Supportability(infrastructure, logistics, workforce) ☐ General customer utility or customer satisfaction ☐ Other

Please indicate how often the different methods were used to quantify risks.

		Never 1	Rarely used 2	Sometimes used 3	Often used 4	Always used 5
79.	No direct quantification, but rank ordering of risks, e.g. 1 to 10 for top 10 risks.	○				
80.	Assessment of risks on scales, e.g. 1-5 scale for probability and impact.	○				
81.	Probabalistic Risk Assessment (PRA) method.	○				
82.	Probability distributions, e.g. triangular distributions with minimum, most likely and maximum.	○				
83.	Monte Carlo simulations (or similar) to aggregate different types of risk estimates.	○				

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

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CONTINUE

DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

Risk Management Process - Risk Evaluation

Prioritization of risks for for proper treatment

How often did you use the following techniques to make decisions about risks in your project/program?

		Never 1	Rarely used 2	Sometimes used 3	Often used 4	Always used 5
85.	Make go/no-go decisions based on risk assessment.	○	○	○	○	○
86.	Resources are allocated to reduce target risks as early as possible.	○	○	○	○	○
87.	Risk assessments are used to set more 'realistic' or 'achievable' objectives.	○	○	○	○	○
88.	Forecasts and projections (e.g. cost, schedule, performance) are adjusted based on risk assessments.	○	○	○	○	○
89.	The results of the risk analysis are considered in making technical, schedule and/or cost trade-offs.	○	○	○	○	○
90.	Decisions are made based on risk-benefit trade-offs, e.g. larger risks are only acceptable for significant expected benefits.	○	○	○	○	○
91.	Risk-benefit trade-offs are used systematically to favor 'low risk-high benefit' options and eliminate 'high risk-low reward' options.	○	○	○	○	○
92.	Contracts are derived from detailed cost risk assessments.	○	○	○	○	○

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

93.		

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DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

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Risk Management Process - Risk Mitigation

Treatment of risks with effective mitigation actions

94.	Please indicate which dimensions are used to evaluate risk mitigation actions before they are implemented.	☐ **Cost/resource needs for mitigation action** ☐ **Time requirement for mitigation action** ☐ **Reduction of impact of risk through mitigation action** ☐ **Reduction of probability of occurrence of risk through mitigation action** ☐ **Other**

Please rate in all following questions on the overall risk reduction achieved by different mitigation actions (e.g. by reducing probability of occurrence or reducing the impact of risks):

- **Very low risk reduction: The mitigation action slightly reduced a significant risk.**
- **Low risk reduction: The mitigation action reduced a significant risk.**
- **Medium risk reduction: The mitigation action reduced a number of significant risks.**
- **High risk reduction: The mitigation action resolved one significant risk.**
- **Very high risk reduction: The mitigation action resolved several significant risks.**

If you don't know the answer, **please leave the question blank.**

Mitigation actions to reduce risks regarding organizational efficiency:

		Not used 1	Very low risk reduction achieved 2	Low risk reduction achieved 3	Medium risk reduction achieved 4	High risk reduction achieved 5	Very high risk reduction achieved 6
95.	Supplier/enterprise integration and management, e.g. process harmonization and data integration.	○	○	○	○	○	○
96.	Contractor/government integration, e.g. reporting, feedback, etc.	○	○	○	○	○	○
97.	Organization-internal integration, e.g. process harmonization and data integration.	○	○	○	○	○	○
98.	Financial reserves.	○	○	○	○	○	○
99.	Schedule reserves.	○	○	○	○	○	○
100.	Contractual sharing of cost overruns with contractor(s).	○	○	○	○	○	○
101.	Contractual sharing of cost overruns with other organizations.	○	○	○	○	○	○
102.	Firm Fixed Price contracts.	○	○	○	○	○	○
103.	Holding excess resources (e.g. manpower, inventory or facilities).	○	○	○	○	○	○
104.	Other.	○	○	○	○	○	○
105.	If you selected 'other' above, please specify here						

Mitigation actions to reduce risks regarding general project management efficiency:

		Not used 1	Very low risk reduction achieved 2	Low risk reduction achieved 3	Medium risk reduction achieved 4	High risk reduction achieved 5	Very high risk reduction achieved 6
106.	Detailed cost, schedule and performance simulations and trade-off studies.						
107.	Self-assessments, continuous improvement and implementation of best practices (e.g. Six Sigma, Kaizen).						
108.	More detailed design reviews, increased process monitoring.						
109.	Training program or specialist career path to increase skill level.						
110.	Define 'standard work' or 'standard processes' to increase process reliability.						
111.	Improved engineering change process to speed up changes.						
112.	Adaptation of PD processes to match specific project requirements.						
113.	Active internal lobbying towards top management to promote project/program.						
114.	Other.						
115.	If you selected 'other' above, please specify here						

Mitigation actions to reduce risks regarding requirements, contracting and compliance:

		Not used 1	Very low risk reduction achieved 2	Low risk reduction achieved 3	Medium risk reduction achieved 4	High risk reduction achieved 5	Very high risk reduction achieved 6
116.	Help customer (user) understand what their needs are and make trade-offs (e.g. MATE or other trade-off simulations or calculations).						
117.	Management (and re-negotiation, if necessary) of requirements.						
118.	Active lobbying with key stakeholders outside of direct customer/contractor relationship, e.g. regulatory or policy makers.						
119.	Monitor activities of other organizations (e.g. technology disclosures, bidding strategy, product launches, market entries, analysis of existing products, etc.)						
120.	Other.						
121.	If you selected 'other' above, please specify here						

Mitigation actions to reduce technological risks:

		Not used 1	Very low risk reduction achieved 2	Low risk reduction achieved 3	Medium risk reduction achieved 4	High risk reduction achieved 5	Very high risk reduction achieved 6
122.	Increased testing and prototyping activities.						
123.	Reuse of existing components or off-the-shelf components.						
124.	Develop flexible product architecture (e.g. modular platform).						
125.	Strict configuration control to manage and minimize complexity and uncertainty.						
126.	Engineering with redundancy or safety margins.						
127.	Pursue several engineering solutions in parallel (e.g. set-based design).						
128.	Focus on design for manufacturing and/or design for service.						
129.	Other.						
130.	If you selected 'other' above, please specify here						

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

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DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

Risk Management Process - Monitoring and Review

Sufficient monitoring of risks and execution of the risk management process.

To what degree do you agree or disagree to the following statements on Monitoring and Review processes?

		Completely Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Completely Agree 5
132.	Risks were escalated to senior management according to guidelines.					
133.	Risks were regularly re-assessed according to guidelines, e.g. after specific events or after a certain time interval.					
134.	The risk management process was regularly reviewed and improved.					
135.	A formal feedback system was used to monitor the execution of risk mitigation actions.					
136.	An early warning system was used to track critical risks and decide on activating mitigation measures.					

How often are the following elements formally reviewed in your organization?

		Daily 1	Weekly 2	Monthly 3	Quarterly 4	Bi-annually 5	Annually 6	Once (e.g. at program start) 7	Never 8	Only after specific events 9
137.	Identification of new risks.									
138.	Quantification of risks.									
139.	Risk management measures.									
140.	Risk management process.									
141.	Based on occurrence of specific events.									
142.	If based on specific events, please specify:									

143.	Please indicate if the following methods are used for monitoring:	Risk register or risk catalog Top 10 risks Risk elimination or risk burn-down plans Risk mitigation plans Graphical risk metrics dashboard
144.	Please indicate if the following Key Performance Indicators are used to track risks:	Tracking of error/issue/failure rates Tracking of number of total risks Tracking of number of retired risks Tracking of aggregated risk severity Tracking of number of risk mitigation measures Tracking of resource expenditure on risk mitigation measures (cost, manpower).

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

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Risk Management Performance

Questions to assess how effectively the program dealt with risk and uncertainty and how stable it ran.

Please indicate to what extent you agree with the following statements regarding the role and perception of risk management in the program/project:

		Strongly Disagree 1	Disagree 2	Neither Agree or Disagree 3	Agree 4	Strongly Agree 5
146.	Program/project managers support risk management activities.					
147.	Risk management results (e.g. risk reports, risk reduction metrics) play an important role in the decision making of senior managers.					
148.	Risk management results influence trade-off decisions (e.g. between cost, schedule and performance targets).					
149.	Experience in risk management is valuable for promotions.					
150.	Risk management processes are primary mechanism to determine management reserves for a program/project.					
151.	Findings from the risk management process translate into action (allocation of manpower and funds).					
152.	There is adequate funding and manpower to conduct risk management process and mitigation activities.					
153.	Overall, the organization is satisfied with the performance of the risk management system.					
154.	The fact that the program/project manager has to "budget" for risks (i.e. allocate management reserves) is an incentive against identifying additional risks.					
155.	The ROI of doing risk management was positive.					

Please indicate to what extent you agree with the following statements regarding the influence of risk management on the program/project:

		Strongly Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Strongly Agree 5
156.	Risk management creates and protects value.					
157.	Risk management is an integral part of all organizational processes.					
158.	Risk management is a central part of decision making.					
159.	Risk management facilitates continuous improvement in the organization.					
160.	Risk management has a positive influence on program success.					

How strongly do the following statements apply to the overall program/project execution?

		Strongly Disagree 1	Disagree 2	Neither Agree or Disagree 3	Agree 4	Strongly Agree 5
161.	Program/project management took a proactive stance in addressing risks and issues.					
162.	The program/project ran stable and smoothly. We followed our defined processes.					
163.	We spent a lot of time on "firefighting", i.e. continuously chasing and fixing problems.					
164.	If people had concerns, they were heard and addressed.					
165.	It was OK to report "bad news" and concerns; a constructive solution was sought as early as possible.					
166.	We identified the key risks and were able to mitigate them successfully.					
167.	A large number of unexpected interruptions occurred that caused significant unplanned resource expenditures.					

Please rate the overall program/project success for your organization (if applicable).

		Complete failure to meet target (by more than 30%) 1	Failed to meet target (by 10-30%) 2	Met the target (by +/- 10%) 3	Exceeded our target (by 10-30%) 4	Strongly exceeded our target (by more than 30%) 5
168.	Cost target					
169.	Schedule target					
170.	Technical performance target					
171.	Overall customer satisfaction target					

Optional: If you have any comments regarding the questions on this page or if you would like to provide additional information, please enter it in the box below.

172.		

DoD Risk Management Practices

AN AIR FORCE INSTITUTE OF TECHNOLOGY SURVEY

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Thank you for your time and thoughtfulness filling out and submitting this survey. Your thoughts are greatly appreciated.

173.	General feedback: If you have any general comments regarding the survey (too long or too short, too much or too little detail, etc.), please let us know here:	

References

Aronstein, D.C. and Piccirillo, A.C. *The Lightweight Fighter Program: A Successful Approach to Fighter Technology Transition*. Reston VA: AIAA, 1996.

Cohen, Jacob. "A Power Primer" *Psychological Bulletin*, Vol. 112, No. 1: 155-159 (1992).

Conrow, Edmund H. *Effective Risk Management, 2nd Edition*. Reston VA: AIAA, 2003.

Converse III, Elliott V. *Defense Acquisition 1945 – 1960: Rearming for the Cold War*. Washington: Historical Office, Office of the Secretary of Defense, 2012.

Department of Defense. *Operation of the Defense Acquisition System.* DoD Instruction 5000.02. Washington: GPO, 2008.

Department of Defense, *Technology Readiness Assessment (TRA) Guidance*. Washington: ASD(R&E), April, 2011.

Department of Defense. *Operation of the Defense Acquisition System.* DoD Instruction 5000.02 (interim). Washington: GPO, 2013.

Department of Defense. *Performance of the Defense Acquisition System, 2014*. Washington: OUSD (AT&L), June, 2014.

Department of Defense. *Risk Management Guide for DoD Acquisition, 6th Edition (Version 1.0).* Washington: OUSD (AT&L), August 2006.

Department of Defense. *Risk Management Guide for Defense Acquisition Programs, 7th Edition (Interim Release).* Washington: ODASD(SE), December 2014.

Elm, J.P. and Goldnerson, D.R. *The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey.* CMU/SEI-2012-SR-009. Carnegie Mellon University. November 2012.

Field, Andy. *Discovering Statistics Using SPSS, 3rd Edition*. SAGE. London, 2009.

General Accountability Office (GAO). *Defense Contracting: Post-Government Employment of Former DoD Officials Needs Greater Transparency*. Report: GAO-08-485, Washington: GPO, May 2008.

General Accountability Office (GAO). *Managing Risk to Achieve Better Outcomes*. Report: GAO-10-374T, Washington: GPO, January 2010.

General Accountability Office (GAO). *Weapons Acquisition Reform: Reform Act is Helping DoD Acquisition Programs Reduce Risk, but Implementation Challenges Remain*. Report: GAO 13-103, Washington GPO, December 2012.

George, D., and Mallery, P. *SPSS for Windows Step by Step: A simple guide and reference 11.0 Update.* (4th Ed.). Allyn & Bacon. Boston, 2013

International Council on Systems Engineering (INCOSE). *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, Version 3.2.2*. San Diego: INCOSE, 1 October 2011.

Kline, P. *The Handbook of Psychology Testing (2nd. Ed).* Routledge. London, 1999

Kerzner, H.R. *Project Management: A Systems Approach to Planning, Scheduling and Controlling, 11th ed.* John Wiley and Sons. Hoboken N.J., 2013

Knight, F.H. *Risk, Uncertainty and Profit.* Cosimo, Inc. New York, 2006

Meredith, J.R. and Mantel Jr., S.J.. *Project Management: A Managerial Approach, 8th ed.*. John Wiley and Sons. Hoboken N.J., 2012

National Aeronautics and Space Administration (NASA). *Agency Risk Management Procedural Requirements.* NPR 8000.4A. Washington: NASA, 16 December 2008.

National Aeronautics and Space Administration (NASA). *NASA Engineering and Program/Project Management Policy*. NPD 7120.4D. Washington: NASA, 16 March 2010.

National Aeronautics and Space Administration (NASA). *NASA Risk Management Handbook.* NASA/SP-2011-3422 (Version 1.0). Washington: NASA, November 2011.

Oehmen, J., et al, "Analysis of the effect of risk management practices on the performance of new product development programs", *Technovation*, Vol. 34, Issue 8: 441-453 (August 2014).

Project Management Institute (PMI). *The Guide to the Project Management Body of Knowledge (PMBoK Guide), 5th Edition.* New Town Square: PMI, 1 January 2013.

Sproles, Noel. “The Difficult Problem of Establishing Measures of Effectiveness for Command and Control: A Systems Engineering Perspective” *Systems Engineering,* Vol. 10, No. 2: 145-155 (2001).

United States Air Force (USAF). *Integrated Life Cycle Management.* AFPAM 63-128. Washington: SAF/AQX, 10 July 2014

Ward, D.B., *The Effect of Values on System Development Project Outcomes*. AFIT/GSE/ENV/09-M08. MS thesis, Graduate School of Engineering and Management, Air Force Institute of technology (AU), Wright-Patterson AFB OH, March 2009 (ADA496358).

Wirthlin, J.R., *Identifying Enterprise Leverage Points in Defense Acquisition Program Performance.* PhD dissertation. Massachusetts’s Institute of Technology, Cambridge MA, 2009

Abbreviations

APDP	Acquisition Professional Development Program
CMMI	Capability Maturity Model – Integrated
CPFF	Cost Plus Fixed Fee
DAU	Defense Acquisition University
DoD	Department of Defense
GAO	General Accountability Office
IEC	International Electrotechnial Commission
INCOSE	International Council on Systems Engineering
IPM	Intermediate Project Management Skills Course
ISO	International Organization for Standardization
JSF	Joint Strike Fighter
LFP	Lightweight Fighter Program
MDAP	Major Defense Acquisition Program
NASA	National Aeronautics and Space Administration
PM	Program Management, Project Management
PMI	Project Management Institute
PMT	Program Management Tools
RM	Risk Management
SE	Systems Engineering
TRL	Technology Readiness Level

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14. ABSTRACT

Air Force acquisition programs invest a large amount of resources to develop and field systems. Many of these resources go to risk management in order to help ensure those programs finish successfully with respect to cost, schedule, and technical performance goals. The question arises as to whether this is a sound investment. Although risk management has been shown to be effective in industry, scant empirical evidence exists for its effectiveness within the Air Force. Correlation and regression analysis of survey data show that a positive relationship does exist between specific risk practices and project success. Furthermore, the analysis suggests that organizational behavior practices may reinforce that positive relationship in addition to the structured risk management steps prescribed by organizations such as the Department of Defense and the Project Management Institute.

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