Final Report

Risk Identification Tool (RIT)
For Aerospace Products

Prepared For:

George Mason University
SYST 798: Systems Engineering Capstone Project

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REVISION HISTORY

Revision	Summary of Change	Date Issued
1.0	Initial Release	7 MAY 2012
2.0	Redacted Release	12 May 10 2012

1.0 INTRODUCTION

The George Mason University research project and applications seminar (SYST 798) is designed to be the capstone course for the master's degree program in Systems Engineering. Students complete a major applied group project. Work includes project proposal planning, completion, documentation, and presentation. For Systems Engineering students, the focus is on assessing stakeholder needs, developing a solution, performing analysis to demonstrate that the solution meets stakeholder needs, and developing a business case for the solution. This course provides students with the opportunity to put all of the course material covered in the past into practice. It also provides faculty with the opportunity to test the student's ability to have assimilated the course material and certify that the student is ready to receive the Master of Science degree in System Engineering.

Each team must tackle a complex, unstructured project and develop a solution that will be presented to stakeholders. Students will apply the technical, management, and teamwork skills they have developed during their studies. A major component of the students' grade will be a presentation to be given at the end of the semester to SEOR Department faculty and outside stakeholders.

1.1 Executive Summary

The project given to the Space Cowboys team was the "Risk Identification Tool (RIT) for Aerospace Products." The commercial space market is growing rapidly, paving the way to a space faring civilization. Products designed for space must meet challenging requirements due to the harsh environments in which they operate the need for high reliability, the need to enable repair and refurbishment while in space, and the high cost of complex operational phases. A key driver of feasibility is the ability to identify program risks early in development when the cost to mitigate is orders of magnitude smaller. Delayed identification of risks can lead to program delay and/or failure, particularly for small commercial companies.

Multitudes of existing commercial software tools help aerospace program managers in documenting and tracking their program's risks. Laurie Wiggins of LJW Enterprises LLC, offers an in person service to help program managers develop, mitigate and track their risks, a much more comprehensive and thorough risk analysis methodology than what is offered by existing commercial software tools. Her goal is to improve her business strategy and replace her in person services with a LJW Enterprises LLC proprietary software based risk identification tool that surpasses what is currently available today.

The Space Cowboys assessed the outside stakeholder needs to be a thorough understanding of the marketplace for RIT, where their initial concept for a risk identification interview process can be improved, how RIT can be designed better than competing software tools and what functions in RIT would have the most value added. Answering these needs resulted in a consolidated findings report, survey improvements and a capabilities development document (CDD).

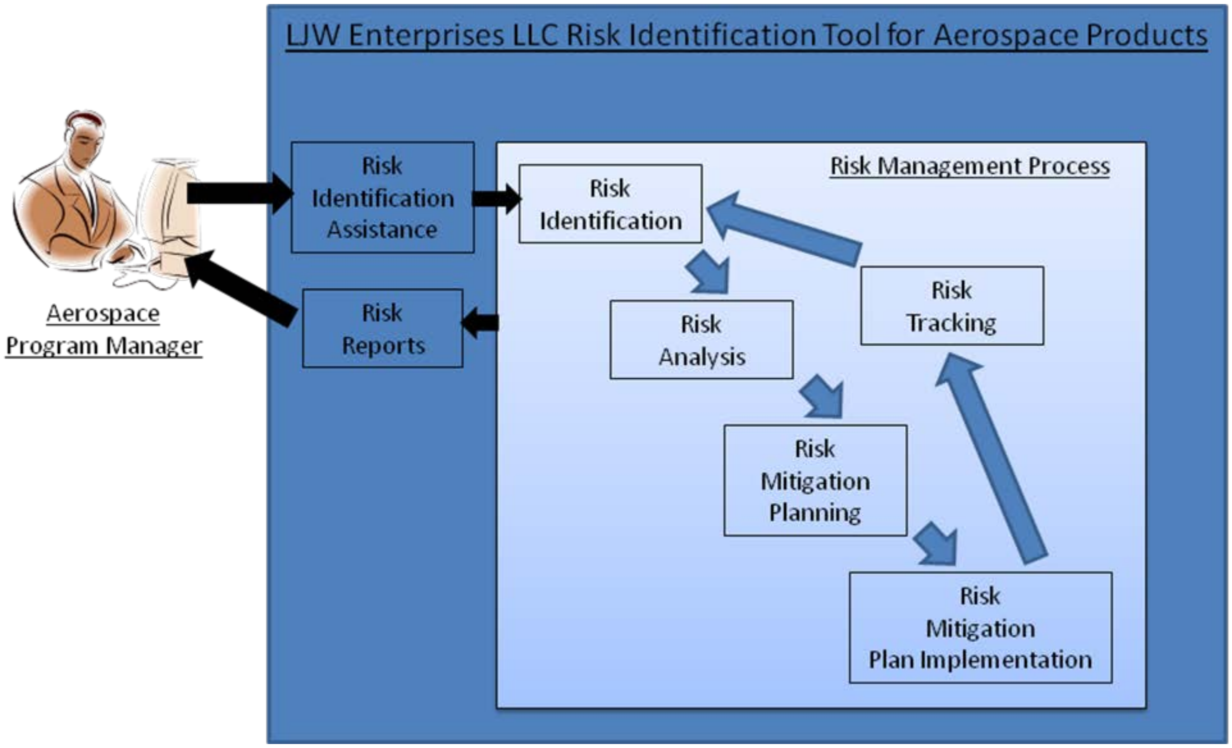

Figure 1: RIT Architecture Diagram

1.2 Background

The target customer for RIT is aerospace program managers. These individuals are heading commercial sector projects on the same budget and complexity of National Aeronautics and Space Administration's (NASA) space shuttle and the United States Air Force's (USAF) launch and operation of military communications satellite constellations. Two example case studies are a remote low earth orbit sensing satellite and a reusable, runway launch, suborbital space taxi. These efforts are driving by profit and any inadequacies in risk management will lead to unacceptable deficiencies in program cost schedule and performance.

1.3 Problem Statement

Risk identification in aerospace programs can be recognized as a very important risk management process in order to achieve the program objective in terms of cost, schedule, scope, and quality.

1.4 Technical Approach

Deliver a body of process oriented work that leads to a capability definition of LJW Enterprises LLc's RIT. The resulting definition will be of a tool that will have a competitive advantage over all other tools in the software based risk management tool marketplace. The final definition resides in the capabilities development document (CDD) that is top level requirements and a consolidation of recommendations from the following preceding efforts:

1. *Market Survey* - Research focused on evaluating risk management tools currently on the market to determine their gaps. A weighted value comparison of all the tools revealed a market gap in risk identification assistance.
2. *Risk Survey Analysis* – A Revisit of the customer's initial development for the risk management tool, a list of survey questions that would take the place of an in person interview that guides an aerospace program manager through risk identification. This list of questions was suited to the purpose of shedding light on a program's weaknesses. The recommended improvements make the questions a proper survey for identifying specific program risks and suitable for incorporation into RIT.
3. *Risk Identification Research* – Research was undergone to understand why risk identification is difficult. Then all possible ways to empower and assist a program manager to identify all critical risks were discovered. These risk identification techniques and processes were evaluated in a weighted value comparison for incorporation in RIT.

The market survey and risk identification research were consolidated into a single findings document that is found in appendix C. The effort for the semester included project management and a series of presentations. The total effort is captured in the work breakdown structure (WBS).

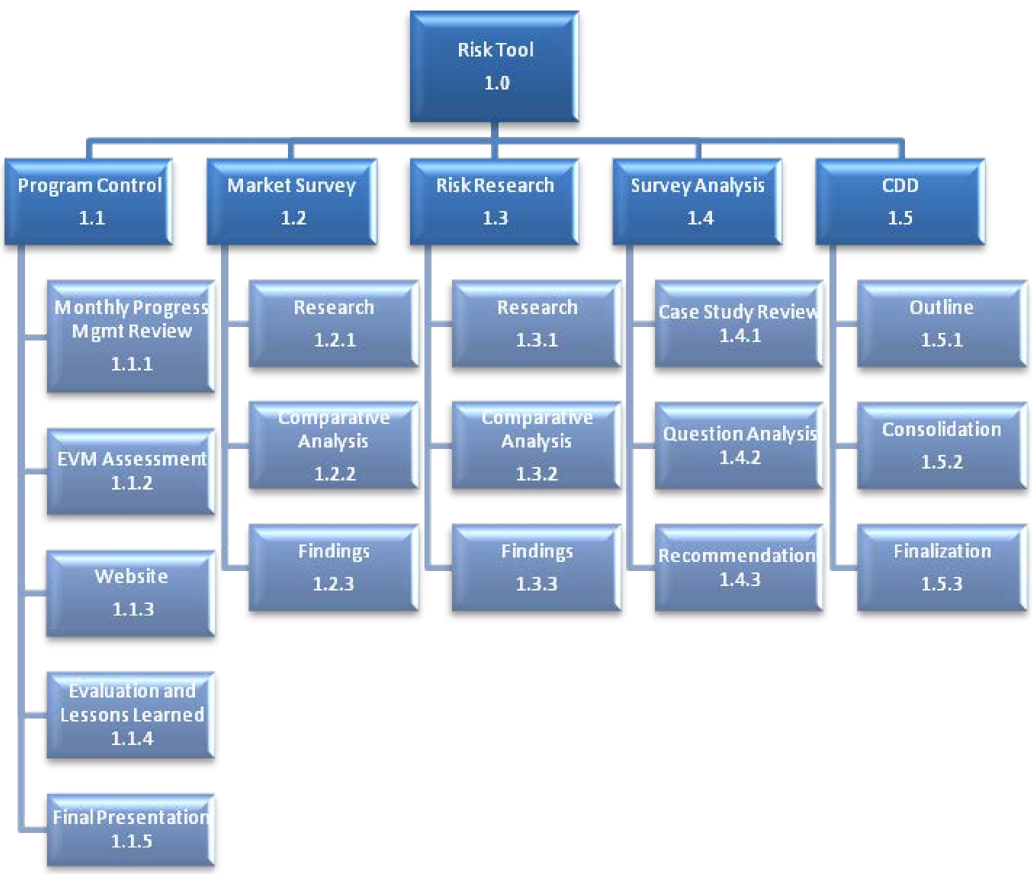

Figure 2 – RIT Work Breakdown Structure

2.0 MARKET ANALYSIS

The market analysis can be found in its entirety in Appendix C, Consolidated Findings. This section serves as a summary of the approach and resultant findings.

2.1 Approach

Starting with LJW's initial comparative matrix for 8 risk management tools, the matrix was expanded to 37 comparative elements and continued research captured an addition 50 tools from the market place. For each element it was determined if the software tool in question offered that functionality. True and False answers were recorded, except for Risk Tool Name, Manufacturer, Price and website. Within Excel TRUE and FALSE values are Boolean 1's and 0's that allow for math functions to be performed. Swing weight analysis was used to determine scoring factors. Tool Ranking was then completed with the following steps:

1. Multiply each element's normalized score (W_i) by the TRUE/FALSE (1/0) values for each tool ($e_{i,j}$), *j* is index for tools
2. Calculate subtotal by summing each of the elements calculated score in the various element categories, F_{j}, j index for element categories
    - Notional example for element category "Risk Types"
        - Risk Tool 23: 1*0.05735 + 1*0.06093 + 1*0.05376 = 0.17204
        - Risk Tool 15: 1*0.05735 + 0*0.06093 + 1*0.05376 = 0.11111
3. After each category's score is calculated all these are summed together to determine a total score for each tool
    - Notional example for overall score
        - Risk Tool 23: 0.17204 + 0.02416 + 0.06471 + 0.02348 + 0.00000 + 0.00000 + 0.00000 = **0.28439**
        - Risk Tool 15: 0.11111 + 0.03724 + 0.25752 + 0.08987 + 0.06845 + 0.02647 + 0.19054 = **0.78120**

$$W_i = \frac{L_i}{\sum_1^i L_i}$$

2.2 Results

The top three risk tools are all from the same company and are Industrial, Professional and Standard versions of the @Risk software and each of these offer much of the same functionality.

The major effort of LJW's tool is to guide users in identifying risks, so this was a major point in investigation the current market risk tools. Only six of the 54 tools, including LJW's, had any form of questionnaires including a free spreadsheet from the Tasmanian Government. Only one tool offered checklists and only one had a form of automated risk identification. None of these tools with any form of risk identification were in the top 10 list. From this survey we conclude that there is a market for a program to assist users in identification of risks. This can include questionnaires, checklists, common risks seen in projects, and others.

Ranking	Risk Tool	Final Score
1*	LJW Tool Proposed	1.283
1	[redacted]	1.043
2	[redacted]	1.043
3	[redacted]	1.015
4	[redacted]	0.995
5	[redacted]	0.897
6	[redacted]	0.769
7	[redacted]	0.769
8	[redacted]	0.752
9	[redacted]	0.701
10	[redacted]	0.671
23	LJW Tool	0.322

Table 1 - Top 10 Competition Risk Tools

3.0 RISK IDENTIFICATION IMPROVEMENTS

LJW Enterprises LLC has a vested endeavor to create a software based risk identification and risk management process tool for aerospace project managers. Initiating this endeavor, an initial collection of experience based risk probing question were created. Concurrent with analysis and improvement recommendation development for these questions, the LJW Enterprises LLC Risk Identification Tool (RIT) was developed as a defined capability through market research, risk identification process research and finding derivation.

The purpose of the RIT survey is to be a virtual interview from a relevant questionnaire. The results of the survey are a LJW Enterprises aided list of important program risks. The survey in the software tool will work with the respondent in the following series of events:

Systems engineering encompasses the development of proper processes and execution for information collection. Surveys are one of the valid forms to collect important system requirements, performance expectations and design preferences. For this application the process to analyze and recommend improvements for the RIT survey questions is as follows[1]:

1. For context review the two case studies of applicable aerospace programs provided by LJW Enterprises LLC.
2. Evaluate each question in the following categories:
    a. Clarity – Is the question clear to the respondent and the researcher? Are double negatives avoided?
    b. Singularity – Could the respondent want to respond affirmatively for one part, but negatively for another?
    c. Feasibility – Can the respondent answer and are they willing?
    d. Unbiased – Does the question avoid biased wording that evokes an emotional response? Are assumptions made that show predisposition by the researcher? Is the question consistent with or contrast with neighboring questions?

[1] http://www.mitre.org/work/tech_papers/tech_papers_05/05_0638/05_0638.pdf

   e. Constructiveness - If it is an open ended question, does it have follow-up questions that result in identifying specific risks? If it is a closed question, are the given sets of responses result in identifying specific risks?
3. Provide recommended survey improvements.

3.1 Survey Improvements

The survey improvements can be found in its entirety in Appendix D, Analysis and Improvement Recommendations for LJW Enterprises LLC's Fundamental Survey Questions. This section serves as a summary of the findings.

Overall there were three repeated recommendations:

1. If the question identifies a program weakness, follow up with a question asking what risk can be identified because of this program deficiency.
2. If the question is not singular then it should be broken into sub-questions or rephrased as a whole.
3. Since the aerospace program manager is utilizing this survey to identify risks in the infant stages of the program, the question could not ask something that can only be feasibly answer further along in the project.

3.2 Risk Identification Tools and Techniques Improvements

The market analysis can be found in its entirety in Appendix C, Consolidated Findings. This section serves as a summary of the approach and resultant findings.

3.2.1 Approach

Through research 18 risk identification tools were identified which provide a technique or approach which helps extend the ability to accurately identify risks. While all of the methods provide the same overall functionality, some do so in a manner that is similar to other tools resulting in the same outcomes and risk identification, and other tools are too complex to be included in the RIT software. To determine which tools are most appropriate to focus on for inclusion in the RIT software, an analysis was performed to balance the Value Added for the end user by including the tool, and the Complexity the software engineer would face when programming the tool into the RIT.

3.2.2 Results

A score needed to be generated to rank and order the methods and techniques to allow for the best to be identified and included within the tool. To do this, scoring weights were calculated measuring a variety of factors to determine order.

Main Category	Sub-Category	Scoring Criteria
Complexity	Precedentedness	High to Low
	Within Scope	True or False
Value Added	Uniqueness	1 to 5
	User Inputs	Simple, Graphical, Math

Table 2 - Elements Surveyed in Risk Methods and Techniques

The score factors as shown in Table X above were used to rank the 18 techniques and methods. Complexity was measured as the difficulty anticipated in programming a given method into a software tool, and value added was measured as the benefit a user would gain by using a specific technique. Specifically, complexity was broken into two factors the precedence and scope. Precedence was based on the availability of software on the market to perform a given technique. An assumption was made that if there were many tools on the market that can perform the function it was less complex and easier to program, conversely if there were no tools on the market to perform the task it was deemed to be very complex. The other measure for complexity was scope, since the RIT has some constraints in design, these factors must be considered when adding new functionality. If certain capabilities were necessary to include a function that were out of scope for the current RIT model then the tool was given a score of 0 in this category (example network connectivity). Value added was measured as how much additional value a given tool would add to the RIT for the end user. To determine the value added two components were measured the uniqueness of the results and the difficulty associated with the user inputs. Techniques were scored 1 to 5 on their basis to provide unique results for the user. Techniques that generated results only that method would produce were scored a 5, and tools that had produced common or otherwise similar results were scored a 1.

The complete set of scores is found in appendix C. Based on the scoring values calculated, Figure 2 was generated to give a visual representation of the data produced. Once the values had been plotted, a line was placed along the Pareto Frontier to produce a cut off for those points which produced high levels of Value Added while minimizing their Complexity. In Table X below, the highest (green) and lowest (red) scoring techniques are identified from the graph.

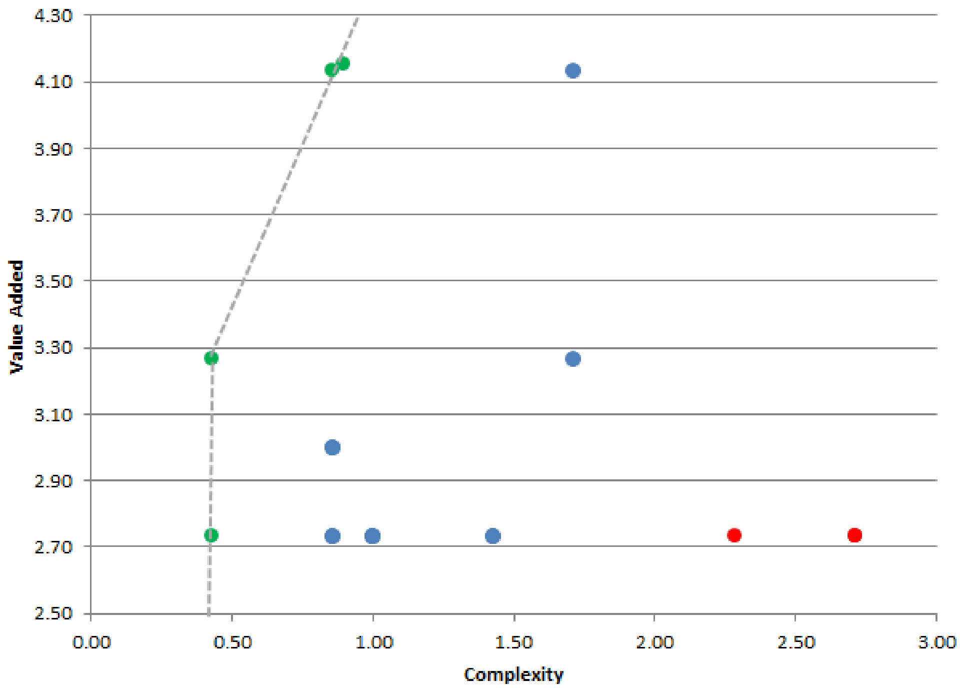

Figure 3 –Value Added vs Complexity of Risk Methods and Techniques

		Complexity	Value Added
12	[redacted]	2.71	2.73
13		2.71	2.73
15		2.29	2.73
7		0.43	2.73
9		0.86	4.13
10		0.86	4.13
18		0.43	3.27

Table 3 - Highest and Lowest scoring Risk Methods and Techniques

[redacted]

[redacted]

4.0 CAPABILITIES DEVELOPMENT DOCUMENT (CDD)

The CDD can be found in its entirety in Appendix E, CDD. This section serves as an overview and highlight of the recommendations.

4.1 Overview

Risk Identification Tool (RIT) is a software-based risk management system designed to provide more cost effective risk management capabilities to an organization. RIT provides the ability to identify program risks early in development when the cost to mitigate is orders of magnitude smaller. Delayed identification of risks can lead to program delay and/or failure, particularly for small organizations.

This document provides a high-level overview of the capabilities within the RIT system. These capabilities include core risk management capabilities such as risk identification, risk analysis but also additional capabilities that enable an organization to track and generated metrics. The high-level capability areas include:

- Systems Characterization
- Risk Identification
- Impact Analysis

- Risk Determination
- Risk Reporting

These capabilities are built to enable an organization to support their risk strategies:

1. Add RIT's risk management capabilities to an existing risk strategy.
2. Utilize RIT as a base platform to track, identify and analyze multiple risks in one centralized system.

This document is not meant to expose all the details about each of these capabilities, but to provide insight into overall capability.

4.2 Recommendations

The RIT design must meet several general requirements derived from the market survey and findings report and this CDD that places some limitations on design guidance.

The RIT shall be a standalone software program, operating on Windows (XP, 7, and 8) with capability to allow data to be shared and updated by multiple users. The focus of RIT shall be on aerospace projects and for a person who has an in depth knowledge of the program (Experienced risk managers, program/project managers, and technical leads) which will be used through every phase of risk management.

[redacted] RIT should be expandable to use possible add-on modules which can be bought to include risks specific to other project specialties (Construction, automotive, defense, etc.). The RIT shall be a proprietary and patented product of LJW Enterprises.

The primary method for risk identification shall be the questions provided by LJW Enterprises, these questions will be presented in a format which elicits responses containing both the severity and probability of the risk being identified. This method will be supplemented by additional capabilities:

[redacted]

[redacted]

5.0 SUMMARY

The project was a complete success. All deliverables culminated in a valuable vision for LJW Enterprises LLC's RIT. The Space Cowboy's effort was tracked by the Earned Value Management (EVM) methodical and scientific management process.

EVM concentrates on three basic parameters:

- BCWS (Budgeted Cost of Work Scheduled) - How much work should have been completed
- ACWP (Actual Cost of Work Performed) - How much money has actually been spent
- BCWP (Budgeted Cost of Work Performed) - What is the value of work that has been accomplished

By comparing these values, assessments were made on a weekly basis about how efficient our RIT project is and where problems may lie. The Space cowboy's EVM performance reporting shows quantified progress toward project completion and provides early warning of technical, schedule and cost performance problems. Any variance that breaks the internal threshold was identified and cause & effect analysis was reported on the EVM summary through a Variance Analysis Report (VAR) tab. The VAR enables the team to take action to mitigate the effects. Figure 1 below RIT Project EVM reporting in graphical form. It summarizes schedule and cost performance for the entire project.

Because the Space Cowboys increased their scope and effort in the early and middle stages of the project, the EVM metrics show the project was overspent and behind schedule for the better part of the semester.

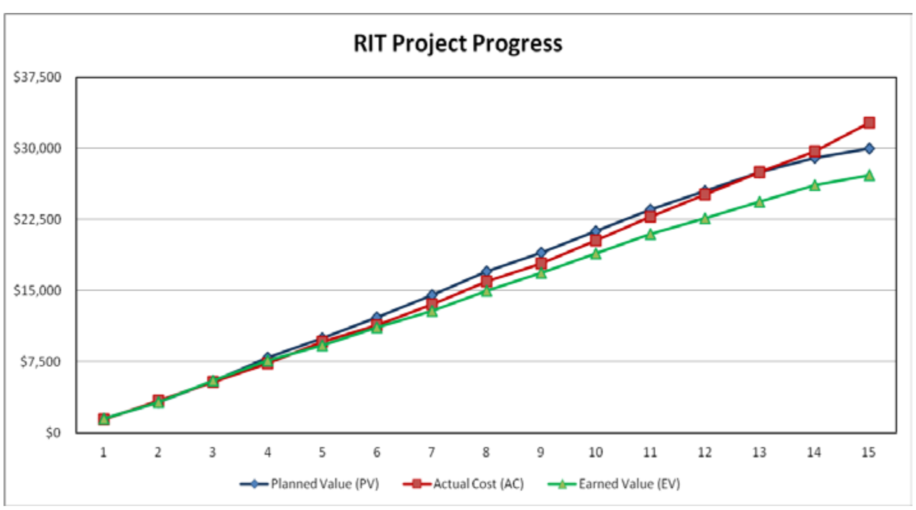

Figure 4 – RIT Project Progress

PROJECT BUDGET	Week 12	Week 13	Week 14	Week 15
Budget at Completion **(BAC)**	$2,000	$2,000	$1,500	$1,000
BCWP - Budgeted Cost of Work Performed **("Earned Value" - EV)**	$1,700	$1,701	$1,802	$1,000
ACWP - Actual Cost of Work Performed	$2,388	$2,313	$2,238	$2,963
BCWS - Budgeted Cost of Work Scheduled	$2,000	$2,000	$1,500	$1,000
Planned Value (PV)	$25,500	$27,500	$29,000	$30,000
Actual Cost (AC)	$25,153	$27,465	$29,703	$32,665
Earned Value (EV)	$22,638	$24,338	$26,140	$27,140

Table 4 – Project Budget

Project Earned Value Analysis					
	Week 12	**Week 13**	**Week 14**	**Week 15**	**Future Trend**
Budget at Completion **(BAC)**	$2,000	$2,001	$2,002	$1,000	**$30,553**
BCWP - Budgeted Cost of Work Performed **("Earned Value" - EV)**	$1,700	$1,700.85	$1,801.80	$1,000.00	**$27,140**
ACWP - Actual Cost of Work Performed	$2,388	$2,313	$2,238	$2,963	**$32,665**
BCWS - Budgeted Cost of Work Scheduled	$2,000	$2,001	$2,002	$1,000	**$30,553**
Cost Variance (CV)	($688)	($612)	($436)	($1,963)	**($5,525)**
CV %	-40%	-36%	-24%	-196%	**($0)**
Schedule Variance (SV)	($300)	($300)	($200)	$0	**($3,413)**
SV %	-15%	-15%	-10%	0%	**($0)**
Cost Performance Index (CPI)	0.71	0.74	0.81	0.34	**$1**
Schedule Performance Index (SPI)	0.85	0.85	0.90	1.00	**$1**
Estimate to Completion (ETC)	$421	$408	$249	$0	**$6,213**
Estimate at Completion (EAC)	$2,809	$2,721	$2,486	$2,963	**$38,878**
Variance at Completion (VAC)	($809)	($720)	($484)	($1,963)	**($8,325)**
Status based on Average Performance Index	**RED**	**RED**	**YELLOW**	**RED**	**RED**
Status Update					

Table 5 - Project Earned Value Analysis

6.0 WAY FORWARD

Significant progress towards LJW's ultimate goal of owning and selling a licensed risk management software tool that is the best product in the marketplace was made this past semester. To reach the next level the Space Cowboys recommend a continued effort by a follow-on George Mason team to accomplish the following:

- Requirements development in a System/Software Requirements Specification (SRS)
    - Functional (What the systems must be able to do)
    - Non-Functional (How well it performs its functions - usability, availability, reliability, supportability, testability and maintainability)
- Develop a Statement of Work (SOW) to support a Request for Proposal (RFP)

- Build a simple, interactive user interface prototype
- Conduct an in-depth business case analysis to determine the market for the RIT and the users' base.
- Conduct cost modeling

7.0 ACKNOWLEDGEMENT

- Ms. Laurie Wiggins
  Project Sponsor,
  LJW Enterprises LLC

- Dr. Kathryn B. Laskey
  Capstone Project Coordinator,
  Dept. of Systems Engineering and Operations Research, GMU

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APPENDIX B: ACRONYM LIST

ACWP	Actual Cost of Work Performed
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CDD	Capabilities Development Document
CONOPS	Concept of Operations
EVM	Earned Value Management
GMU	George Mason University
LJW	Laurie J. Wiggins
MS	Microsoft
NASA	National Aeronautics and Space Administration
PM	Program/Project Manager
RFP	Request for Proposal
RIT	Risk Identification Tool
SOW	Statement of Work
SRS	System/Software Requirements Specification
USAF	United States Air force

APPENDIX C: CONSOLIDATED FINDINGS REPORT

(See supplemental file)

APPENDIX D: ANALYSIS AND IMPROVEMENT RECCOMENDATIONS FOR LJW ENTERPRISES LLC'S FUNDAMENTAL SURVEY QUESTIONS

(See supplemental file)

APPENDIX E: CAPABILITIES DEVELOPMENT DOCUMENT (CDD)

(See supplemental file)