Calysto: Risk Management for Commercial Manned Spaceflight

by

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Abstract

The Calysto: Risk Management for Commercial Manned Spaceflight study analyzes risk management in large enterprises and how to effectively communicate risks across organizations. The Calysto Risk Management tool developed by NASA's Kennedy Space Center's SharePoint team is used and referenced throughout the study. Calysto is a web-base tool built on Microsoft's SharePoint platform. The risk management process at NASA is examined and incorporated in the study. Using risk management standards from industry and specific organizations at the Kennedy Space Center, three methods of communicating and elevating risk are examined. Each method describes details of the effectiveness and plausibility of using the method in the Calysto Risk Management Tool. At the end of the study suggestions are made for future renditions of Calysto.

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1. Introduction

1.1. Overview

Risk management is a key to success and needs to be acknowledged in any size of project. In industries where large amounts of funding and lives are at risk, there is a need to pay close attention to all known risks and identify unknown risks. If a risk surfaces during a project, the phase and method identified needs to be acknowledged for reference in future endeavors. The more data collected about a risk, the easier it is to properly mitigate and prevent from reoccurring in similar projects.

The National Aeronautics and Space Administration's (NASA) Kennedy Space Center (KSC) engages risk management at multiple organizational levels. Risk review boards are set up at each level in the organizational hierarchy and each may have different methodologies of identifying, analyzing and mitigating risks. When a risk is perceived to have a high consequence and likelihood of occurring, the risk is presented to the group's leadership. Each level of leadership determines a risk's consequence and likelihood based off a predetermined standard created by the risk review board. An approach of automation and consistency is needed to accurately track and determine the mitigation of a known risk.

Multiple risk management systems are currently used at NASA and KSC deployed by commercial providers or developed internally to the organizations. In an effort to standardize risk management systems at NASA and KSC, a risk management tool dubbed Calysto was developed on top of the Microsoft SharePoint platform written in C# with Visual Studio 2008. The Calysto name was chosen as a misspelling of the Callisto moon of the planet Jupiter to tie in the application to NASA's mission of space exploration. The Calysto Risk Management Tool was developed to answer the question of how to effectively manage risks at the enterprise level with early identification for high visibility to the organizations leadership.

Each organization at NASA and KSC scores risks differently using a “Risk Scorecard”. At a lower level organization or a project, a method should exist to accurately roll the risk data up the organizational hierarchy. Converting a project risk to a NASA center risk automatically can be accomplished through an algorithm; however, the final decision to rollup a risk should be done by a risk review board. The visibility produced by Calysto Risk Management Tool allows for the number of uncertainties, potential hazards, and pitfalls to be brought to attention quicker to reduce budget, time spent and potentially save lives.

The goal of the proceeding study is to develop a standard methodology of risk management utilizing a web-based approach. Current standards exist in risk management commercially and the methodologies have been adopted partially at NASA and KSC. NASA provides an agency directive for the requirements of risk management in the NASA Procedural Requirements document numbered 8000.4A [1]. The requirements outlined in 8000.4A are for all levels of the agency, including programs and projects, but does not specify the tool to manage risks. Building on the agency directive and applicable center directives, standard risk management software is to be built with an easy to use graphical user interface allowing derived from NASA leadership policies and industry standards. Utilizing the Calysto software, the organizations at NASA can share similar risk data amongst each other, allowing for visibility for similar circumstances and the lessons learned during the mitigation process. Using the agile approach of software project management, portions of the Calysto software are to be released to the production environment allowing feedback from users to be incorporated in the next iteration of the software. The Calysto project will be in a continuous phase of development and release at NASA and KSC to allow the users to be provided the tools they need to successfully manage risks as the needs for features are produced.

1.2. Curriculum Scope

Developing a standard methodology for risk management encompasses proficiency in risk management procedures and the development of automation tools written for a web-based medium. The Calysto software will be the custom automation tool produced in this study and allow for a central location for multiple organizations to manage risks across an agency or business. The tools used consisted of the Microsoft SharePoint platform and custom developed code written in the C# language via Microsoft Visual Studio.

Throughout my academic studies, I have focused primarily on computer science and management. The two academic tracts allow for a correlation in this study allowing for use of management methodologies to produce a detailed application consisting of industry standards in both software development and risk management. Developing the Calysto Risk Management Tool has brought attention to the need for effective project management. Software engineering needs project management to deliver a successful project. There are a variety of project management methods to be chosen when developing software and one is needed to be selected and maintained to produce a product at an efficient and effective pace.

The Calysto project aligns with Gannon University's Computer and Information Science graduate program at the documentation, project management and software development levels. An important part of the Calysto project is to accurately capture requirements and make the transformation to a software product. The Calysto tool is designed to add a valued contribution to the aerospace industry by effectively managing risks through the careful design of the product.

The role taken in developing the Calysto software was not only as the software developer, but also a project manager and business analyst. As a student in the Computer and Information Science

department at Gannon University, each role was covered in the classroom and labs. I focused primarily on the software development aspect while at Gannon, but both the project management and business analyst studies have proven to be a vital asset in this study and my career.

The roles of software developer, project manager and business analyst are usually broken up in an organization with three different individuals. The KSC SharePoint team is a small group, and the resources did not exist for the Calysto project. While in the business analyst role, I was required to obtain requirements from the customer and prospective end users. Transferring the requirements primarily from discussions to a formalized baseline document was the pivotal step in the project's lifecycle. As discussions with the customer progressed, the document was modified multiple times to encompass the new changes. To facilitate the expanding scope creep, the Scrum software development methodology was introduced into the project. Utilizing Scrum, iterative versions of the product was introduced into the production environment, giving the user the tools they needed at quick pace while developing the nice to have features as time progressed.

1.3. Project Management Plan

The primary approach of development of this project was with the use of Microsoft SharePoint. Used both as a development platform for the product produced and as the project management tool to track progress throughout the project. SharePoint offers the flexibility needed for rapidly developing a custom tool to be used for a large user base as well as document management and collaboration amongst a group of individuals.

From the start of the Calysto Risk Management Tool project, there was no project champion identified for the software. There was a need for the product but no individual was immediately identified as a leader of the project. As the development schedule allowed, pieces of the product were

put together at a slow pace. As time progressed, a strong alpha version of the project was developed and a demonstration was given to IT leadership at NASA's Kennedy Space Center (KSC). Immediately leadership realized the value of the project and assigned a champion in the form of the leader of the IT Risk Management Team, Anthony Smith. With Smith's knowledge of the current manual risk management process for the IT organization, he provides valuable insight on how the tool should work from an end user's perspective.

Smith was selected by the KSC Chief Information Officer, Michael Bolger, to represent the IT organization for the Center Risk Management Working Group (CRMWG) at KSC. He is the leader of the IT risk review board, managing risks throughout the organization. Smith holds a Bachelor's degree in Electrical Engineering and a Master's degree in Engineering Management. Working in the front office of the IT department at KSC, smith is involved in a variety of IT projects and their lifecycle.

Working with Smith, his experience with how risks are analyzed, mitigated, and presented throughout the organization offer valuable insight. Smith's insight allows an end user to be more involved in the development of the product to be delivered. Now with a champion for the product and a high demand, the project jumped to the top of the priority list and was subsequently delivered using the scrum approach of application development.

When a champion was identified, the project gained a driving factor to deliver a fully functional solution in a timely manner. During the development, ideas for the tool have been proposed from the KSC IT Risk Management Team to add functionality and make modifications to features of the system. At the KSC IT organizational level the customer’s satisfaction was won and given the approval to reach out to other organizations in the enterprise to assist with their risk management needs. The IT champion is to remain in close contact to help facilitate discussions and modifications with new customers of the Calysto Risk Management Tool.

Using SharePoint as the project management tool allowed for collaboration with internal KSC SharePoint team members to review the progress, execute store testing procedures and schedule meetings and demonstrations. The customer was giving access to sections of the project management SharePoint site to review the schedule of completed release and to access demonstration materials in the form of Microsoft PowerPoint slides as well as release notes. A challenge of sharing information and knowledge was overcome by use of the project collaboration portal allowing a central location to store shared documents and lists of applicable data.

2. Survey of the Literature

2.1. Literature Perspective

Risk management plays a part in near all industries and fields. Most tasks involve some level of risk. If there is no risk, the reward for completing the task may be minimally beneficial. With the advancement of science and technology, new theories are produced with actions involving substantial risk. The field of risk management involves a methodology to assess, mitigate, and evaluate known risks. Implementing risk management for a project incorporates risk reducing measures to balance the operational and economic costs of protective measures [2]. The five main components of risk management identified in the ClearRisk whitepaper [3] and used in this study are:

- Identify Potential Risks
- Measure Frequency and Severity
- Examine Alternative Solutions
- Decide Which Solution to Use and Implement It
- Monitor Results.

Each component is further examined later in this chapter (See Figure 1: Risk Management Process)

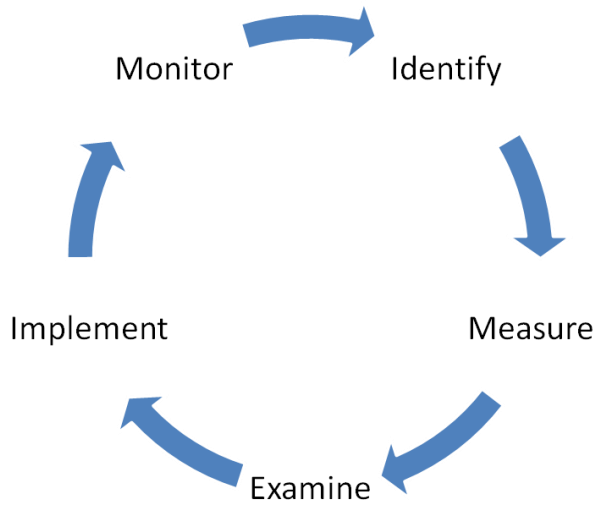


FIGURE 1: Risk Management Process

Risk Management is the "coordinated activities to direct and control an organization with regard to risk" [4]. A risk is composed of the uncertainty on objectives where the objectives can have different aspects and can apply at different levels of an organization [4]. The risk is expressed with a combination of consequences and the likelihood of the risk to occur. Consequences of the risk to occur are determined to be applicable by the organization performing risk management.

Depending on the level of detail, or granularity an organization would like to track about a risk, a variety of risk matrices are available for use. A risk matrix is the tool used to rank and display risks by defining ranges for consequence and likelihood [4]. The standard risk matrix is a 5x5 table ranging from low to high risk with green cells depicting a low risk, yellow a medium risk and red a high risk. (See FIGURE 2: 5x5 Risk Matrix) Some may choose a less granular approach by using a 3x3 risk matrix. The same color representations exist, but the number of possible combinations is substantially reduced from 25 in the 5x5 matrix to 9 in the 3x3 matrix.

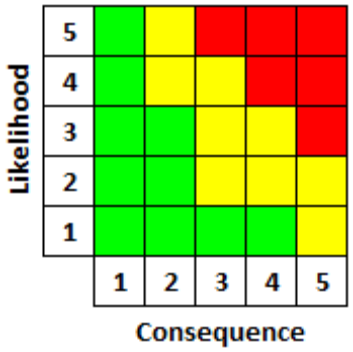


FIGURE 2: 5x5 Risk Matrix

Information tracked for a risk can vary within different organizations. Table 1: Risk Fields is an example of the data collected for an individual risk. The data is reviewed frequently and updated to present in risk review board meetings. The data is typically tracked to note modifications of previous versions.

Field	Description
Project	Project abbreviation
Risk Title	Enter a short descriptive title about the risk
Originator	
Originator Dept Code	The initiator's department code
Origination Date	The date the risk was initiated
Risk Statement	Enter Risk Statement which provides a description of the condition and consequence: Given the condition (state condition) there is a possibility that (state Consequence)
Risk Context	Enter Risk Context Statement - A detailed description of the risk
Likelihood	Assessment of the likelihood of occurrence - 1 - Very Low (Occurrence is very unlikely: ≤ 5%) 2 - Low (Occurrence is unlikely: > 5% - ≤ 25%) 3 - Moderate (Occurrence is likely: >25% - ≤ 50%) 4 - High (Occurrence is very likely: > 50% - ≤ 75%) 5 - Very High (Occurrence is almost certain: > 75%)
Consequence - Technical	Impact (0 - None, 1 - Very Low, 5 - Very High)
Consequence - Schedule	Impact (0 - None, 1 - Very Low, 5 - Very High)
Consequence - Cost	Impact (0 - None, 1 - Very Low, 5 - Very High)
Consequence - Management	Impact (0 - None, 1 - Very Low, 5 - Very High)
Consequence – Safety	Impact (0 - None, 1 - Very Low, 5 - Very High)
Timeframe	The timeframe indicates the level of urgency for action to be taken on the risk. It is up to the subsystem to determine the timeframe.
Cost of Consequence	Enter the estimated cost ($) of the consequence if the risk is not addressed (if applicable)
Mitigation/Approach Overview	Enter a brief description of how the risk will be handled, resolved or minimized
Fallback Contingency Plan	Enter the details (if applicable) of how the risk will be resolved or minimized should the initial plans fail or prove insufficient.
Mitigation Tasks	This field provides the task(s) that are / or will be implemented for the mitigation plan. Enter a date (mm/dd/yy) for each mitigation task.

Risk Owner	
Risk Owner Org	Organization that owns the Risk
Status Risk Planning Approach	Enter the current status of the risk if known
Status Report	Text summary of current status
Estimated Completion Date (ECD)	The Estimated Completion Date (ECD) is the date that the risk is expected to be closed.
Rationale	The closure rationale is provided when the status of the risk is changed to closed, rejected, or accepted.
Actual Completion Date (ACD)	The Actual Completion Date is the date when the risk is closed or accepted.

TABLE 1: Risk Fields

Risk management can be incorporated into each phase of a project's cycle [2]. Assessing and mitigating risks in a project will allow for a greater chance of success. The activity of the project is the main focus of risk management. However, the stakeholders and future projects are also affected both in the short term and long term. Risk management is primarily management's responsibility [5]. Management will delegate to their subordinates the findings from a risk management review board.

2.2. Fundamental Literature

2.2.1. Risk Review Board

The risk management review board can be set up at each organizational level to determine the suitability, adequacy and effectiveness of the subject matter to achieve established objectives. Through review boards, the determined risk is communicated to internal and external stakeholders by providing information regarding the current state of risk [4]. The risk review board has the responsibility of determining the strategic direction for the organization [5]. The board should be privy to all organizational standards and procedures for the risk management process. By determining high level strategies, the risk review board may relay information to individuals responsible for implementation the necessary tasks to mitigate the risk.

Each business unit involved in the risk should be represented during the risk review board meetings to appropriately filter information down to subordinates. Meetings should occur regularly amongst representatives to accurately track progress. Risk management should not occur only at board meetings, but through the individual project's lifecycle on a daily basis [5].

During a risk review board meeting all members of the meeting will be properly identified with their association to corresponding risks. The meetings are typically run by a risk manager designated for the organization. New and updated risks are brought to the group and discussed in detail. Any items changed since the last meeting will be denoted for clarification.

2.2.2. Identify Potential Risks

Identifying a potential risk is the first step to effective risk management [3]. Each organization may have distinct categories of risks and will typically produce a tailored risk scorecard. A risk scorecard, or consequence chart, is a "relationship between risk levels and their corresponding attribute ranges" [7]. The scorecard can be used to gauge new projects against a predetermined set of consequences. Using numerical values and ranges, the level of likelihood and consequence can be standardized across all risks [7]. FIGURE 3: Ames Research Center Consequence Chart shows an example of the likelihood and consequences ranges used at the center. Established organizations have a history of past projects and it will be easier to identify common risks compared to a new organization or new type of project.

Risks evolve over the course a project's lifecycle, and this is why it is imperative to engage in the risk management process throughout the project's lifetime. New, previously unknown, risks may surface causing unforeseen circumstances. With proper identification, the risk the can be carefully tracked and mitigated accordingly.

Attribute		Level				
		1 (Very Low)	2 (Low)	3 (Moderate)	4 (High)	5 (Very High)
Likelihood (L) Non-Human Safety Risks		≤ 0.01	0.01 < ≤ 0.10	0.10 < ≤ 0.33	0.33 < ≤ 0.50	> 0.50
Consequence (C) Non-Human Safety Risks	Cost	Overrun of ≤ 2%	Overrun of 2% < ≤ 5%	Overrun of 5% < ≤ 10%	Overrun of 10% < ≤ 15%	Overrun of > 15%
	Schedule	Overrun of ≤ 2% or No impact to critical path	Overrun of 2% < ≤ 5% or No impact to critical path	Overrun of 5% < ≤ 10% or ≤ 1 Month impact to critical path/milestones	Overrun of 10% < ≤ 15% or >1 to ≤ 6 Month impact to critical path/milestones	Overrun of > 15% or > 6 Month impact to critical path/milestones
	Mission Success (Technical Performance)	Loss of ≤ 2% success/exit criteria	Loss of 2% < ≤ 5% success/exit criteria	Loss of 5% < ≤ 10% success/exit criteria	Loss of 10% < ≤ 15% success/exit criteria	Loss of > 15% success/exit criteria
	Facilities, Equipment. or other Assets	More than normal wear and tear	Property damage $1K < ≤ $25K	Property damage $25K < ≤ $250K	Destruction of non-critical assets or damage $250K < ≤ $1M	Destruction of critical assets or damage > $1M
	Environmental	Non reportable OSHA/EPA violation	Reportable OSHA/EPA violation that does not require immediate remediation	Reportable OSHA/EPA violation which requires immediate remediation	Reportable OSHA/EPA violation causing temporary stoppage	OSHA/EPA violations resulting in termination of project
Likelihood (L) Human Safety Risks		≤ 10^{-6}	10^{-6} < ≤ 10^{-3}	10^{-3} < ≤ 10^{-2}	10^{-2} < ≤ 10^{-1}	> 10^{-1}
Consequence (C) Human Safety Risks	Human Safety	Injury or illness with no adverse or long-term health effects or lost time	Injury or illness with no adverse or long-term health effects but resulting in lost time	Injury or illness resulting in adverse or long-term health effects	Injury or illness resulting in permanent or disabling health effects	Injury or illness resulting in death

Urgency	Low	Medium	High
	Mitigation can start at earliest convenience	Mitigation should start before next relevant milestone	Mitigation should start as soon as possible

Notes:

1. The Project may tailor the values in this table to reflect their situtation, but shall document them and their mapping onto the 5X5 matrix (Figure 2).
2. Facilities, Equipment, or other Assets monetary consequences are based on Mishap Classification Levels of NPR 8621.1.

FIGURE 3: Ames Research Center Consequence Chart (Risk Scorecard) [7]

2.2.3. Measure Frequency and Severity

The second step of the risk management process, Measure Frequency and Severity, involves categorizing and prioritizing risks [3]. Using the organization's scorecard, or consequence chart, the likelihood (frequency) and consequence (severity) attributes will be assigned. Determining the attributes will prioritize the risk amongst the existing risks for the organization. Once the likelihood and consequence attributes have been properly mapped for a risk, the individual risk is rank by the product.

The product for a risk is used to determine the rank of the risk. To calculate the product, the likelihood is multiplied by the highest consequence. In a 5x5 risk matrix, the highest product can be 25. Using a 3x3 risk matrix, the highest product can be 9. Each organization may have multiple consequences and there is no minimum or maximum. The product calculation handles for the differences in the number of consequences for an organization.

Once a risk has been properly identified and measured, it can be placed on an overview report for the organization. The overview report displays the risk in relation to other organizational risks. There are different routes to portray this information to stakeholders and one common way is to sum the number of risks for a given cell in the risk matrix. The resulting report is displayed in Appendix D, FIGURE 15: Risk Overview Web Part.

2.2.4. Examine Alternative Solutions

The next step of the risk management process is to examine alternative solutions [3]. An organization can incorporate a risk list to help determine priority in examination. The risk list will give a high level view on the organizations risks with the items with the greatest risk appearing at the top of the list. The risk review board will analyze each risk and prepare for a solution. During the review stage, the review board takes into account solutions similar to the following:

- **Reject** - the risk should not be categorized as a risk at the current organizational level.
- **Watch** - keep track of and monitor the risk.
- **Accept** - no further action is taking. The risk is accepted and work is to continue.
- **Mitigate** - take actions to reduce risk.
- **Research** - determine solutions to reduce risk.
- **Transfer** - reassign ownership of the risk to a different organization.
- **Close** - the risk was successfully mitigated and/or did not occur. The risk poses no further consequence.

When determining options for solutions of a risk, the goals and mission of the organization should be carefully considered [2].

2.2.5. Decide Which Solution to Use and Implement

After the alternative solutions to a risk have been examined, the solution is chosen and implemented in the next step of the risk management process. Multiple challenges may be present during implementation phase due to:

- Funding - most initiatives require funding to support the solution.
- Management support - senior management and stakeholders will need to approve the solution.
- Training - support personnel need to be properly trained to execute the selected solution.

[3]

Once the decision is made, taking into account the above challenges, the team responsible for the project is approved to implement the solution. Depending on the solution, no additional action may be needed and the project team is to continue work as originally planned. Each risk has its unique

characteristics. However, previous mitigation strategies are taken into account in this phase to utilize previously successful implementations.

2.2.6. Monitor Results

As a project continues throughout its lifecycle, the project should be continuously monitored for risk. The risk management process does not have a definitive end time during a project other than the end of the actual project. The fifth step of the risk management process is not the end of the process, but a step to allow the repetitive risk management process to begin from the start.

During new project development, past projects data is collected and analyzed to determine similarities in risk characteristics. Setting up a continuous risk monitoring process for data sets to be collected and used in the future. By incorporating regular audits and reviews for policy and standards compliance, opportunities for improvement will become present [5].

During the monitoring phase, the more data collected for a risk, the better the organization will be prepared for future occurrences [3]. Similar to the dynamic nature of an organization and its environment, risks can be constantly changing and the appropriate attention should be required. All personnel involved in a risk need to carefully understand and follow procedures of the organization to provide the proper assurance all aspects are accounted for in the process [5].

2.3. Literature Summary

Risk management can have many different meanings across organizations. However, as long as the organization complies with the agreed upon risk management process, effective risk management can occur. ISO GUIDE describes the risk management process as the "systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and review risk" [5]. The five phase process of risk management described in this chapter reflects one example of an approach to risk management and complies with the ISO standards.

Effective risk management allows an organization to save money, people, income, property, assets and time [3]. All organizations, large and small, should engage in risk management to circumvent any potential threat. Much like an organization, risk management is dynamic in nature and should be adjusted with the organization. Organizational policies should be examined regularly to reflect the updates to the risk management process.

3. NASA Risk Management Methodology

3.0. Risk Management Perspective

The risk management process is performed by all NASA centers across the United States. Agency guidelines dictate the proper procedures to effectively manage risks. Each center derives each of their methodologies based off the Agency guidelines. There is general conformity to procedures; however some alterations in the methods of managing risks are seen across centers. Different centers and their organizations use different tools to capture and report upon risk data. The tools used to capture data consist of; a manual process use Microsoft Office products, commercial applications and custom in house developed applications. With the different routes taken to collect and manage risks, a risk collected at one center may be perceived differently at another center.

NASA's Kennedy Space Center Information Technology directorate developed a simple, but effective risk management tool using Microsoft SharePoint lists, built-in and custom reporting tools. SharePoint lists can be considered a table in a database or spreadsheet. The lists are stored in web-based system allowing a central location for multiple users to access and update data without copies of the data transferring ownership via email with no known authoritative source. Using lists in SharePoint allows quick customization of form fields without the need to write code to handle the read and write methods for a data source. Built in reporting tools for SharePoint lists come in the form of "views"; the views are displayed in a tabular format with the column headings on the first row and a row with corresponding values for the headings for each record. In a view, columns can be sorted, filtered, ordered and toggle visibility.

A conceptual application can be built with relative ease given proper requirements and a knowledgeable SharePoint designer resource. On top of the built-in features, two custom reports were developed using XML and an XSL style sheet for the first iteration of KSC's risk management tool. The

data from the SharePoint lists were translated into XML by the SharePoint engine and transformed into HTML by an XSL style sheet. The reports consisted of a “Dashboard” report displaying a subset of all the risk data collected by the form and a “Dashboard Rollup" report displaying all of an organization’s risk and any risk from a sub organization. To gain the technological perspective of an organization hierarchy, each organization was created in a SharePoint “site” and the child organizations were created as a “sub-site”. The relational URL path for an IT “sub-site” at KSC would have “KSC/IT” in the URL. The “/” in the URL denotes the value to the right is considered a child of the value to the left. An organizational hierarchy can be built using this methodology and allows assistance in rolling risk data up the hierarchy. (See FIGURE 4: Calysto SharePoint Site Hierarchy)

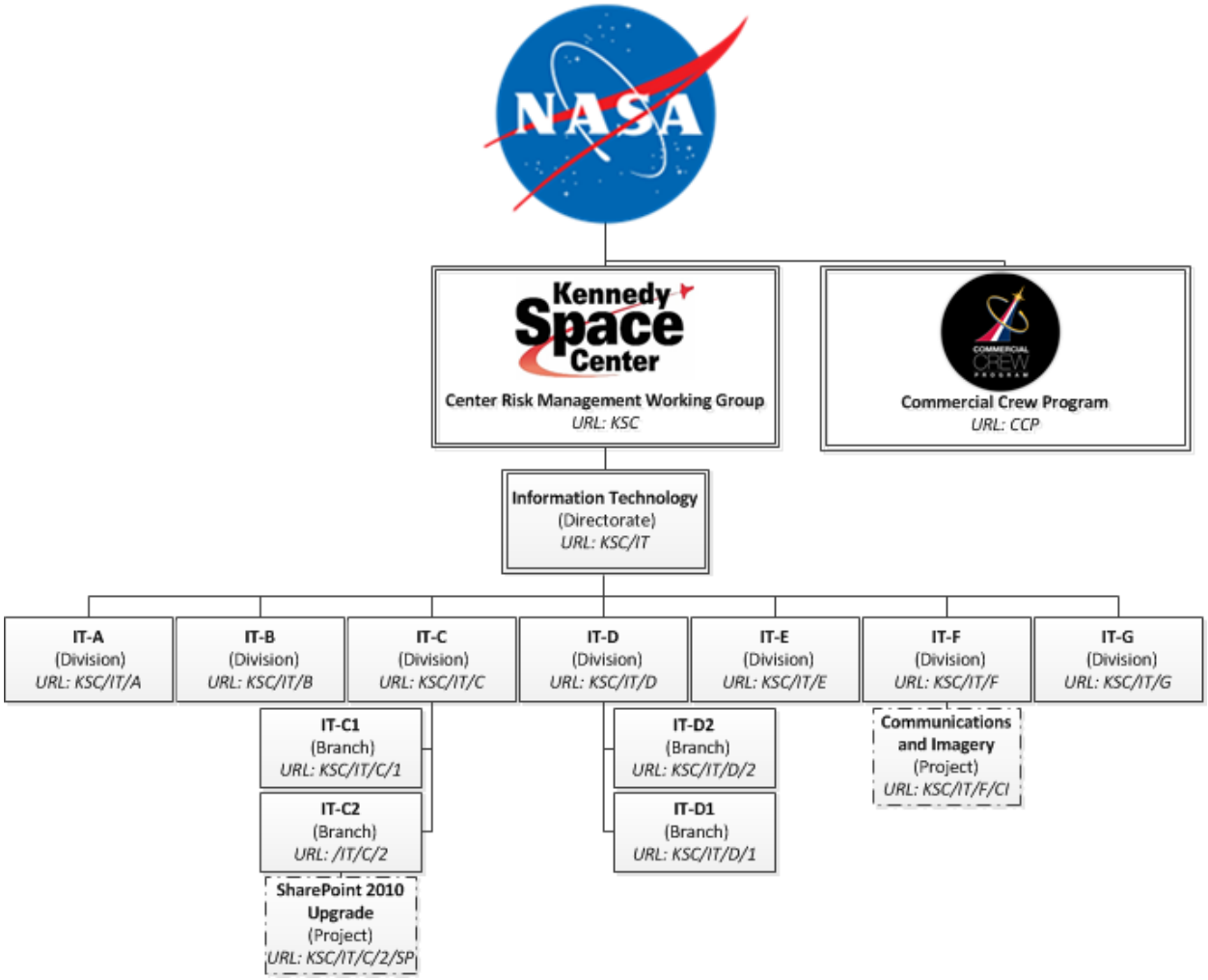


FIGURE 4: Calysto SharePoint Site Hierarchy

The concept for KSC's risk management tool was originally built in less than a month, giving the IT directorate a method to store their information effectively and to allow a level of sharing data previously unknown. Immediately upon using the tool for live risk data, shortcomings of the tool were identified. SharePoint's built-in reporting tools created a technical limitation of setting a limit of 15 organization units to a single report. The report would render properly at a lower organization level when a small amount of projects would be included in the rollup view. However, at the higher levels of an organization, the reports recursively rolled up risk data and obtained the maximum SharePoint data

sources on the page. With the rapid acceptance of the tool across the directorate and the increasing number of organizations utilizing the tool, the need existed for a scalable solution.

Aside from the technical limitations identified, the business logic in the risk management tool did not effectively capture the needs of organizations managing risks. At the center organization level at NASA, the perception of a risk in one organization can be different if viewed by an individual or group at a higher level of the organization or across organizations. The main issue in this study of risk management is how to effectively gain visibility of a risk across all organizational levels with a continuity of the relationship against the level and probability of risk. With manual processes, the owner of a risk (a person or an organization) must present or send out risk reports to gain the visibility of parent organizations or other organizations at the center. As part of the Calysto project, an electronic process was conceived to assist in the "rollup" (i.e. making the risk visible to parent organizations) process.

The issue identified is part of the risk review process allowing for assistance in high profile decision making by upper management and individuals with experience in properly mitigating risks. The manual process can be considered a "pull" method of transferring information. The risk owner must initiate the process using multiple mediums to address the risk to the proper audience. Once the risk has been documented or noted, the risk owner needs to either be physically involved in a risk review board meeting or be sure to send a presentation to the appropriate individual. Incorporating an automated method, or "push" method, once a risk has been documented or noted, will automatically broadcast the risk to the proper audience.

An automated conversion was originally proposed by the SharePoint development team during the design phase to be built into the Calysto Risk Management Tool. The conversion was designed to track the magnitude of the differences in numerical fields when escalating a risk up the organizational hierarchy. Without a complex conversion algorithm written in the Calysto tool, the risk posed to gain no

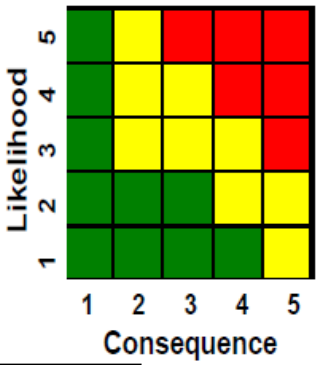
visibility at a center if it was generated at a lower project level. The loss of translation would ultimately occur upon factoring the loss of severity during escalation. As a risk traverses up throughout the organizational hierarchy, likelihood and consequence mappings would automatically reduced the attribute's level at each organization. If a risk was five levels deep in the hierarchy and at each organizational level the attribute (likelihood and consequence fields) mapping is set to reduce the value by one, the likelihood and/or consequence fields could automatically be set to zero or possibly negative values. A risk with a likelihood value of five and highest consequence value of five, distinguishing a high risk, could ultimately reduce the risk to zero. See section 5.2 Findings - Automatic Approach for a detailed analysis of the automatic approach.

3.1. Fundamental Risk Management

3.1.1. Data to Capture for a Risk

Standard sets of data are to be collected for a risk at each organizational level. The required fields will vary at each NASA center; however the fields should be shared across all organizations at the local center. The Likelihood and Consequence of a risk are standard attributes to a risk. Depending on the Risk Matrix (3x3 or 5x5) for a center, the Likelihood will be a value of 1-3 (or 1-5) and the Consequence will be a value of 0-3 (or 0-5). The criticality of a risk is determined by the location of the Likelihood and the highest Consequence on a 3x3 or 5x5 risk matrix. (See FIGURE 5: GSFC Risk Management Consequence Chart and Legend) Goddard Space Flight Center [6], similar to most NASA centers, utilizes the 5x5 risk matrix with four consequence categories (consequence categories and their definitions vary across centers). The Consequence Chart and Legend is used as a reference for the values the risk owner is to assign to the Likelihood and Consequence.

Likelihood	Safety (Estimated likelihood of safety event occurrence)	Technical (Estimated likelihood of not meeting performance requirements)	Cost/Schedule (Estimated likelihood of not meeting cost or schedule commitment)
5 Very High	($P_{SE} > 10^{-1}$)	($P_T > 50\%$)	($P_{CS} > 75\%$)
4 High	($10^{-2} < P_{SE} \leq 10^{-1}$)	($25\% < P_T \leq 50\%$)	($50\% < P_{CS} \leq 75\%$)
3 Moderate	($10^{-3} < P_{SE} \leq 10^{-2}$)	($15\% < P_T \leq 25\%$)	($25\% < P_{CS} \leq 50\%$)
2 Low	($10^{-6} < P_{SE} \leq 10^{-3}$)	($2\% < P_T \leq 15\%$)	($10\% < P_{CS} \leq 25\%$)
1 Very Low	($P_{SE} \leq 10^{-6}$)	($0.1\% < P_T \leq 2\%$)	($P_{CS} \leq 10\%$)



Consequence Categories					
Risk	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Safety	Negligible or No impact.	Could cause the need for only minor first aid treatment .	May cause minor injury or occupational illness or minor property damage.	May cause severe injury or occupational illness or major property damage.	May cause death or permanently disabling injury or destruction of property.
Technical	No impact to full mission success criteria	Minor impact to full mission success criteria	Moderate impact to full mission success criteria. Minimum mission success criteria is achievable with margin	Major impact to full mission success criteria. Minimum mission success criteria is achievable	Minimum mission success criteria is not achievable
Schedule	Negligible or no schedule impact	Minor impact to schedule milestones; accommodates within reserves; no impact to critical path	Impact to schedule milestones; accommodates within reserves; moderate impact to critical path	Major impact to schedule milestones; major impact to critical path	Cannot meet schedule and program milestones
Cost	<2% increase over allocated and negligible impact on reserve	Between 2% and 5% increase over allocated and can handle with reserve	Between 5% and 7% increase over allocated and can not handle with reserve	Between 7% and 10% increase over allocated, and/or exceeds proper reserves	>10% increase over allocated, and/or can't handle with reserves

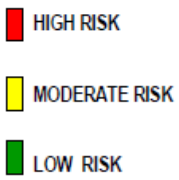


FIGURE 5: GSFC Risk Management Consequence Chart and Legend

NASA's Ames Research Center (ARC) utilizes the 5x5 risk matrix as stated in NASA Procedural Requirements 8000.4 and 8621.1 [7]. The consequence categories vary from GSFC, however the assigned attribute range for Likelihood and Consequence remain the same since both are using the 5x5 risk matrix. (See FIGURE 6: ARC Risk Management Consequence Chart) Throughout the agency, the 5x5 risk matrix is a standard, with limited deviations. The Commercial Crew Program deviates from the NASA standard and uses a 3x3 risk matrix (See FIGURE 7: ARC Risk Management Consequence Chart) to assign the level of risk in the range of none (0), low (1), medium (2), and high (3).

Attribute		Level				
		1 (Very Low)	2 (Low)	3 (Moderate)	4 (High)	5 (Very High)
Likelihood (L) Non-Human Safety Risks		≤ 0.01	0.01 < ≤ 0.10	0.10 < ≤ 0.33	0.33 < ≤ 0.50	> 0.50
Consequence (C) Non-Human Safety Risks	Cost	Overrun of ≤ 2%	Overrun of 2% < ≤ 5%	Overrun of 5% < ≤ 10%	Overrun of 10% < ≤ 15%	Overrun of > 15%
	Schedule	Overrun of ≤ 2% or No impact to critical path	Overrun of 2% < ≤ 5% or No impact to critical path	Overrun of 5% < ≤ 10% or ≤ 1 Month impact to critical path/milestones	Overrun of 10% < ≤ 15% or >1 to ≤ 6 Month impact to critical path/milestones	Overrun of > 15% or > 6 Month impact to critical path/milestones
	Mission Success (Technical Performance)	Loss of ≤ 2% success/exit criteria	Loss of 2% < ≤ 5% success/exit criteria	Loss of 5% < ≤ 10% success/exit criteria	Loss of 10% < ≤ 15% success/exit criteria	Loss of > 15% success/exit criteria
	Facilities, Equipment. or other Assets	More than normal wear and tear	Property damage $1K < ≤ $25K	Property damage $25K < ≤ $250K	Destruction of non-critical assets or damage $250K < ≤ $1M	Destruction of critical assets or damage > $1M
	Environmental	Non reportable OSHA/EPA violation	Reportable OSHA/EPA violation that does not require immediate remediation	Reportable OSHA/EPA violation which requires immediate remediation	Reportable OSHA/EPA violation causing temporary stoppage	OSHA/EPA violations resulting in termination of project
Likelihood (L) Human Safety Risks		≤ 10^{-6}	10^{-6} < ≤ 10^{-3}	10^{-3} < ≤ 10^{-2}	10^{-2} < ≤ 10^{-1}	> 10^{-1}
Consequence (C) Human Safety Risks	Human Safety	Injury or illness with no adverse or long-term health effects or lost time	Injury or illness with no adverse or long-term health effects but resulting in lost time	Injury or illness resulting in adverse or long-term health effects	Injury or illness resulting in permanent or disabling health effects	Injury or illness resulting in death

Urgency	Low	Medium	High
	Mitigation can start at earliest convenience	Mitigation should start before next relevant milestone	Mitigation should start as soon as possible

Notes:

1. The Project may tailor the values in this table to reflect their situtation, but shall document them and their mapping onto the 5X5 matrix (Figure 2).
2. Facilities, Equipment, or other Assets monetary consequences are based on Mishap Classification Levels of NPR 8621.1.

FIGURE 6: ARC Risk Management Consequence Chart

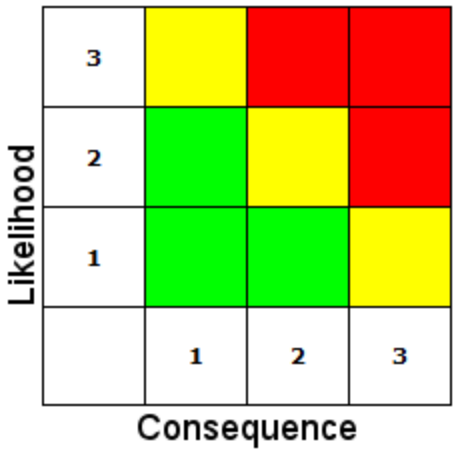


FIGURE 7: 3x3 Risk Matrix

3.1.2. Method of Collecting Risk Data

The methods used to collect risk data is standard across the NASA enterprise; however the tools used to the collect the data are at the discretion of the center, program or project. NASA Program and Project Management Processes and Requirements 7120.5 states "The program or project manager shall apply risk management principles as a decision-making tool which enables programmatic and technical success" [8]. The majority of tools used across centers are manual methods of data input consisting of Microsoft Office products Word, Excel and PowerPoint. The margin of error and lack of version control are both major issues with using only Microsoft Office products for risk management. Different programs and projects have developed their own custom applications, primarily written in Microsoft Access; however, some have purchased third-party tools. Ames Research Center has employed a Risk Management tool built on Microsoft SharePoint and Microsoft Project Server similar to the first iteration of KSC's tool. The Calysto Risk Management Tool is the first deployable SharePoint implementation written primarily in C# for the agency.

3.1.3. Reporting Risk Data

Risk Management reporting standards are shared across the agency and each center/program/project reports on similar fields. As stated in the Goddard Technical Standard for Risk Management Reporting [6], the key data fields to be reported for risks are:

- Rank based on criticality to the project
- ID number
- Criticality
- Trend
- Risk Statement
- Approach and Plan
- Current Status
- Estimated closure

The terms used for the reported fields may vary; however the definitions are consistent. The list does not encompass all fields collected for a risk; however it gives management a snapshot of a list of risks displayed in the report. The ranking system, based on criticality, displays the records with the highest level of risk at the top of the report. Each program or project may choose to add additional fields and displays when reporting risks. All implementations will use a risk statement. To clarify why a risk exists, a risk statement is used with a construct to allow the reader of the risk to understand the situation [6]. (See FIGURE 8: Components of a Risk Statement)

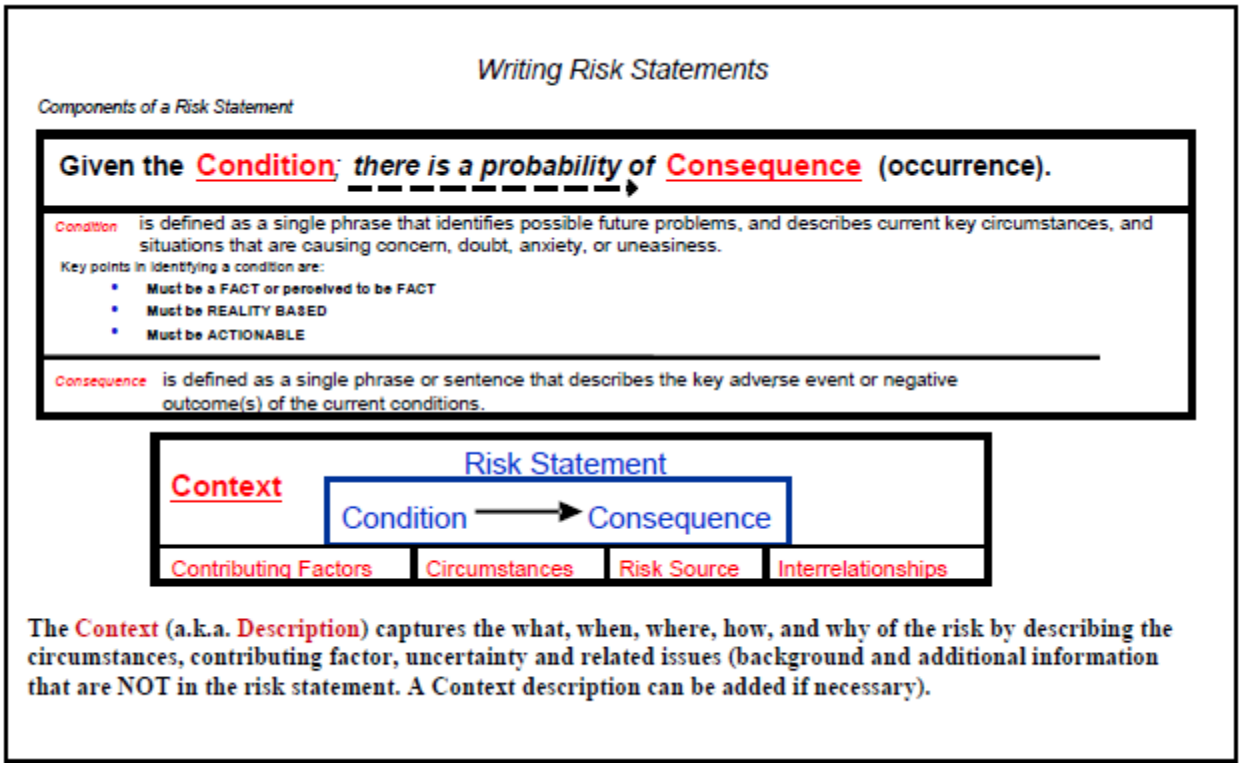


FIGURE 8: Components of a Risk Statement

The goal of the Calysto risk management tool is to standardize reports across all organizations. With the "rollup" functionality in Calysto, reporting against the same fields and format offers continuity when working with another organization. The scalability offered in Calysto allows for reports to be created and stored in one location; when an update is needed for the report, a change is made once and replicated to all organizational sites. The previous iteration of the Risk Management Too (RMT) required reports to be updated in each organizational site. The reports are relatively static in the Calysto RMT and will only require updates when standards are changed for risk reporting.

3.1.4. Communicating Risk Data Across Organizations

The Risk Management Board (RMB) for an organization is responsible for properly communicating risks to other organizational elements. A RMB is typically set up at each organizational level reviewing projects below the organization. Board reviews take place approximately every quarter

to review new and existing risks. If a risk is posed to impact additional organizations, the decision will be made to communicate and escalate the risk to the organization(s) independent RMB [7]. During the board reviews, each risk is analyzed and the scope is examined. All organizations involved in the risk are properly notified and the corresponding information about the risk is shared in detail. If the risk affects sibling organizations (organizations at the same level in hierarchy with the same parent organization), the risk will be escalated to the parent organizations risk review board. If the risk affects the parent organization's siblings, the risk will again be escalated to the next level's risk review board.

The decision to escalate a risk is a manual process based upon discussions referencing the associated data for a risk. The method for transferring the knowledge of the risk to another RMB is also a manual method using today's technological standard for reporting (Microsoft PowerPoint presentations). The Calysto RMT is designed to automatically assign a risk to RMB allowing for ease of escalation. The "rollup" feature aids and speeds up the escalation process allowing for high visibility in a near instantaneous procedure previously taking hours and possibly multiple days' worth of work.

3.2. Summary

Risk management is performed differently at each organizational at NASA with some common characteristics. The method for entering data widely consists of a manual process with most organizations understanding the need for aide in automation. There will always be a need for human interaction when assessing risks. By adding standardization and automation, the identification and mitigation of risks can occur at a faster pace with consistency. Using a tool similar to Calysto can help the data input and reporting aspect of the risk management process.

Communication is the key to successful risk management. The risk owners must properly communicate the risk to their pertinent risk review boards and the boards must determine to escalate the risk and associate external entities to assess and mitigate the risk. Assistance with automating the

communication by means of a central location (Calysto) will speed up the risk management lifecycle and allow for quick assessment and mitigation of a risk.

4. Methodology of Analysis

4.0. Introduction

To examine communicating risk data up an organizational hierarchy, three methods to "rollup"/escalate data both programmatically and manually were analyzed. The effectiveness of each method was assessed to determine the method to be incorporated into the Calysto Risk Management Tool. The three approaches are categorized as: manual, automatic and hybrid. Within each method used, human factors played a decisive role in regards to configuration or the ultimate decision to escalate a risk. Each risk is unique; however there can be similarities in methods of mitigation and determination of the level of both likelihood and consequence while a risk moves recursively up an organization to the enterprise level.

Different routes to achieve escalation could be used, and the three examined were picked based on the goals of simplicity and effectiveness. The end user should take minimal steps to perform the escalation process. The escalation should be real time without the need for batch processing or any waiting period. The automation of escalating risk data comes with shortcomings and poses to be a unique process. To make a risk visible to the largest audience, when needed, is a reoccurring scenario. Using current business processes and available technology, an automated process is to be examined.

4.1. Objectives of the Analysis

The objective of the research was to determine the most effective route for escalating an individual risk up the organizational hierarchy. Each method poses advantages and disadvantages. The research was to determine the shortcomings and the strengths for the methods. With the qualitative data, the best route was determined and incorporated into the Calysto tool. Real world user scenarios were used to determine how and when a risk should be escalated up the hierarchy.

In addition to the user scenarios, a survey was answered by users of Calysto to determine the effectiveness of communicating risks. The survey was be a final measure of determining the proper methodology, but gave insight on the how the user base portrays the rollup process as both an electronic form (Calysto) and as a business process. The data collected added value to each of the three methods, allowing for the end user audience to be incorporated into the study. Additional questions were fielded to ask the users how they portray the escalation process if it were to be automated.

The research question involves streamlining a manual business process with the use of the Calysto tool and the objective of the process to efficiently mitigate risks cannot be diminished. There was the possibility of disconnection to the end result of the proper mitigation of a risk with an automated process versus a manual process. This study is to determine what the best combination of the methods is and how to determine the visibility level of a known risk to the parent level of an organization recursively.

4.2. Methodology Application

The three methods of rolling a risk of the organizational hierarchy consist of: using a flag to mark the risk to be rolled up to the top level of the organization (manual), using a mapping to determine the relationship of likelihood and level of consequence across organizations (automatic) and selecting the organizational level to rollup the risk (hybrid). The three methods vary with level of user input and will effectively produce similar output. The output is the determining factor on the proper method to escalate a risk. If there is a substantial loss of the level of severity, the method may not be the best choice to properly elevate a risk. Each method used the same risk attributes as inputs and throughout the escalation process, the attributes were analyzed to ensure accurate representations of the risk.

Ten users of the Calysto Risk Management Tool from the KSC IT working group and the IT Project Management Office attributed to the study. The users ranked from Senior Technical Management to

Engineers. With detailed knowledge on how the risk is related to their pertinent organization, the user group gave valuable insight to the three methods describe in the following sections.

4.2.1. Manual

The manual approach to escalating a risk up the organization is in the form of a flag on an individual risk. When the flag is marked for the risk by a risk review board at any organizational level, the item is automatically rolled up to the top level of the enterprise. At each level of the organization, the risk becomes visible with the same likelihood and consequence attributes as it contains at the originating level. The manual approach allows the risk to be visible at all levels of an organization or only at the originating level.

4.2.2. Automatic

An attribute mapping key for each level of an organization assists with rolling up a risk while using the automated approach. At each level, a risks consequence or likelihood is diminished to degrees in the mapping key. If the risk is six (6) levels deep with a likelihood to occur of four (4), the mapping key for the parent level denotes a minus one (-1) likelihood converting the risk three (3) at the parent level. The mapping in turn changes the position of the risk on the 5x5 risk matrix automatically according to the mapping and recursively transitions up to the top level of the enterprise. The automatic approach also makes the risk visible at all levels of an organization or only at the originating level. However, the likelihood and consequence attributes changes at each organizational level depending on the current level's attribute mapping.

4.2.3. Hybrid

The hybrid approach incorporates the manual method and similarities to the mapping aspect of the automated method. The risk is still flagged to be rolled up the organization; however, an additional attribute allows the risk to stop at a specified level. With the influence of individual risk review boards,

at each level of an organization the risk can be reviewed and determined if it should be elevated to the next level. The parent level of the organization automatically receives the risk based off the sub levels determination to rollup the risk. The hybrid approach allows a risk to be made visible to all organizations in the hierarchy, up to a specific level of the hierarchy or only at the originating level.

4.3. Statement of Analysis Scope

Limits in the study presented are both technological and relate to human factors. The limits are due to the dynamic attributes of likelihood of the risk to occur and the consequence of a risk. The attributes pose a different meaning at each organizational level and depends on a human factor to appropriately label overall risk by selecting the corresponding value for the likelihood or consequence attributes. In the study, predetermined attribute mappings for a risk will be used for each level of the hypothetical organization. The depths of an organization may vary within an enterprise and multiple depths are represented within the study. The Calysto application is designed to house approximately 1,000 organization levels, albeit unlikely in an enterprise. However, the study depicts a typical Kennedy Space Center organizational hierarchy of approximately six (6) levels, including projects and sub-projects.

A key factor in the research is to automate as many details as possible without limiting the accuracy of a given risk. It is apparent a fully automated process is not feasible and there is a need for human intervention at each level of an organization. The manual method of determining the level of risk is not portrayed on an individual risk level using actual risks and the business process methodology. However, the human factor of determination is simulated with varying degrees of the level of risk. Risks used in the study are not actual risks identified at KSC but model what attributes a risk can contain in terms of likelihood and consequence.

4.4. Methodology Challenges

The three distinct methods of rolling risk data up an organization pose questions and answers to problems facing enterprise risk management. The majority of technology is designed to limit human interaction; however, when dealing with dynamic occurrences and assumptions regarding high levels of risk, a group of experienced individuals can also influence the decision making process. The correct combination of automation and manual inputs are needed to properly escalate a risk.

A challenging point to test the three methods is the intervention of a group of individuals. A specific risk can be perceived differently to different audiences. Gaining a generic level of understanding for a risk is an issue and the understanding can be altered with a specific group's background on the risk. The goal of the risk management tool is to make a risk both unique without going into detail of the specifics of the risk.

5. Results of Analysis

The findings from the analysis of procedures to elevate a risk up an organizational hierarchy where captured from feedback of experienced users from the Calysto Risk Management. The users operated under the risk manager role for their associated organization and have been experienced in the risk management field prior to the user of Calysto. During initial deployment for an organization, training sessions were held to educate users on data input, navigation and reporting within the system. Each session lasted approximately one hour with follow up questions answered via email. With the user's knowledge and perceptions on how risk management should work in large organizations, the following findings were identified.

5.0. Findings - Manual Approach

Through user feedback from the Calysto Risk Management Tool, it was found the manual approach, consisting of flagging an individual risk for rollup, did not work as anticipated in all implementations of the tool. Depending on the organizational hierarchy, and the level of projects within an organization, risk review boards are set up at multiple levels. A risk may only need to be elevated to the parent level of the organization instead of rolling up the entire organizational hierarchy. With the manual approach, the risk is either within its project or if it is flagged for rollup, it will traverse up the organizational hierarchy and be visible at all levels.

Using the manual approach, the flexibility of the system is hindered. The desired approach of using the organizational hierarchy and subsequent projects makes risks visible in the entire organizational hierarchy and causes confusion for top level organizations. Risks created at a deep level in Calysto and marked to rollup, display at the top level site. The risk may only need to be elevated to the parent level of the source project. Risk managers for parent level projects have been recursively clearing sub-organization and project risks to “rollup”. The approach may work for the second level

organizations. However, the source project for the risk distinctively marked the risk to rollup so it may be viewed in the risk's containing parent project.

5.1. Findings - Automatic Approach

With assistance of a consequence and likelihood mapping list at each organizational level, the automatic approach to roll risks up the organizational hierarchy was designed to give automatic visibility of an individual risk to the parent organization depending on the original selected likelihood and consequence attributes. The approach was proposed to suggest a risk to be elevated and if deemed appropriate, the risk would be brought to the parent organization's risk review board for analysis. The consequence and likelihood mapping list would be maintained at each organizational/project level in Calysto and by default, the mapping attributes would be inherited from the parent level.

The main issue with the automatic approach lies within the limited number of consequence levels. In a 3x3 risk matrix only 4 possible choices (0-3) exist and in a 5x5 risk matrix there are only 6 possible choices (0-5). If a risk were to exist multiple levels deep in the Calysto hierarchy, a risk has the potential to be automatically converted into a risk with a zero (0) consequence. If a limit of the number of levels inside Calysto existed, it would be feasible to use the automatic approach. However, with the dynamic nature of the Calysto software and following a typical enterprise organizational hierarchy, the software must be able to handle potentially an unlimited number of levels of organizations and projects.

A consequence and likelihood mapping consists of a SharePoint lists, essentially a database table, with two columns. The first column, called [Field] distinguishes either "Likelihood" or the consequence name. The second column, called [Relation], consists of negative numerical value or zero (0). A project in the 5x5 risk matrix version of Calysto will have a SharePoint list similar to the data in TABLE 2: Example Consequence Mapping.

Field	Relation
Likelihood	0
Consequence - Safety	-2
Consequence - Technical	-1
Consequence - Cost	0
Consequence - Schedule	-1
Consequence - Center Capabilities	-1

TABLE 2: Example Consequence Mapping

To validate the predictions from the automatic approach of risk rollup, two experiments were performed. Each experiment uses the same consequence and likelihood mapping table. The organizational hierarchy used for the experiments models the NASA Kennedy Space Center's IT-F. (See FIGURE 9: Organizational Hierarchy) IT-F is KSC's Project Management Office. KSC's organization abbreviations are not acronyms and are based on the number of organizations, written out alphabetically. Two distinct risks are generated with different consequences and likelihoods. The risk is originally created in the example Communications and Imagery project, converted into an IT-F risk (See TABLE 3: C&I (Communications and Imagery) Project Mapping) , converted into an IT risk (See TABLE 4: IT-F Branch (Project Management Office) Mapping) and then converted into a Kennedy Space Center risk (See TABLE 5: IT (Information Technology) Directorate Mapping).

FIGURE 9: Organizational Hierarchy

Field	Relation
Likelihood	0
Consequence - Safety	-1
Consequence - Technical	-1
Consequence - Cost	-1
Consequence - Schedule	-1
Consequence - Center Capabilities	-1

TABLE 3: C&I (Communications and Imagery) Project Mapping

Field	Relation
Likelihood	-1
Consequence - Safety	-1
Consequence - Technical	-1
Consequence - Cost	0
Consequence - Schedule	-1
Consequence - Center Capabilities	-1

TABLE 4: IT-F Branch (Project Management Office) Mapping

Field	Relation
Likelihood	-1
Consequence - Safety	0
Consequence - Technical	-1
Consequence - Cost	-1
Consequence - Schedule	-1
Consequence - Center Capabilities	-1

TABLE 5: IT (Information Technology) Directorate Mapping

NOTE: The experiments depicted below on the 5x5 risk matrix chart shows the risk converting from its original value (O) to the top level KSC (K) value. While the risk traverses up the organizational hierarchy, the representation on the risk matrix changes for each conversion and organizational level. The location of the risk on the risk matrix shown in FIGURE 10 and FIGURE 11 is taken by mapping the likelihood and the highest consequence value.

Experiment 1

Field	Value	IT-F	IT	KSC
Likelihood	4	4	3	2
Consequence - Safety	2	1	0	0
Consequence - Technical	5	4	3	2
Consequence - Cost	4	3	3	2
Consequence - Schedule	5	4	3	2
Consequence - Center Capabilities	4	3	2	1

TABLE 6: Experiment 1 Table

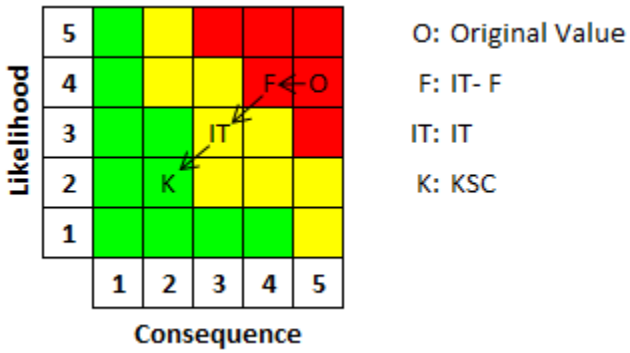


FIGURE 10: Experiment 1 Risk Matrix

The first experiment performed starts as 4x5 (likelihood by highest consequence) on the risk matrix with a product of 20. The risk is originally denoted as a high risk. Traversing up through the organizational hierarchy, the conversions made change the risk to a 2x2 risk with a product of 4. The automatic conversions change the risk from a high risk to a low risk. The drastic change in product (likelihood multiplied by the highest consequence) is an indication automatic conversions are not feasible.

Experiment 2

Field	Value	IT-F	IT	KSC
Likelihood	3	3	2	1
Consequence - Safety	2	1	0	0
Consequence - Technical	4	3	2	1
Consequence - Cost	2	1	1	0
Consequence - Schedule	3	2	1	0
Consequence - Center Capabilities	3	2	1	0

TABLE 7: Experiment 2 Table

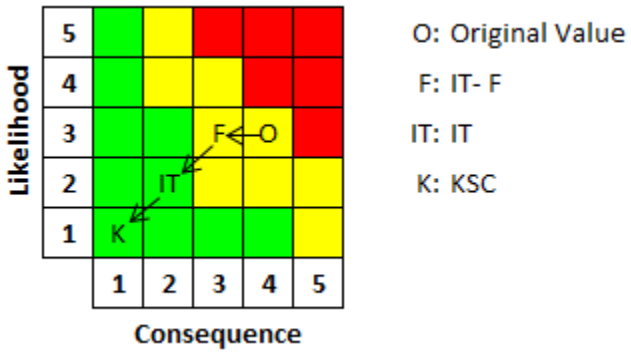


FIGURE 11: Experiment 2 Risk Matrix

The second experiment is considered to be more successful than the first due to the single category change from medium to low risk. However, the risk still experience a high percentage of change in product as it change from a 3x3 risk with a product of 9 to a 1x1 risk with a product of 1. The automatic conversion effectively changes the medium risk to close to no risk. The drastic change in product solidifies the theory automatic conversion will not work for deep project levels.

5.2. Findings - Hybrid Approach

Using the hybrid approach of assigning a risk to rollup to specified project level gives the user the most flexibility for using the Calysto system out of the three methods proposed. During feedback discussions with end users of the Calysto Risk Management, all three methods were discussed and the most receptive response was the hybrid approach. Using this method allows users to manually assign the level of rollup for an individual risk. Some risks may not need to be rolled up to the top level of the Calysto hierarchy but do need to be elevated past the current project level. Allowing the user to select the specific organizational unit or project gives the flexibility to promote a risk through multiple risk review boards.

Throughout the Calysto application, "rollup views" are displayed as reports consisting of all risks marked for rollup at or below the current project level. Incorporating the hybrid approach into the rollup view is with minimal effort. The field type for the rollup field is changed to a drop down list and populated with all parent organizations. Minimal additional code is used to populate the organizations dynamically. The risk marked to rollup to a specified level will store the target level's URL in the risk data. The rollup view for a specified project filters out all risks not including the current project's URL from displaying in the report. The URL is to be selected by the user in a friendly form. The target project's name will be displayed in a drop down list with the project's URL stored as the value. The theory behind setting the cutoff point for a rollup lies within individual risk review boards set up at corresponding levels of the organizational hierarchy. By denoting a cutoff point, top level organizations will not have the need to filter out risks deemed unnecessary for review.

Comparing the hybrid approach with both the manual and automatic approach clarifies the benefits of selecting the hybrid approach for implementation into the Calysto system. The configuration of the approach allows for an individual risk setting for rollup. Risks are unique in nature and will not

benefit in "one size fits all" approach for rollup similar to the automatic method. The Calysto system has proven the manual approach has benefits but does not fit within a large hierarchal organization. The hybrid method allows to rollup risks in both small and large organizations.

6. Discussion

As shown in the previous chapter, the three methods analyzed to rollup or escalate a risk (manual, automatic, and hybrid) have both benefits and limitations and will be discussed later in this chapter. Using the risk management life cycle discussed in Chapter 2, the rollup procedure is incorporated in each phase of the process through the risk management review board. Since organizations should have their own review board established, decisions to promote the risk lie within the board to allow additional visibility and resources to the risk. With additional resources added to the risk at both management and technical roles, the likelihood for a risk to occur can be reduced through proper mitigation techniques.

The main goal of risk management is to assess, mitigate and evaluate risks before they occur [Chapter 2]. Documenting and tracking risks are only beneficial if the proper audience has visibility to the risk. Various methods could be used to communicate risks. Utilizing an electronic tool, similar to Calysto, allows near instantaneous communication of a risk once it has been established. The different routes discussed are not the only ways to effectively communicate risks throughout the organization. However, the methods allow the most effective use of the Calysto infrastructure.

6.1. Discussion - Manual Approach

At the time of this writing, the manual approach of for risk rollup is currently implemented. The method was initially incorporated into the Calysto tool as a "one size fits all" approach. It was quickly realized the method was not in the greater benefit to the end user and the organization. The functionality was too simple and did not offer flexibility to a large dynamic organization.

The route taken by an end user to rollup a risk to the top level of the organization is to create a new risk, or edit an existing risk, and select the check box next to the "Roll Up Risk" field. (See FIGURE 12:

Risk Rollup) Once the user clicks on the edit button, the risk would effectively become a risk visible throughout the organizational hierarchy. It has been found risks may not need to traverse up the entire organization. While a user manages a risk, an option to select the level to stop the risk is need. The functionality is further explained in the hybrid approach.

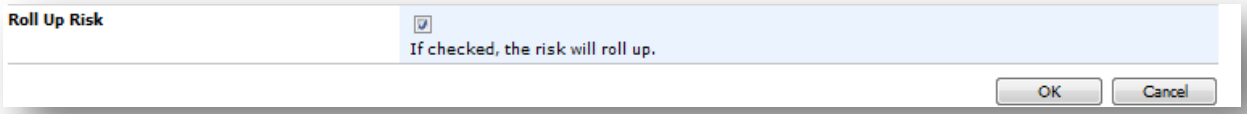


FIGURE 12: Risk Rollup

6.2. Discussion - Automatic Approach

As shown in Chapter 5, the automatic approach for risk rollup can ultimately cause a risk with a level of consequence and likelihood to become a zero risk. In the real world, automatic method is not practical. A risk with high risks attributes (ex. likelihood = 5 and consequence =5) should be distinguished as a high risk regardless where the risk originated in the organizational hierarchy. The method is site specific and does not offer granularity to select individual risks to select for the rollup process. The loss of translation during the traverse is unacceptable by organizations. A potentially costly consequence of risk may be missed or not handled with priority if the automatic approach would be incorporated into Calysto.

Technically speaking, the automatic approach is the most programmatically involved out of the three methods considered. At each organization level, an additional configuration list would need to exist. Changes to the automatic site provisioning process would need to be incorporated as well as retroactively adding the list to all existing sites. By default, all lists would be pre-populated as having a zero for the relation factor. Once the lists are properly provisioned, outreach would need to be performed to train all users how to navigate and select the appropriate relation.

Additional configuration options add to the complexity of the Calysto application with room for human error. Although only administrators of the Calysto organizational site would have access to their rollup configuration list, the options selected could be mistakenly entered or potentially tampered. The route to edit the configuration was proposed to be simple. (See FIGURE 13: Automatic Approach Configuration) Once a use navigated to the configuration list, all fields and relations would be populated. To edit and individual field, the user would click on the edit icon [ ] and would then be displayed the options for the field's relation (-5, -4, -3, -2, -, 1, 0 , 1, 2, 3, 4, 5). (See FIGURE 13: Relation Edit Form)

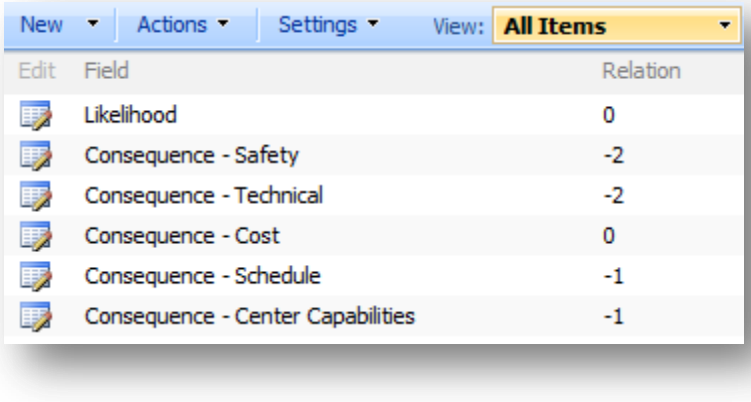


FIGURE 13: Automatic Approach Configuration

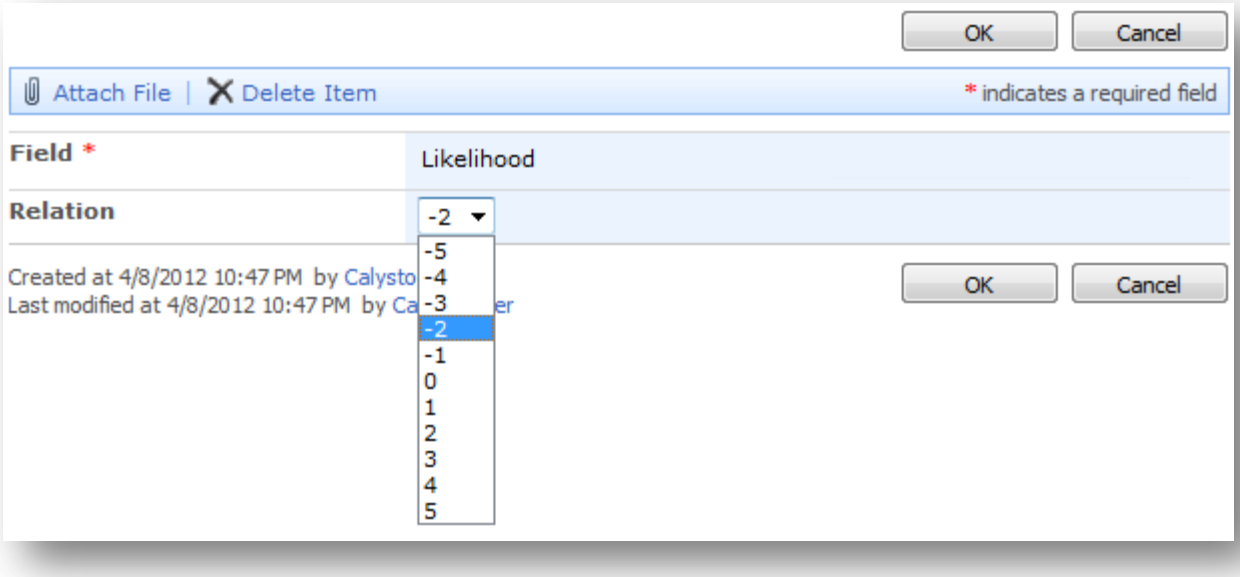


FIGURE 14: Relation Edit Form

As seen in the results for experiments 1 and 2 in Chapter 5 for the automatic approach, risks could potentially be converted into a low risk when originally created as a high risk. The method is an automatic route to convert risks and rollup the data with minimal human intervention. However, the end result is deemed inefficient and it is suggested to not be considered for implementation in the Calysto Risk Management Tool.

6.3. Discussion - Hybrid Approach

The results in Chapter 5 show the hybrid approach is the clear choice for the Calysto risk management tool. The simplistic method allows a user to select the specific organizational level to stop the rollup process. (See FIGURE 15: Hybrid Risk Rollup and Chapter 3 FIGURE 4: Calysto Hierarchy) When a user adds a new risk or edits an existing risk, the check box field in Figure 12 is replaced with a drop down list displaying all parent organizational levels for the current organizational site as options.

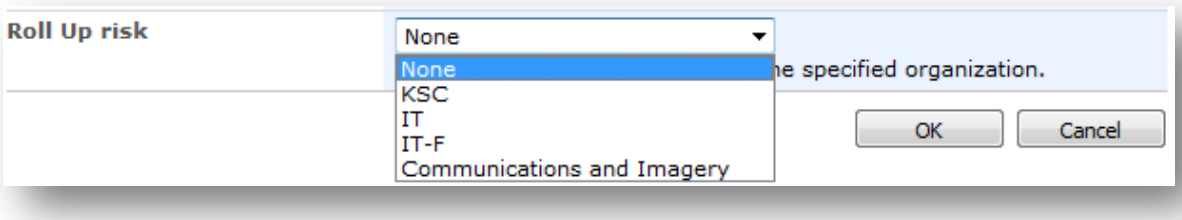


FIGURE 15: Hybrid Risk Rollup

The level of effort required to implement the hybrid approach is minimal and will require zero maintenance by the end user. Compared to the automatic approach, the human error factor is substantially reduced in the hybrid approach. With the granular method, the chance of error is reduced for an individual risk. All risks in an organizational site would not be affected similar to the automatic approach. If an error is made in classifying the level of rollup, a correction can be made by editing the risk and selecting the correct rollup level.

6.4. Discussion - Benefits of SharePoint

The Calysto Risk Management Tool and the included rollup functionality are built in Microsoft Office SharePoint Server (MOSS) 2007. The platform was chosen for the overall extendibility of a proven solution. SharePoint sets the stage for development work by already completing a data access layer of tiered development. SharePoint lists replace standard database tables and have built in storage commands allowing for quick development.

When developing for Microsoft's SharePoint technologies, scalability is always in the developers mind. A solution deployed to a SharePoint server farm is usually in at least one of the following feature "scopes"

- Farm – consists of all SharePoint web applications, site collections and webs
- Web Application – consists of SharePoint site collections, and webs

- Site Collection – consists of a collection of SharePoint webs
- Web – a SharePoint site consisting of lists, libraries and pages

[9]

Features are activated at each scope to deploy a set of reusable instructions. With scalability in mind, features can be used to create templates and standardization across a set of SharePoint sites. In the architecture used for the Calysto Risk Management tool, features are used at the Site Collection and Web levels. The RMT is a separate site collection in a part of the enterprise's SharePoint farm. A Site Collection feature activates the Calysto Infrastructure in preparation for activating the Calysto Web features. The Web features used in Calysto create the required lists, libraries and pages. Reports used in Calysto are shared across the Webs in the Site Collection and exist at the root web (Reference IT54-SDD-Calysto). The central location for reports allows a cascading update when modifications are made to the reports: a change is made in one place and replicated n times across the site collection, where n equals the amount of webs in the site collection.

SharePoint custom web parts displaying the reports and custom features added to the solution allow for the scalable architecture of Calysto. Allowing growth to the application overcomes the restrictions of the first iteration of the RMT. Using Microsoft’s best practices for SharePoint development compared to the limited SharePoint design restrictions allows for the tool to be a practical solution for the foreseeable future.

7. Conclusion

The study of *Calysto: Risk Management for Manned Spaceflight* was successful in determining the proper method to elevate, or "rollup" individual risks identified by an organization or project throughout an organizational hierarchy. The method found to give the best value in risk rollup was determined to be the hybrid method. Compared to the manual method, the hybrid approach allows a user to specify the cutoff point while traversing up the hierarchy, whereas the manual method sets the individual risk to rollup to all parent organization. The automatic approach was determined to be flawed as the premise of automatically converting risks based off mapping values at each organizational level leads to converting an item with high risk to zero risk.

The end result of the study has paved the way for a future rendition of the Calysto Risk Management took and has added value behind the upgrades. The original intent of the study was to investigate how to manage and communicate risks in a large organization. The study has shown with the proper techniques in place, risk management can become an added value to any size of organization, large or small. The risk management process is adaptable to specific organizations and while organizations change directions, the risk management process needs to adapt. The method of managing and communicating risks will need to change with organization change as well as new technological resources.

Using NASA's Kennedy Space Center's Calysto Risk Management Tool user base as the prime research consultants posed concerns to both contract and governmental data restrictions. To address these concerns, no actual data was used in the study. Example data was used in replacement. NASA policy is to restrict data access between competing contractors and by displaying the data in the study

would violate the policy. To overcome the issue of NASA internal only document references, all documentation used in the study is made publicly available and accessible via the internet.

Using the Calysto Risk Management Tool at NASA's Kennedy Space Center, and any organization large or small, adds value to the organization's risk management process and procedures. By offering standardization for risk capture and analysis, data can be transferred between organizations with minimal loss of translation. Data will become available to necessary parties involved at quicker pace to allow for a quicker response. Time is of the essence for risk management and by utilizing Calysto, organizations can react in a timely manner to reduce the consequences of risk.

Works Cited

[1] O'Conner, Bryan. (2008 December). *Agency Risk Management Procedural Requirements .* [Online]. Available: http://nodis3.gsfc.nasa.gov/npg_img/N_PR_8000_004A_/N_PR_8000_004A_.pdf

[2] G. Stoneburner, A. Goguen, and A. Feringa. (2002 July). *Risk Management Guide for Information Technology Systems.* [Online]. Available: http://csrc.nist.gov/publications/nistpubs/800-30/sp800-30.pdf

[3] ClearRisk, Inc. (2010 May). *The Risk Management Process.* [Online]. Available: http://www.clearrisk.com/Manager/Whitepapers/ClearRisk-RiskManagementProcess.pdf

[4] ISO. (2009). *Risk Management – Vocabulary (First Edition).* [Online]. Available: http://www.pqm-online.com/assets/files/standards/iso_iec_guide_73-2009.pdf

[5] AIRMIC, ALARM, and IRM. (2002). *A Risk Management Standard.* [Online]. Available: http://www.theirm.org/publications/documents/Risk_Management_Standard_030820.pdf

[6] Alcorn, George. (2009) *Goddard Space Flight Center: Goddard Technical Standard – Risk Management Reporting*. [Online]. Available: http://standards.gsfc.nasa.gov/gsfc-std/gsfc-std-0002.pdf

[7] Worden, S. Pete. (2011). *NASA Ames Research Center Procedural Requirements: Risk Management Process Requirements*. [Online]. Available: http://server-mpo.arc.nasa.gov/Services/CDMSDocs/Centers/ARC/Dirs/APR/APR8000.4.html

[8] Greenfield, Michael A. (2000). *Langley Research Center: Risk Management Tools*. [Online]. Available: http://www.hq.nasa.gov/office/codeq/risk/docs/rmt.pdf

[9] Rice, Frank. (2008). *Microsoft: Creating a Custom Feature in SharePoint Server 2007*. [Online]. Available: http://msdn.microsoft.com/en-us/library/cc263911(v=office.12).aspx

Appendix A: Glossary

RMT	: Risk Management Tool - A tool used for the practice of risk management. i.e. Calysto
Calysto	: Risk management tool used at Kennedy Space Center developed by the KSC Institutional SharePoint team.
Consequence	: Outcome of an event affecting objectives [5].
CRMWG	: Center Risk Management Working Group - Group creating at the top level of KSC's organizational hierarchy encompassing all sub organization representatives.
Frequency	: Number of events or outcomes per defined unit of time [5].
KSC	: Kennedy Space Center - NASA facility located in Merritt Island Florida.
Likelihood	: Chance of something happening [5].
NASA	: National Aeronautics and Space Administration - United States government organization for aeronautics and aerospace.
Risk Identification	: Process of finding, recognizing and describing risks [5].
Risk Management Process	: Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and Identifying, analyzing, evaluating, treating, monitoring and reviewing risk [5].
Risk Management	: Coordinated activities to direct and control an organization with regard to risk [5].
Risk Matrix	: Tool for ranking and displaying risks by defining ranges for consequence and likelihood [5].
Risk Scorecard	: Detailed table showing mappings of level of consequence and likelihood for risk management.
RMB	: Risk Management Board - An organizational group setup to analyze and track risks.
XML	: Extensible Markup Language
XSL	: Extensible Stylesheet Language

Appendix B: Project File Repository Definitions

SharePoint repository provided by Gary Dillaman:
http://my.dillaman.net/thesis

Subversion repository provided by Gannon University:
http://cissvn.gannon.edu:8080/SVN/CISCourse/CIS698AY11-12

Appendix C: Calysto System Requirements Specification

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1. INTRODUCTION

1.1. Purpose

This Software Requirements Specification provides a complete description of all the functions and specifications of the Calysto Risk Management Tool (RMT).

1.2. Intended Audience

The expected audience of this document is any organization at NASA expected to use this system, the KSC Institutional SharePoint Team and the developer.

1.3. Scope

Calysto is to be installed on a web based server to allow members of an organization to enter information about a risk, assign mitigation tasks, and assist in risk review boards and rollup a risk to parent level of their organization. The data will be held in a Microsoft SQL server database and accessible via a web interface.

1.4. Glossary

1.4.1. Acronyms

KNPD – Kennedy NASA Policy Directive

NPR – NASA Procedural Requirements

RMT – Risk Management Tool

1.4.2. Definitions

Risk Consequence - A representation of the qualitative or quantitative severity of the performance degradation that would result if the risk statement became true

Risk Likelihood - As defined in NPR 8000.4, “A measure of the possibility that a scenario will occur that also accounts for the timeframe in which the events represented in the scenario can occur.”

Risk Owner - As defined in NPR 8000.4, “The ‘risk owner’ is the entity, usually a named individual, designated as the lead for overseeing the implementation of the agreed disposition of that risk.”

Risk Product - The highest consequences multiplied by the highest likelihood.

Risk Trend - Status of the risk since last review: New, Unchanged, Increasing, or Decreasing. Value is defined by evaluating whether the Risk Product has remained the same, increased, or decreased.

Risk Matrix - A 3 by 3 or 5 by 5 grid with the level of consequences on the Y axis and the likelihood on the X axis

Risk Scorecard - A table of consequences with a numerical value associated with description of a consequence.

Scorecard Mapping - A mapping a parent to child project site risk scorecards to allow for different levels of consequences

Project Site - A container for an organization comprising of: risk data, mitigation tasks, risk scorecard, risk scorecard mapping, and options for configuration.

Rollup - Includes the current project's risks and all child projects’ risks.

1.5. References

1.5.1. NPR 8000.4

Agency Risk Management Procedural Requirements

1.5.2. KNPD 8000.4

KSC Center Risk Management

1.5.3. Section 508

http://www.section508.gov/

2. DESCRIPTION

2.0. System Identification and Overview

The Calysto Risk Management Tool (RMT) will be a central location to identify, track, analyze and mitigate risks for an organization. Using an organizations hierarchy, individual project sites will be created at the corresponding level. At each project, risks will be individually scored based off a series of questions and automated calculation. The RMT will allow the user to manually "rollup" a risk to the parent level and will display suggested risks to rollup based off a mapping of the risk score card (Appendix B).

2.1. Operating Environment

The RMT will be deployment in a Microsoft Office SharePoint Server 2007 farm. The farm will consist of two web front end servers, an application server used for search and indexing, a Microsoft SQL Server 2008 database server. All servers in the farm will run the Windows Server 2008 R2 operating system.

2.2. User Documentation

The RMT will provide an online user guide for each user role depicting all features provided by the application. The online guide will be accessible on any page of the application. Additionally, support contacts will provide throughout the system and the online user guide will be available for download in PDF format.

3. REQUIREMENTS

3.0. Functional Requirements

3.0.1. Data Input

3.0.1.1. The RMT software shall import project sites via user inputs.

3.0.1.2. The RMT software shall import risk data for a project via user input. (Appendix A)

3.0.1.3. The RMT software shall import mitigation task data for a risk via user inputs. (Appendix B)

3.0.1.4. The RMT software shall import a risk project scorecard data via user inputs. (Appendix C)

The RMT software shall import risk scorecard mappings via user inputs.

3.0.1.5. The RMT software shall provide configuration settings for the project owners via user input.

The RMT project configuration settings shall provide, the ability to: enable/disable approvals, select risk schema, select automatic or manual trending, turn on email alerts, modify the project editor, select the risk matrix, and modify the "Risk ID" naming convention

3.0.2. Data Processing

3.0.2.1. The RMT software shall calculate a "Product" based off the highest consequence multiplied by the likelihood of the risk.

3.0.2.2. The RMT software shall send an email to the "Risk Owner" upon assignment of a risk.

3.0.2.3. The RMT software shall report risks in a single display view. The view shall display all fields for a specific risk.

3.0.2.4. The RMT software shall report risks in presentation view. The view shall display a web based version of a PowerPoint presentation with a subset of fields for a specific risk, a collection of risks for a project, or a rollup collection of risks.

3.0.2.5. The RMT software shall report risks in a dashboard view. The view shall display a horizontal subset of fields for a specific risk, a collection of risks for a project, or a rollup collection of risks.

3.0.2.6. The RMT software shall report risks via an interactive risk matrix. When a cell in the risk matrix is clicked the RMT shall filter a horizontal display of fields for a specific risk, a collection of risks for a project, or a rollup collection of risks.

3.0.2.7. The RMT software shall report risks via a suggested rollup view. The view shall display risks suggested to be elevated to the parent project based off the risk's scorecard mapping.

3.0.2.8. The RMT software shall generate a unique Risk ID based off the project site structure, the year, and a unique identifier.

3.0.2.9. The RMT software shall mark items as delete but keep the data intact for ease in restoration of a risk.

3.0.2.10. The RMT software shall automatically trend a risk if trending is enabled in the configuration for the project site.

3.0.2.11. The previously approved version (if approvals are enabled) shall be the baseline for the trend representation.

3.0.2.12. The trend representation shall depict the color of the risk matrix for the consequence and likelihood.

3.0.2.13. The RMT shall export risk data into Microsoft PowerPoint for a selected risk or a group of risks.

3.0.2.14. The RMT shall export risk data into Microsoft Excel for a selected risk or a group of risks.

3.0.3. Required States and Modes

3.0.3.1. The RMT software shall present data to users via a graphical user interface.

3.1. Non-functional requirements

3.1.1. Accessibility

3.1.1.1. The RMT software must be accessible via all internet browser software.

3.1.1.2. The RMT software shall be Section 508 compliant.

3.1.2. Configuration Management

3.1.2.1. The RMT software shall utilize a Microsoft SQL Server to host and store data

3.1.3. Disaster Recovery

3.1.3.1. The RMT software shall be backed up with full backups occurring weekly and incremental backs occurring nightly.

3.1.4. Security

3.1.4.1. The RMT software shall contain a security principle for owners of a project site with administrative functions and the ability to approve risks.

3.1.4.2. The RMT software shall contain a security principle for members of a project site with read and edit abilities for all data in the site.

3.1.4.3. The RMT software shall contain a security principle for visitors of a project site with a read only ability for all data in the site.

Appendix D: Calysto System Design Document

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1. INTRODUCTION

The purpose of this document is to give a detailed description of the Calysto Risk Management Tool (RMT) and its components. This document will give the developers and project managers a detailed view of the design requirements for the system. The purpose of creating Calysto is to provide a scalable solution to an evolving practice of Risk Management.

Reference: **IT54-SRS-Calysto**

2. SYSTEM OVERVIEW

Calysto will reside in a Microsoft SharePoint site collection consisting on multiple sub sites for each project/organizational level. The data inserted and retrieved will be stored in SharePoint lists ultimately residing in a Microsoft SQL Server instance. SharePoint forms will handle inserts and updates to the data with custom event handlers triggering automated calculations upon save. Reports will be displayed to the users via a custom web part rendering list data XML into HTML with an XSL style sheet. The reports will be filtered based off predetermined and user customizable SharePoint views.

The Calysto System Owner role in the SharePoint permission schema will provision new Calysto sites. The system will be installed on the site by activating a SharePoint web scoped feature upon creation. Calysto Owners will have the ability to modify configuration settings for the project for setting: the Project Name, Rollup of Risks, Approvals, Trending, Email Alerts, Schema, Naming Convention and editor. The Calysto Contributors role in the SharePoint permission schema will have the ability to add and update new risks for the projects and Calysto Visitors will have read-only access to the Calysto project.

3. DESIGN CONSIDERATIONS

3.0. ASSUMPTIONS AND DEPENDENCIES

3.0.1. PREREQUISITES

The following SharePoint Site Collection features must be activated in order to install Calysto:

- SharePoint Publishing Infrastructure
    - Allows for publishing to be enabled at the site level, allows multiple levels of fly-outs for the top navigation menu
- NASA Menu
    - Allows the SharePoint Quick Launch to be turned into a multiple level horizontal fly-out menu
- KSC SharePoint Branding Infrastructure
    - Brands the SharePoint site with custom graphics and CSS
- Calysto Infrastructure
    - Creates dependent files for a Calysto site

The following SharePoint Site features must be activated in order to install Calysto on a Site:

- SharePoint Publishing
    - Creates a Pages document library used to store publishing pages. This will allow for auto generation of .ASPX files used to house the custom Calysto web parts.
- Calysto
    - Creates .ASPX pages with custom Calysto web Parts and provisions dependent Calysto SharePoint lists for data storage and configuration.

3.1. GENERAL CONSTRAINTS

The roles for Calysto will be customized to disallow editing of pages and web part zones to restrict the user from modifying custom Calysto web part properties.

3.2. DEVELOPMENT METHODS

Calysto will be developed using Microsoft Visual Studio 2008 with the WSPBuilder Extensions installed. Any graphics created will be designed using Adobe Photoshop.

4. ARCHITECTURAL STRATEGY

4.0. INTEGRATION WITH SHAREPOINT

Calysto will have a seamless integration with SharePoint. Each of the pages for data entry and reporting will mirror the OTB SharePoint design. The concepts of views and default views will be incorporated into Calysto. Views will allow each customer the flexibility of adding and removing certain fields from the report. Calysto views will differ from SharePoint views as there will be mandatory fields and the user will not be able to remove them from the view.

4.1. DATA AVAILABILITY

The data for Calysto will have the same up time and availability of SharePoint. However, in the rare instance of the SharePoint infrastructure becoming unavailable due to unforeseen circumstances, users will not be able to access Calysto.

4.2. FUTURE PLANNING

Calysto will be developed with the mindset to easily maintain future upgrades. The Calysto application can be installed in multiple locations on the SharePoint farm, however and upgrade to the product will only need to be performed in one location and cascaded throughout the sites.

5. SYSTEM ARCHITECTURE

5.0. BACK END

SharePoint lists will store the Calysto data used throughout the sites collection. The insert, update, delete commands will be interpreted in the SharePoint object model. Versioning will be turned on in all lists to allow historical data representation by time and user performing the update.

5.1. FRONT END

The front end of Calysto will consist of SharePoint master pages, themes, page layouts and web parts. Each implementation of Calysto can consist of a different master page and theme chosen by the site owner. The page layouts and web parts will be standard across all implementations of Calysto.

6. POLICIES AND TACTICS

6.0. SITE COLLECTION SCOPED FEATURE

The site collection scoped feature will create the page layouts and their associated content types. They will be reused throughout the sub sites of the site collection. The feature will also add the Calysto custom web parts to the site collection web part gallery. In order for the feature to be activated, it has a prerequisite of having the "Office SharePoint Server Publishing Infrastructure" feature activated. The feature will automatically activate the web scoped feature at the root of the site collection. The feature will create the following SharePoint content types: Error Log, Configuration, Risk, Mitigation Task and Scorecard Mapping. The Error Log list will be created at the root of the site collection to store errors from any sub site.

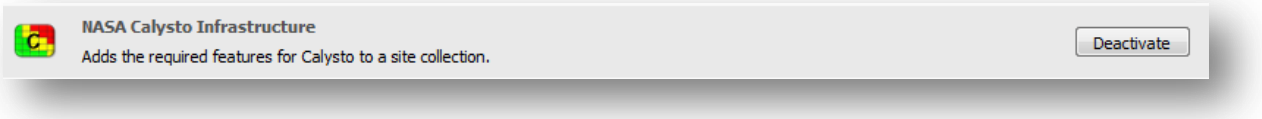

FIGURE 16: Site Collection Scoped Feature

6.1. WEB SCOPED FEATURE

The web scoped feature will create the pages and navigation for the data manipulation and reporting tools of Calysto. When creating the pages, it will programmatically add the proper web parts to the page and configure them accordingly. In order for the feature to be activated, it has the prerequisites of having the Calysto site collection scoped feature activated and the "Office SharePoint Server Publishing" web scoped feature activated. Upon activation, the default page for the sub site will be set as the Dashboard Rollup. The configuration properties for the parent site will be inherited to the new Calysto sub site.

The web scoped feature will create the following lists on the current site: Configuration, Risk, Risk Rollup, Mitigation Tasks and Scorecard Mapping.

The following pages will be created with the proper web part added and configured: Administration, Dashboard, Dashboard Rollup, Presentation, Presentation Rollup and Risk Overview

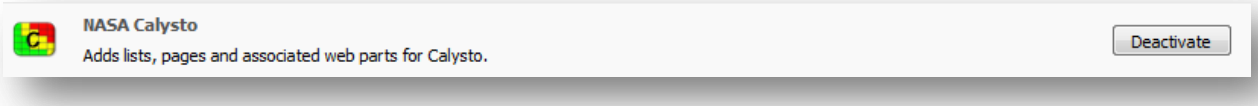

FIGURE 17: Web Scoped Feature

7. DETAILED SYSTEM DESIGN

7.0. OBJECT MODEL

Reference: **IT54-OM-Calysto.pdf**

7.1. NAVIGATION

7.1.1. TOP LINK BAR

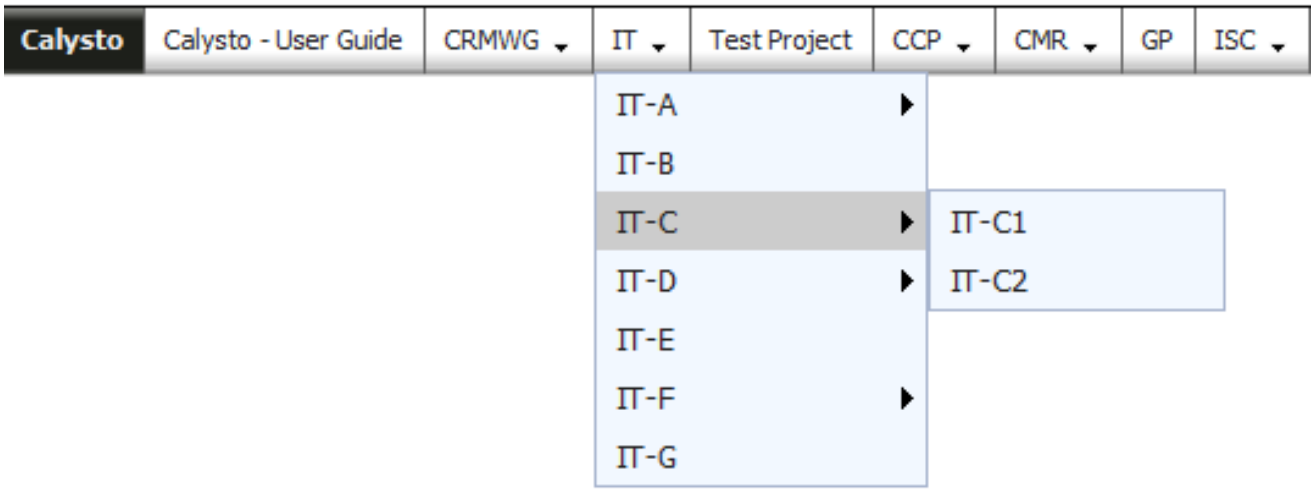

FIGURE 18: Top Link Bar

The Top Link bar is replicated on all Calysto project sites and sub sites. Each organization can have multiple sub organization/projects. When an organization/project is clicked, the corresponding Dashboard page will be displayed.

7.1.2. PROJECT MENU

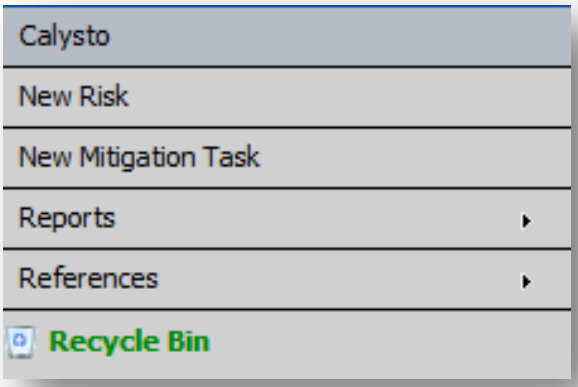

FIGURE 19: Project Menu

The Project Menu is displayed on every page within a project. The links are relative to the current site.

The Reports Menu includes links to:

- Overview
- Dashboard
- Dashboard Rollup
- Presentation
- Presentation Rollup
- Risk Data

The References Menu includes links to:

- Consequence Chart
- Legends
- User Guide

7.1.3. SITE ACTIONS

The Site Actions menu is located in the top right hand corner of every page in a Calysto Project site. Only Calysto System Owners or Calysto Owners for the current project will see the menu. Three menu options will be visible to the owner:

Create Project – Directs the user to the Administration page displaying a new project form.

Manage Configuration **–** Directs the user to the Administration page displaying the configuration options for the current project.

People and Groups – Directs the user SharePoint's built in tool for managing group permissions.

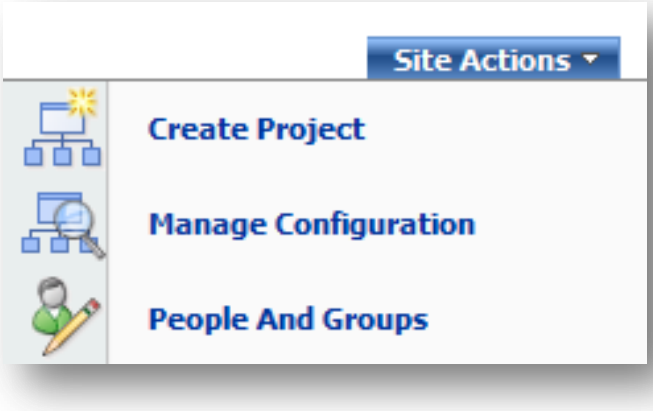

FIGURE 20: Site Actions Menu

7.2. PAGES

7.2.1. ADMINISTRATION

Filename: Administration.aspx
Web Part(s): Configuration Web Part
Access: Calysto System Owners, Calysto Owners
Linked from: Site Actions Menu

7.2.2. DASHBOARD

Filename: Dashboard.aspx
Web Part(s): XSL Web Part
Access: Calysto System Owners, Calysto Owners, Calysto Visitors
Linked from: Project Menu, Top Link Bar

7.2.3. DASHBOARD ROLLUP

Filename: DashboardRollup.aspx
Web Part(s): XSL Web Part
Access: Calysto System Owners, Calysto Owners, Calysto Visitors
Linked from: Project Menu

7.2.4. PRESENTATION

Filename: Presentation.aspx
Web Part(s): XSL Web Part
Access: Calysto System Owners, Calysto Owners, Calysto Visitors
Linked from: Project Menu

7.2.5. PRESENTATION ROLLUP

Filename: Overview.aspx
Web Part(s): XSL Web Part
Access: Calysto System Owners, Calysto Owners, Calysto Visitors
Linked from: Project Menu

7.2.6. RISK OVERVIEW

Filename: Overview.aspx
Web Part(s): Calysto Overview Web Part
Access: Calysto System Owners, Calysto Owners, Calysto Visitors
Linked from: Project Menu

7.3. WEB PARTS

7.3.1. CONFIGURATION WEB PART

The Configuration web part is placed on the "Adminsration.aspx" page on each project site and only accessible to Calysto System Owners and Calysto Owners. The web part has no custom properties to configure.

If the Administration page is supplied the query string pair of "type=Configuration", the Configuration version of the web part will be display. When added to a page in a Calysto site, the web part will read from the current site's configuration list. Upon save, event handlers on the configuration list will modify the properties for the sites lists and features. The following events will be triggered upon save:

Project Title – No events triggered; updates the SharePoint site title.

Rollup Risks - The default value for the Risk Rollup checkbox will be set as checked for new Risk items in the Risk list.

Approvals – When set to "On", approvals will be required to make the risk visible by all users of the Calysto site; only Calysto Owners and the person adding/editing the record will see the updates. When set to "Off", all users of the Calysto site will immediately see the changes to the Risk.

Trending – When set to "On", trending will be calculated automatically based of the previous version of the risk (previous approved version if Approvals are turned on. When set to off, a new field called Trending will be visible in the Risk item. The user will have the following options for setting the trending: New, Increasing, Decreasing or Unchanged.

Email Alerts- When set to on, the user supplied in the Risk Owner field of the Risk item will be sent an email notifying of Risk ownership.

Schema – Multiple schemas will be available for a risk site; this will allow for different field types and field names. The schemas will be managed by Calysto System Owners but selectable by Calysto Owners. Modifying the schema will update the Risk list to reference the new field names and field types.

Naming Convention - The naming convention is a maximum three character starting point for Risk IDs. The "KSC" naming convention will create a risk id in the form of KSC-2011-1 or [Naming Convention]-[Current Year]-[Unique ID for the Naming Convention and Year].

Editor – The text entered in the "Editor" field will show up in the footer of each page in the site to denote the editor of the current Risk site.

Matrix- the Matrix configuration option will only be visible to Calysto System owners and available only to the root site of the site collection. When changing from a 3x3 to 5x5 (or vice versa) the options in the drop downs for both consequences and likelihood will be set to 3 or 5 respectively.

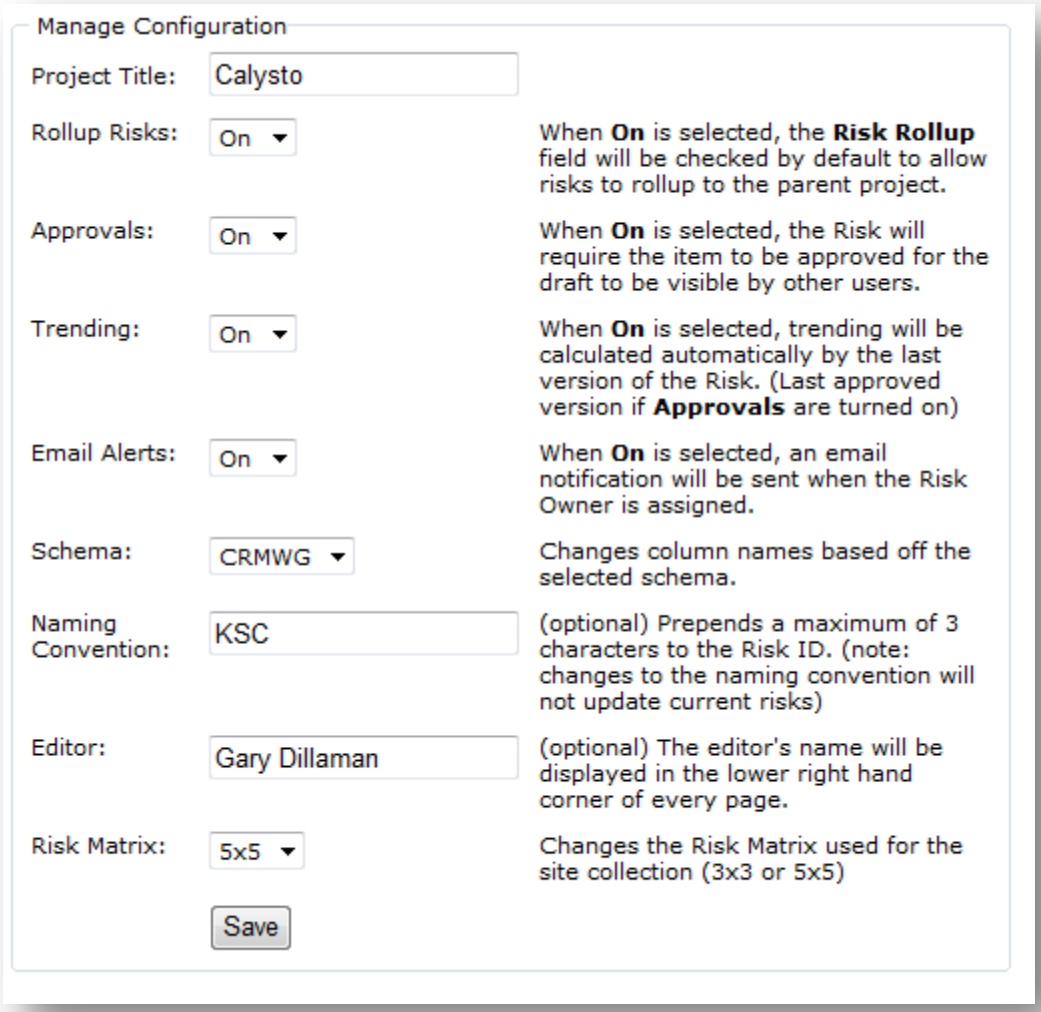

FIGURE 21: Configuration Web Part using the Configuration Query String

If the Administration page is supplied the query string pair of "type=Project", the create project version of the web part will be display. The web part will display two fields required to create a new project:

Project Title – Any length of characters allowed; displayed throughout the application as references to the project.

Project URL – A maximum of five characters allowed; used for the URL of the project and building the Risk ID.

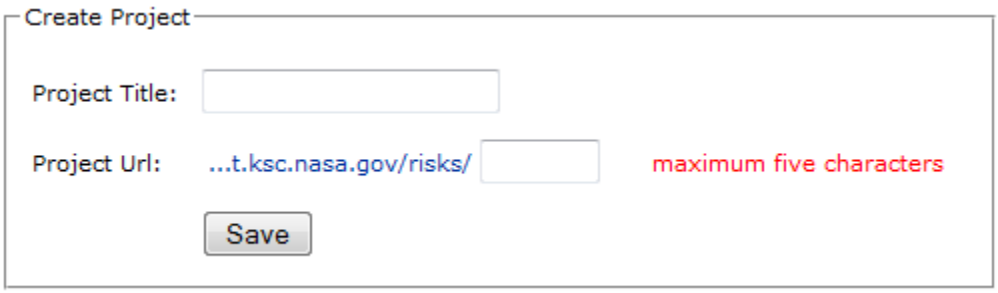

FIGURE 22: Configuration Web Part using the Project Query String

Once saving the data for the new project, an alert will be displayed notifying the user to wait for the creation of the project. Once the project has been created, the user will be redirected to the new blank project site.

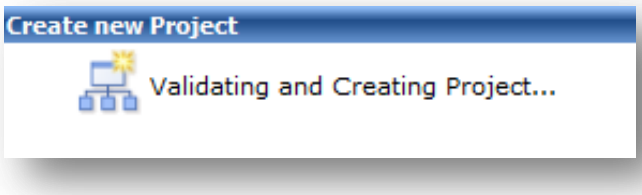

FIGURE 23: Create New Project Notification

7.3.2. XSL WEB PART

The XSL Web Part has web part properties made accessible via a custom tool part allowing page post backs when changing certain fields. The web part is made accessible on the following pages: Dashboard, Dashboard Rollup, Presentation and Presentation Rollup. The proper report is displayed on the page by selecting the “List” property (Risk or Risk Rollup), the Display Type (Dashboard or Presentation) and the report XSL file. The reports are stored in the “XSL” document library at the root web of the site collection.

Selecting any check box and clicking the Export link button will export the risk data to either Microsoft PowerPoint or Microsoft Excel depending on the button clicked. Clicking the Printable link will open a new browser window with minimal chrome and display only the current report.

FIGURE 24: XSL Web Part using the Dashboard/Dashboard Rollup report configuration

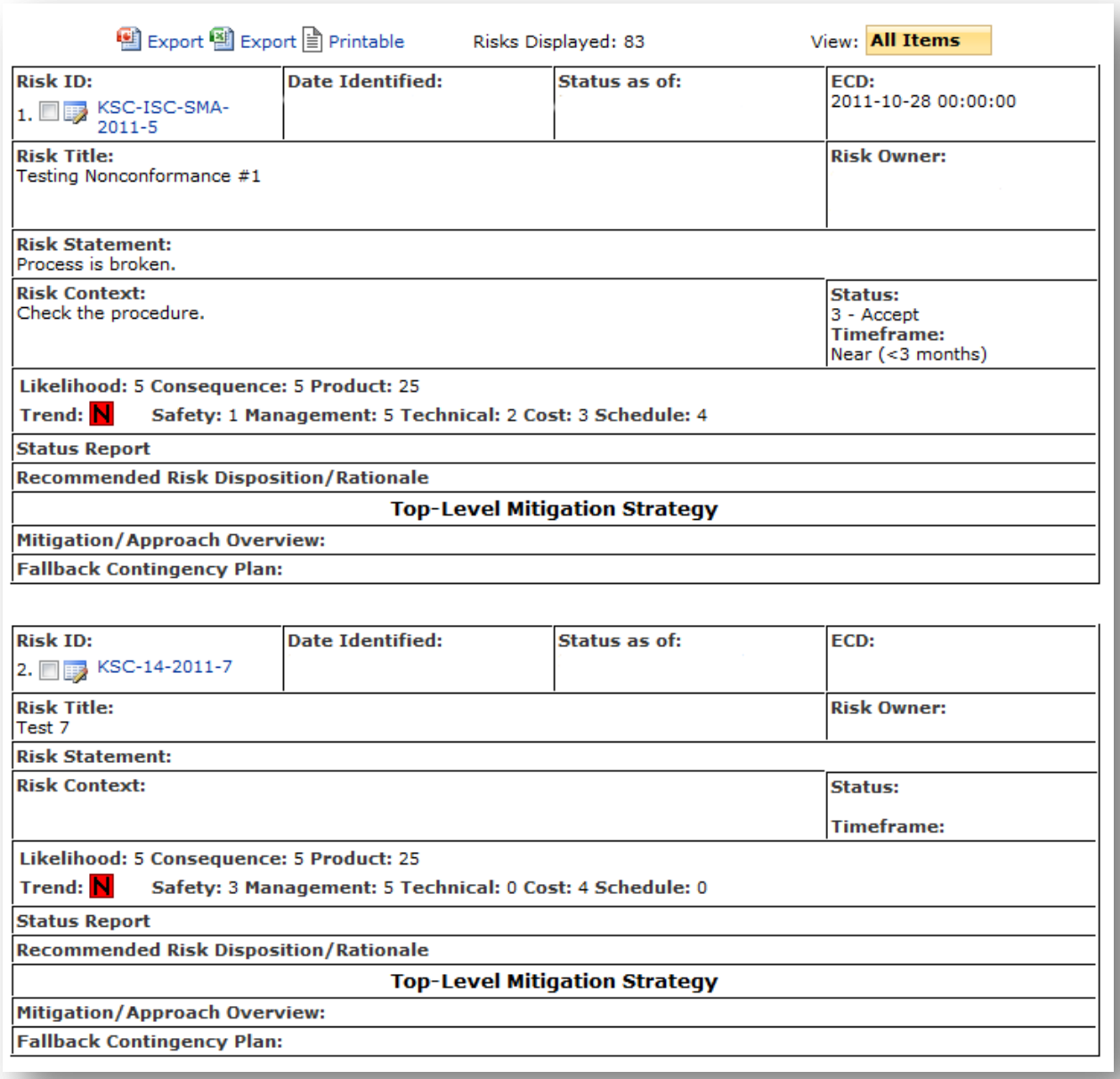

FIGURE 25: XSL Web Part using the Presentation/Presentation Rollup report configuration

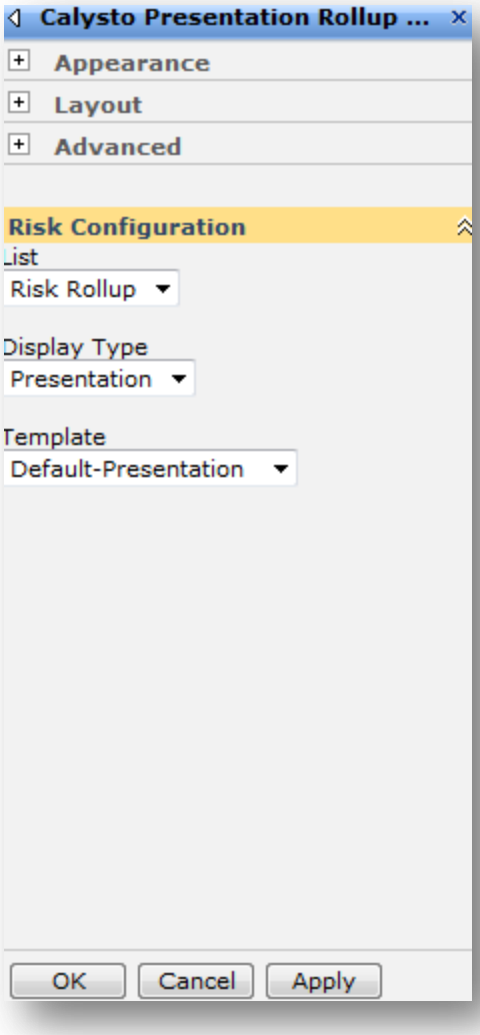

FIGURE 26: XSL Web Part Properties

When selecting to export a Risk or group of Risks to PowerPoint by clicking on the corresponding checkbox and selecting the PowerPoint export button Export , the user will be displayed a window to select either a new or existing slide library.

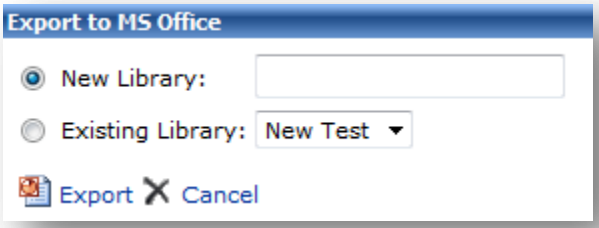

FIGURE 27: Export to PowerPoint

Once the Export button is clicked, the user will be notified the PowerPoint slides are being exported. Upon successful export, the user will be directed to the selected slide library showing a view of the new slides for the Risk(s).

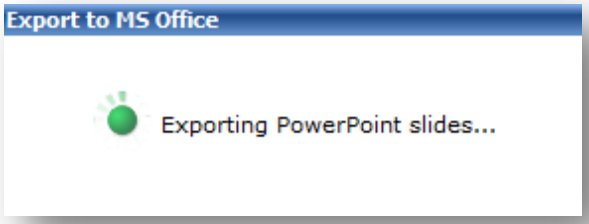

FIGURE 28: Export to PowerPoint Message

When selecting to export a Risk or group of Risks to Excel by clicking on the corresponding checkbox and selecting the Excel export button Export, the user will be directed to the newly export Excel export in the project sites "Excel Exports" document library.

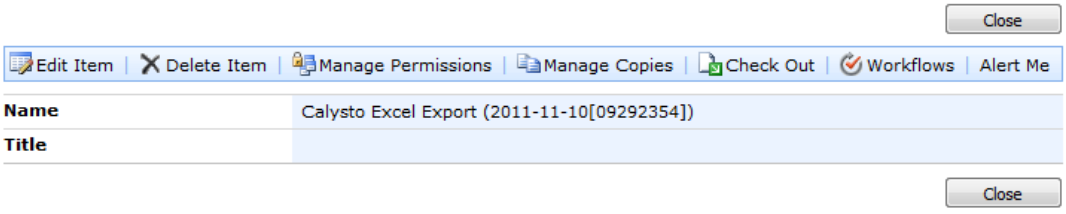

FIGURE 29: Excel Export

7.3.3. OVERVIEW WEB PART

The Overview web part is displayed on the Overview page accessible from the “Reports” section of the Project menu. There are no configurable web part properties; the web part will determine the current project site and display either the current project or the rollup for the current project. The web part displays the risk matrix (5x5 or 3x3) with a risk list filtered based off the selection of a cell in the risk matrix.

Selecting any check box and clicking the Export link button will export the risk data to either Microsoft PowerPoint or Microsoft Excel depending on the button clicked. Clicking the Printable link will open a new browser window with minimal chrome and display only the current report.

	Rank	Risk Title	Trend	Risk ID	L	Consequences T	S	C	Sa	M	P
	1	Test 18	N	KSC-2011-21	4	3	4	5	2	3	20
	2	Test Email Notification	N	KSC-2011-8	4	5	3	2	2	4	20
	3	3x3 Test	N	KSC-2011-11	4	3	5	4	2	1	20
	4	Test 16	N	KSC-2011-18	4	2	4	1	3	5	20
	5	Test 26	N	KSC-2011-29	4	3	2	4	2	4	16
	6	Test Li2	N	KSC-2011-7	3	3	4	3	2	5	15
	7	Test 22	→	KSC-2011-25	3	3	5	4	2	3	15
	8	Test 24	N	KSC-2011-27	3	4	5	4	2	1	15
	9	Test Li	N	KSC-2011-7	3	2	4	3	1	5	15
	10	Test 23	N	KSC-2011-26	3	3	2	4	1	5	15
	11	Test 20	N	KSC-2011-23	3	2	5	4	1	2	15
	12	Test 25	N	KSC-2011-28	3	5	2	1	2	4	15
	13	Test 1	N	KSC-2011-8	3	3	3	3	4	4	12

FIGURE 30: Risk Overview Web Part

7.4. INPUT FORMS

7.4.1. RISK

The Risk new form is located in each project site at <site>/Lists/Risks/NewForm.aspx. The Risk edit form is located in each project site at <site>/Lists/Risks/EditForm.aspx?ID={CurrentID}. The CurrentID reference will be the SharePoint ID for the risk currently being edited. A subset of fields are required forcing the user to enter data before saving the record. Once the record has been saved, the user will be directed to the All Items view of the Risk list.

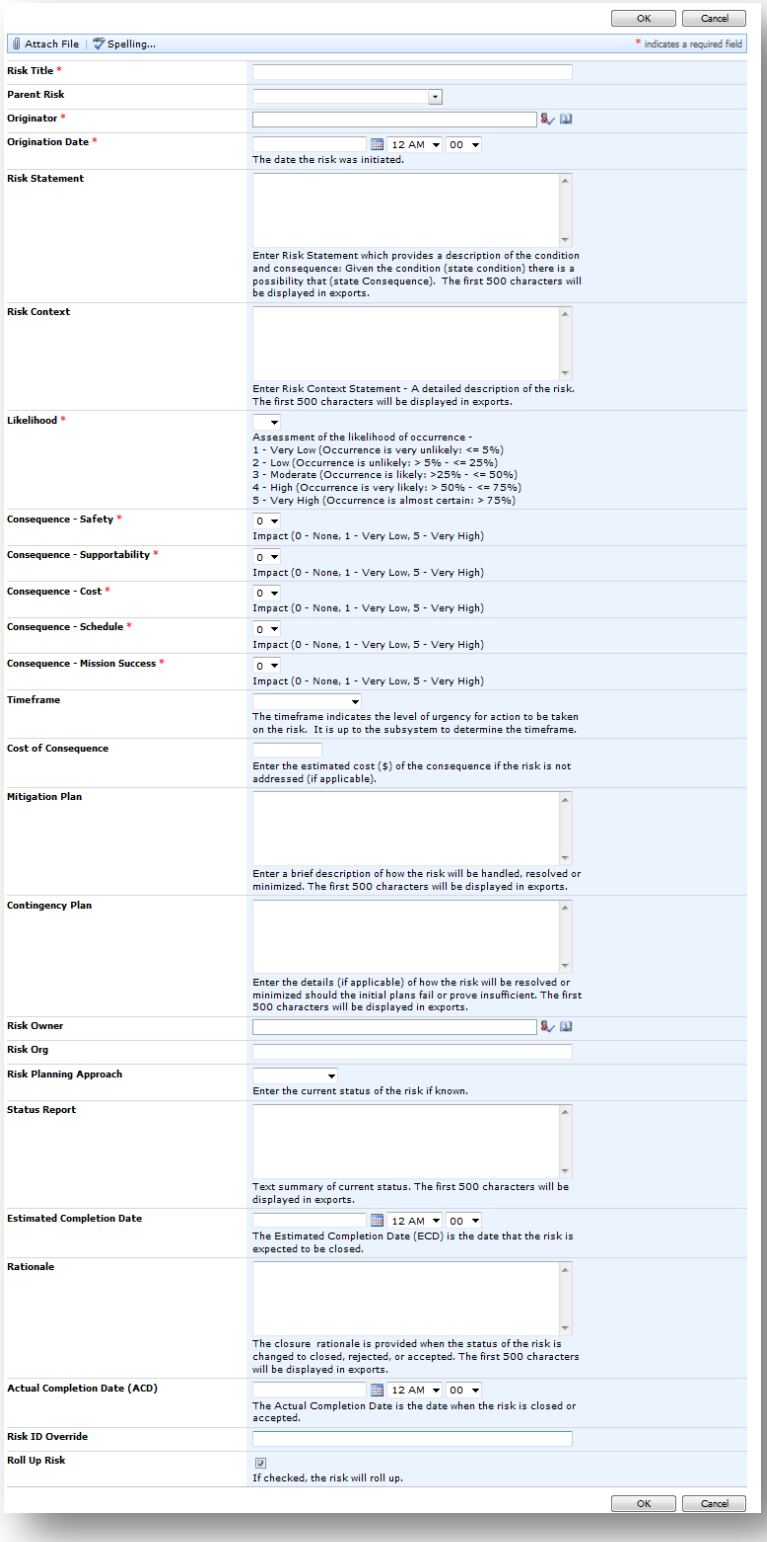

FIGURE 31: Risk Input Form

7.4.2. MITIGATION TASKS

The Mitigation Tasks new form is located in each project site at <site>/Lists/Mitigation Tasks/NewForm.aspx. The Mitigation Task edit form is located in each project site at <site>/Lists/Mitigation Tasks/EditForm.aspx?ID={CurrentID}. The CurrentID reference will be the SharePoint ID for the Mitigation Task currently being edited. Two fields are required, forcing the user to enter data before saving the record. The Risk field is a SharePoint lookup field display a list of all Risk IDs from the current project's Risk list.

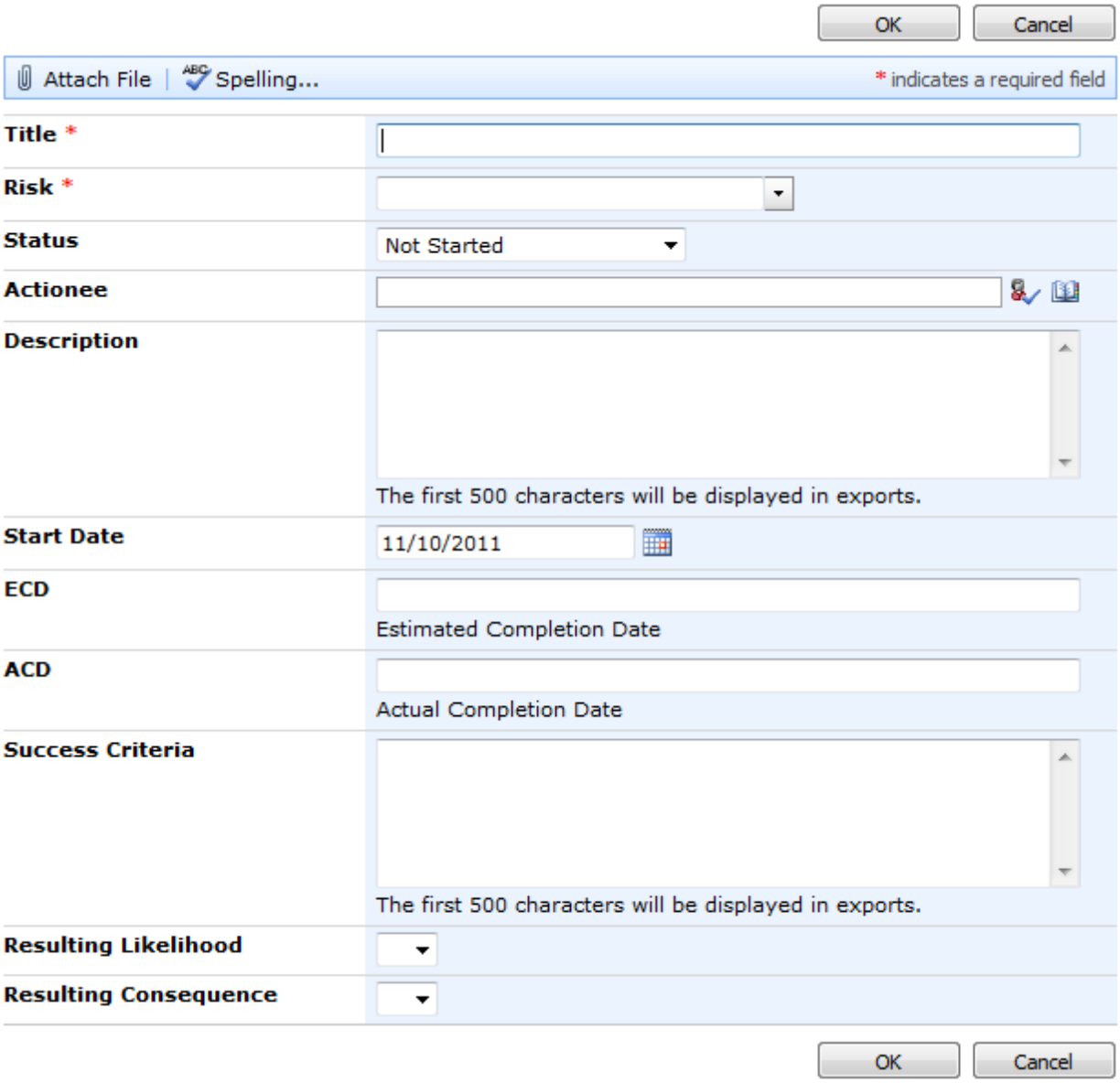

FIGURE 32: Mitigation Task Form

7.5. CALCULATIONS

7.5.1. RISK ID

The Risk ID for a risk is calculated based off the current project, the year, and the unique risks for the year. For example, if a risk the KSC IT organization is created, the first risk for the 2011 year will be: KSC-IT-2011-1. If the risk is a child risk for the example, it will append a period followed by a unique identifier: KSC-IT-2011-1.1. The template for Risk IDs is {PROJECT}-{YEAR}-{ID}.

7.5.2. TREND REPRESENTATION

The Trend Representation is used throughout Calysto to depict where the Risk sites in the risk matrix and how the risk is trending based on previous updates to the risk.

The color for the trend representation will be either:

Green - Low risk

Yellow - Medium risk

Red - High risk

The options for the trend are:

New – There is no previous version

Unchanged – The risk product has not changed from the previous version

Decreasing – The risk product has dropped since the previous version

Increasing – The risk product has increased since the previous version

To calculate the color of the cell in the risk matrix for a current risk, the follow code will be used:

```
if ((Likelihood == 3 && HighestConsequence == 5) || (Likelihood == 4 && HighestConsequence >= 4) ||
(Likelihood == 5 && HighestConsequence >= 3))
{
        strLevel = "High";
}
else if ((Likelihood == 1 && HighestConsequence == 5) || (Likelihood == 2 && HighestConsequence >= 3)
|| (Likelihood == 3 && HighestConsequence >= 3) || (Likelihood == 4 && HighestConsequence >= 2) ||
(Likelihood == 5 && HighestConsequence >= 2))
{
   strLevel = "Medium";
}
else
{
   strLevel = "Low";
}
```

The trend for the risks will be automatically calculated if the option is set in the configuration for the project site. To automatically calculate the trend, the previous version's product (Likelihood times the Highest Consequence) is compared to the current version's product. If automatic trending is turned off, a drop down will be displayed in the Risk form to depict "New", "Unchanged", "Decreasing", or "Increasing".

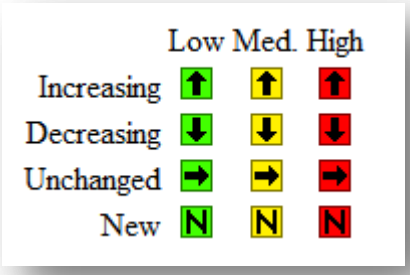

FIGURE 33: Trend Representations

7.6. PERMISSIONS

7.6.1. CALYSTO SYSTEM OWNERS

The Calysto System Owners will have SharePoint's built in Full Control permission level. Only the administrators of the application will have Full Control. The Calysto System Owners group is to be used for provisioning new projects, support, and modifying/creating reports for use across the application

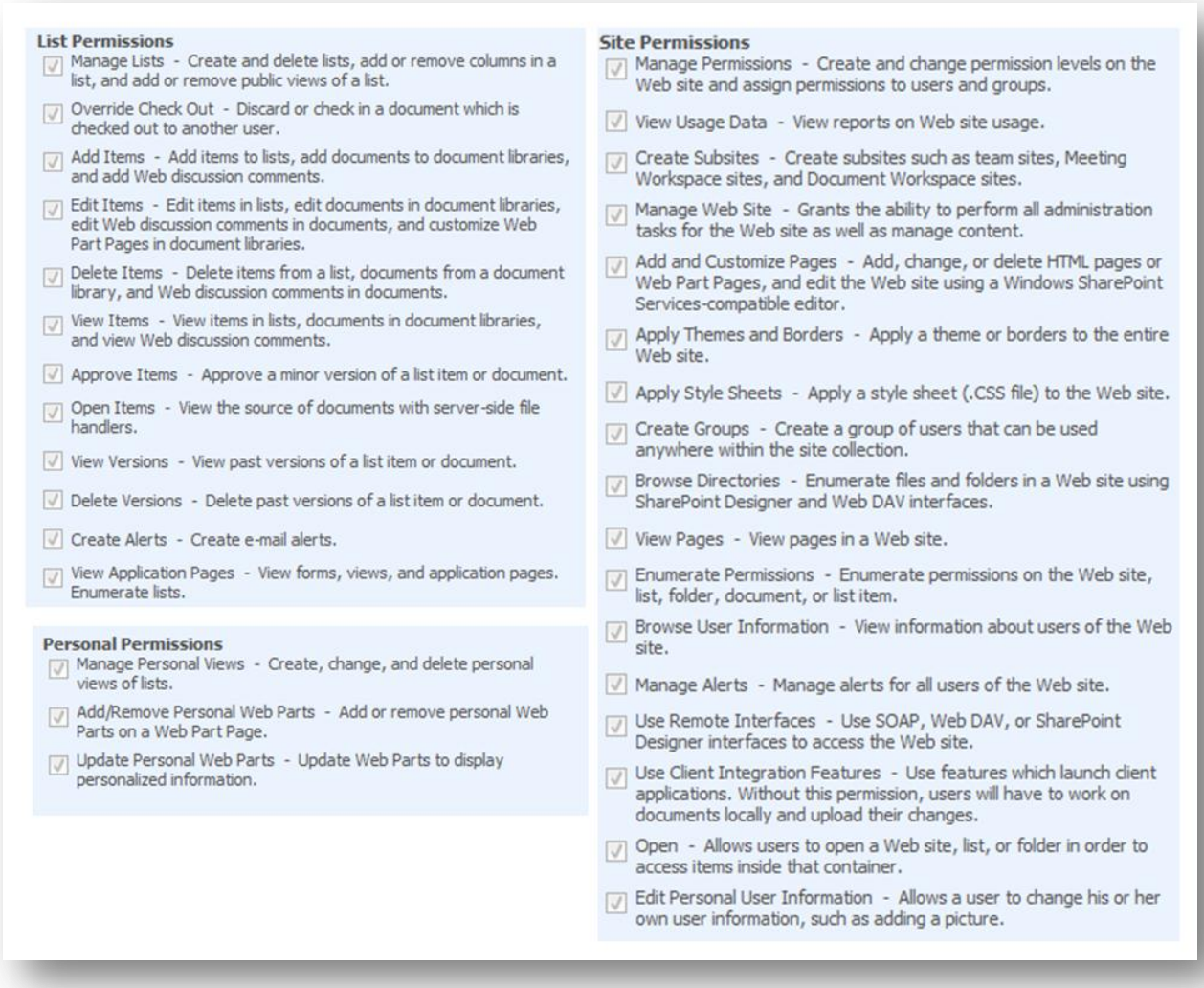

FIGURE 34: Calysto System Owners Permission Level

7.6.2. CALYSTO OWNERS

The Calysto Owners group for a project site is a derivative of SharePoint's built in Contribute permission set. Calysto owners are allowed to approve items in addition to all permissions in the Contribute permission set.

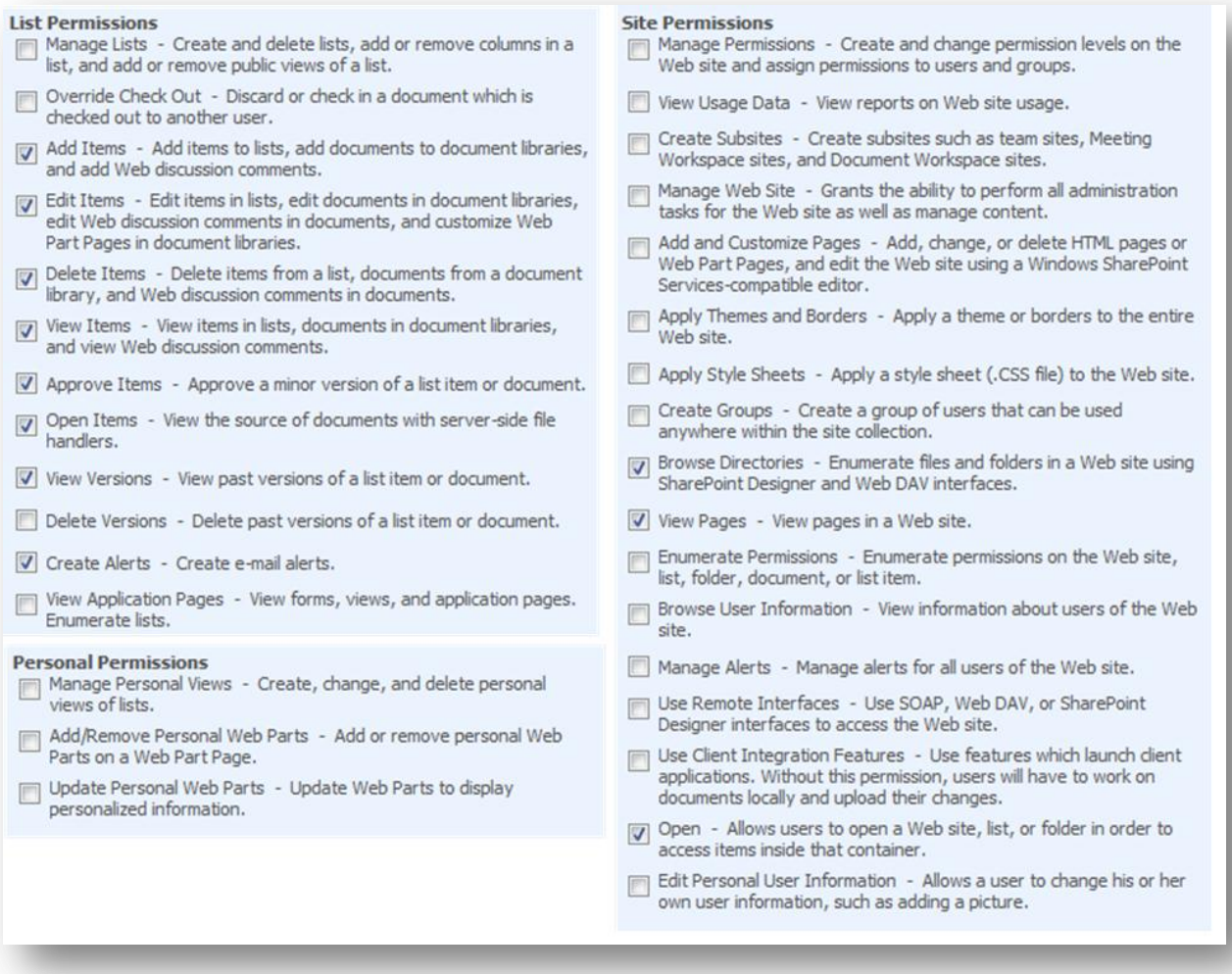

FIGURE 35: Calysto Owners Permission Level

7.6.3. CALYSTO MEMBERS

The Calysto Members group for a project site is a copy of the standard SharePoint Contribute permission set.

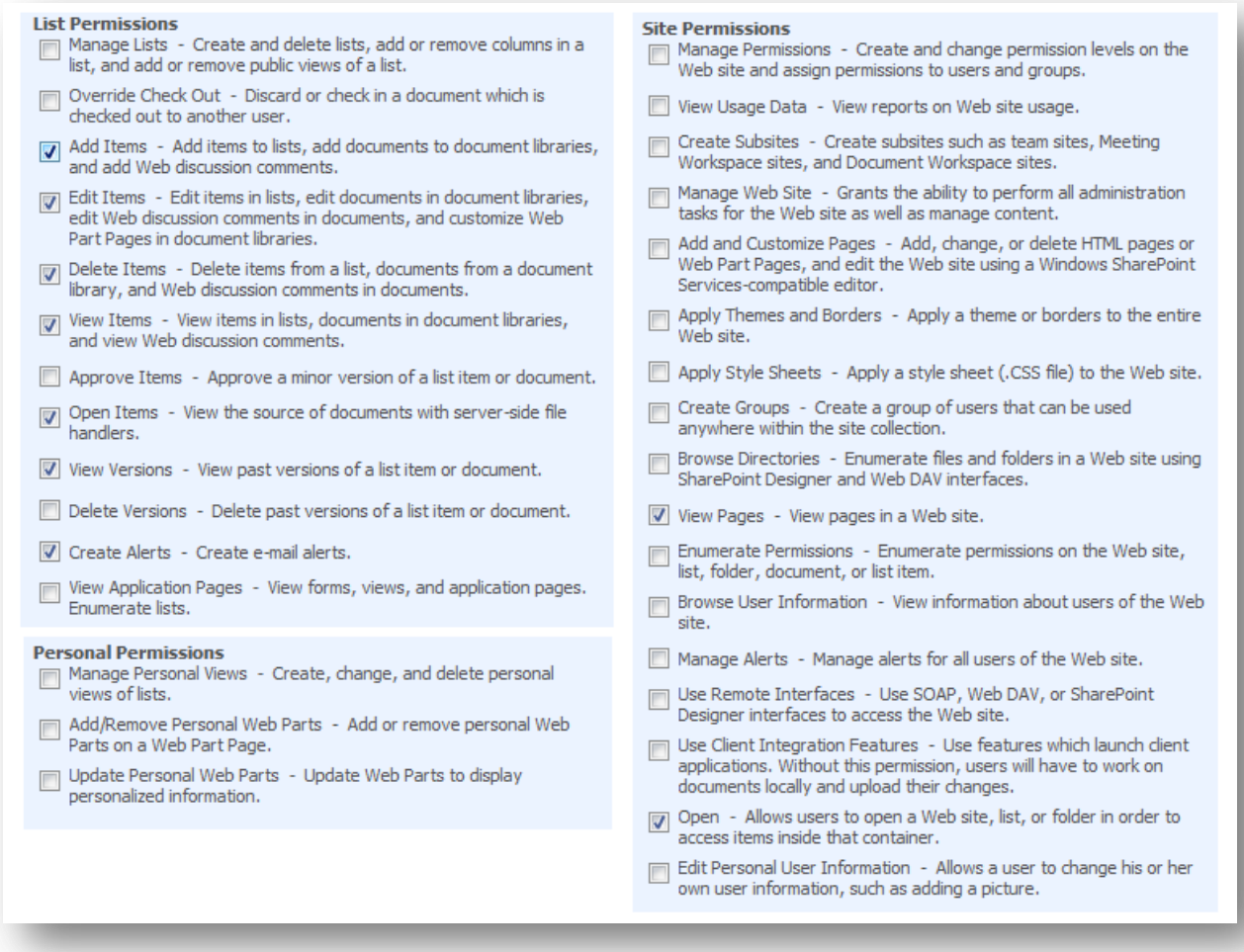

FIGURE 36: Calysto Members Permission Level

7.6.4. CALYSTO VISITORS

The Calysto Visitors group is a copy of the standard SharePoint Read permission set.

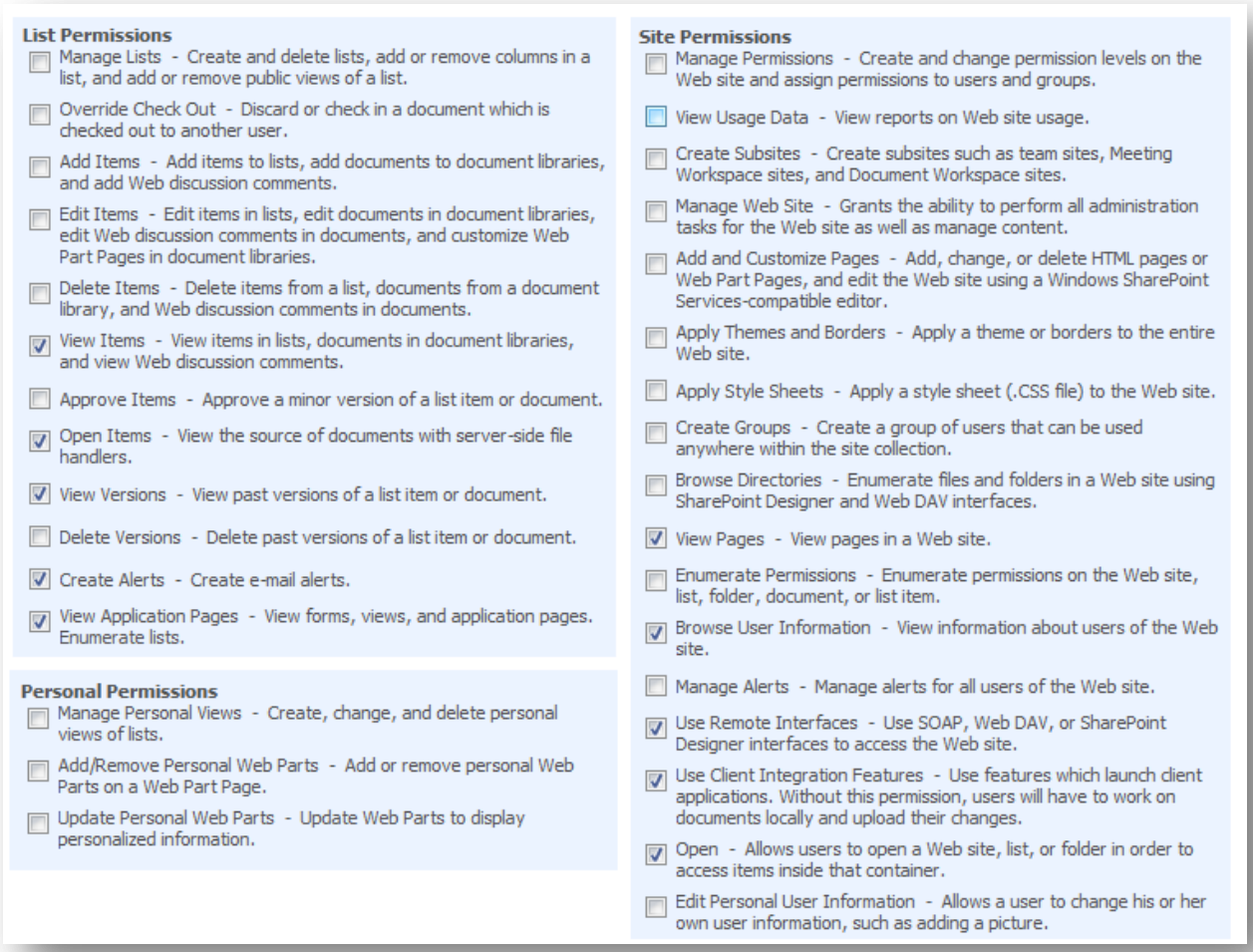

FIGURE 37: Calysto Visitors Permission Level