An Integrated Risk Management Tool and Process

Jeevan Perera, PhD, JD
NASA-Johnson Space Center
Houston, Texas 77058
(281) 483-5814
jeevan.s.perera@nasa.gov

Jerry Holsomback
NASA-Johnson Space Center
Houston, Texas 77058
(281) 244-7956
jerry.b.holsomback@nasa.gov

Abstract—Most project managers know that Risk Management (RM) is essential to good project management[1][2]. At NASA, standards and procedures to manage risk through a tiered approach have been developed – from the global agency requirements down to a program or project implementation. The basic methodology for NASA's risk management strategy includes processes to identify, analyze, plan, track, control, communicate and document risks. The identification, characterization, mitigation plan, and mitigation responsibilities associated with specific risks are documented to help communicate, manage, and effectuate appropriate closure. This approach helps to ensure more consistent documentation and assessment and provides a means of archiving lessons learned for future identification or mitigation activities.

A new risk database and management tool was developed by NASA in 2002 and since has been used successfully to communicate, document and manage a number of diverse risks for the International Space Station, Space Shuttle, and several other NASA projects and programs. Program organizations use this database application to effectively manage and track each risk and gain insight into impacts from other organization's viewpoint. Schedule, cost, technical and safety issues are tracked in detail through this system.

Risks are tagged within the system to ensure proper review, coordination and management at the necessary management level. The database is intended as a day-to-day tool for organizations to manage their risks and elevate those issues that need coordination from above. Each risk is assigned to a managing organization and a specific risk owner who generates mitigation plans as appropriate. In essence, the risk owner is responsible for shepherding the risk through closure. The individual that identifies a new risk does not necessarily get assigned as the risk owner. Whoever is in the best position to effectuate comprehensive closure is assigned as the risk owner. Each mitigation plan includes the specific tasks that will be conducted to either decrease the likelihood of the risk occurring and/or lessen the severity of the consequences. As each mitigation task is completed, the responsible managing organization records the completion of the task in the risk database and then re-scores the risk considering the task's results. By keeping scores updated, a managing organization's current top risks and risk posture can be readily identified including the status of any risk in the system.

A number of metrics measure risk process trends from data contained in the database. This allows for trend analysis to further identify improvements to the process and assist in the management of all risks. The metrics will also scrutinize both the effectiveness and compliance of risk management requirements.

The risk database is an evolving tool and will be continuously improved with capabilities requested by the NASA project community. This paper presents the basic foundations of risk management, the elements necessary for effective risk management, and the capabilities of this new risk database and how it is implemented to support NASA's risk management needs.

TABLE OF CONTENTS

[2] IEEEAC paper #1389, Version 3, Updated November 29, 2004

1.0 INTRODUCTION

There are many challenges and obstacles in implementing a risk management system for a program or project. The approach utilized to successfully implement a comprehensive risk management system for the International Space Station Program Office is outlined below. Like many projects and programs, the International Space Station Program was previously utilizing only the basic framework of a risk management system and processes in order to satisfy oversight requirements levied. To be candid, the program manager was skeptical of the benefits of a risk management system and did not actively use or encourage others to use established risk management processes in the pursuit of program goals.

2.0 RISK MANAGEMENT OVERVIEW

Project management is the function of planning, overseeing, and directing the numerous activities required to successfully achieve the requirements, goals, and objectives of the project/program, within the specified cost and schedule constraints. Project management is comprised of three major areas of emphasis, all equally important. They are project control, systems engineering, and safety & mission assurance. It is critical for the success of the project that the project management team understands that these major areas must be successfully implemented and continually used throughout the project lifecycle. As seen in Figure 1, risk management should encompass all the different management functional areas (People, Safety, Technical, etc…). Effective project management can be thought of as a three-legged stool supported by project control, systems engineering and safety & mission control, while risk management is the base that provides unifying support and ensures stability and success.

As most are familiar, the risk management process is performed to identify potential problems before they occur, so that risk-handling activities may be proactively planned and invoked, as needed, across the life of the project in an efficient and effective manner. Risk management is a continuous, iterative process performed to reduce the probability of adverse threats, in other words, increase the probability of successfully completing the project. It is a key element and an integral part of project management and engineering processes.

Typically the project manager is the sponsor and primary customer of the risk management processes which support project resource allocation decisions and advanced planning. However, all other project team members are responsible for risk identification, analysis, planning, tracking, and controlling, including communicating (see Figure 2 below) with all relevant stakeholders and decision makers. Risks can be identified from program/project data including constraints or requirements, fault-tree analysis results, failure modes and effects analysis (FMEA) results, test data, expert opinion, brainstorming, hazard analysis, lessons learned from other project/programs, technical analysis or trade studies and other resources.

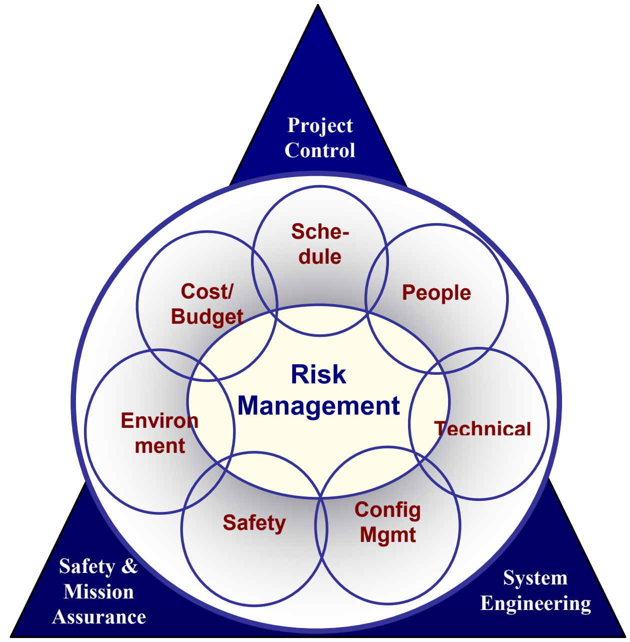

Figure 1, Elements of Project Management

Before prioritizing, the risks should be classified or grouped with similar risks. There are several purposes for risk classification. One purpose of classification is to understand the nature of the risks and group related risks which can help in building more comprehensive mitigation plans (problem areas can be better determined). Another purpose is to merge or eliminate equivalent or duplicative risks. Additionally, risks are classified so that they can be tracked and monitored by various elements of the program. For example, a functional area such as financial or safety may want to concentrate on the subset of risks within their functional area to assure that all these risks are adequately resolved. Perhaps all the risks related to the acquisition process may be classified together for purposes of performing acquisition planning or source selection. Once classified, the risks should be prioritized. The purpose of prioritization is to sort through a large number of risks and determine which are the most important and, therefore, should be dealt with first.

One widely used method of prioritizing risks is through the use of risk scoring matrices that quantify the likelihood and consequence of occurrence. The scoring methodology can be tailored to fit the needs, complexity, or experience base of a program/project. The scoring matrix used by the International Space Station program is shown in Figure 3.

Likelihood is the probability that an identified risk event will occur. Consequence is an assessment of the worst credible potential result(s) of a risk. The measurement units differ depending on the specific risk. For example, the consequence of a cost risk may correspond to specific dollar amounts or percentages of the program/project budget or the consequence of schedule risks may correspond to the length of time delays in terms of the project's master schedule.

Figure 2, Continuous Risk Management

The likelihood and consequence matrix (including threshold definitions for each of the likelihood and consequence scores) are shown in Figure 3:

Timeframe is the time in which action must be taken to handle the analyzed risk or the time period in which the program/project will be impacted by it.

The next step of risk management is risk planning, which begins with assigning responsibility to research the risk in more detail and then determine the approach to handle the identified risk. If a decision is made to mitigate the risk, the subsequent development and implementation of a detailed action plan will follow.

Risk tracking involves collecting, updating, compiling, organizing and analyzing risk data and reporting risk trends to determine whether particular risks are decreasing, staying the same, or increasing over time. Tracking focuses primarily on risks identified for mitigation, research, and monitoring, although all risks, including accepted risks, should also be tracked to ensure that conditions or assumptions have not changed to the point that reevaluation is necessary. For research actions, tracking serves to assure that the research efforts are progressing satisfactorily and that the identified timeframe still permits further investigation and anaylsis. Risk tracking should provide the insight on which to draw conclusions about the effectiveness of mitigation actions, or the need to take action on monitored risks that are increasing toward or beyond a trigger level. "Trigger" levels are the warning or control limits often used to flag the risk owner that alternate plans may be required. Trigger levels may be predetermined for particular risks (if the risks are being monitored) to signal the need for action. Trigger levels also identify those effects on the overall program/project, not only relative to the critical path but also to the resources and performance results; critical decision-making points; variations on systems capabilities; and other elements. Tracking results should be made readily available to the program/project team members.

Risk control is the feedback process of reevaluating, based on recent tracking information, what actions to take concerning a particular risk, and implementing those decisions. Actions may include changing the current action plan, closing the risk (accepting the residual risk), invoking a contingency plan when the original plan is found to be ineffective or continuing with the original plan and continuing to track the risk. Each of the risks identified, analyzed, planned, and tracked should be periodically reviewed (usually bi-weekly with the ISS program office) to ensure that decisions made are effective and that associated actions remain applicable.

Effective risk management requires open, clear, and ongoing communication within the program/project team. The risk management documentation process ensures that risk management policies are established, understood, implemented, and maintained, and that a formal audit trail is developed to establish the origin of, and rationale for, all risk-related decisions. Risk management documentation must be readily accessible to the entire team; e.g., in an automated form, and under configuration control.

Consideration should be given to establishing a program/project risk management repository to provide an easily accessible way to store program/project risk information and thereby aid every step of the risk management process. This would also provide a risk record archive, making tracking and analyzing risk, past methods, and results available for all to view, including any lessons learned.

3.0 BASIC REQUIREMENTS FOR EFFECTIVE RISK MANAGEMENT

As previously mentioned, the International Space Station Program was only implementing a risk management system on paper. Actual use by program management of risk management processes was minimal and intermittent. However after many internal and external management audits of the program, program management gave the approval to implement a more comprehensive integrated system and began to use and stress the elements of risk management to all levels of program personnel – this was a key milestone for risk management within the program office. The first and foremost requirement to ensure successful implementation of risk management is the need for management "buy-in" and their communication and insistence to the program. As program personnel directly and indirectly observed program leadership stressing and *using* risk management and when they begin sensing evidence of a cultural change within their organization, improvements to risk management will finally take root. The ISS program team began to see first hand the benefits – both as a reporting mechanism and a structured technique for managing their own risks.

As management demonstrates a commitment for risk management, the risk manager should develop a comprehensive Risk Management Plan for the program/project. It should contain common definitions (risk, success criteria, acceptable risk, …), the qualitative measures used to score, rank and prioritize risks, the detailed implementation plan on how risk management elements will be institutionalized within the program management structure, and finally how risk management interfaces with other elements of program control, systems engineering and safety, reliability/maintainability and quality assurance functions.

The basic elements of the plan should describe a continuous process for identification, assessment, mitigation planning, tracking and control. The process should be proactive, there should be defined and utilized methods for ferreting out new risks from all aspects and corners of the program. Once identified there should be a formalized approach to begin the evaluation and integration process. Integrating risks also assists the decision maker in understanding how a risk's decision can affect other risks (better understand the cross-coupling effects and the entire risk landscape of the program).

It is important in the implementation of risk management that the processes are integrated using existing control mechanism (embed in existing board process and becomes part of the existing management infrastructure). This will limit the "cost of" risk management to the program and ensures that emphasis and commitment by program personnel remains. As such, risk management should be part of everyone's job description. There should not be a separate set of risk practitioners that are responsible for identifying and mitigating risks. The risk office should be fairly small, with only the responsibility to help develop the processes, assist in facilitation and integration of risk, and finally monitor and control the effectiveness of the

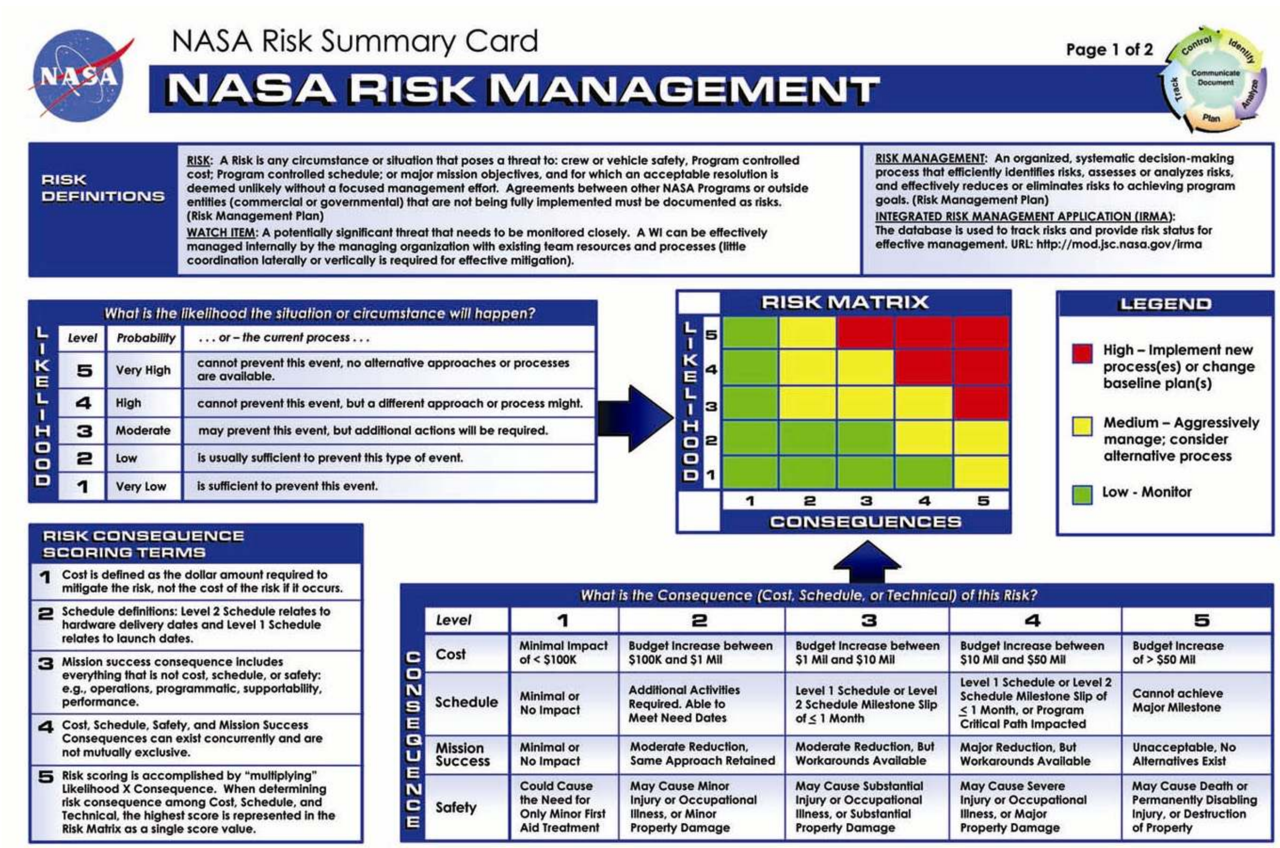

Figure 3, Example of a Risk Scoring Scheme

processes. Part of the measure of effectiveness is whether there is an efficient flow of risk data from the individual that identifies the risk to the appropriate decision maker. Ideally, risks should be managed at the lowest appropriate level with issues being elevated to higher levels of management. Therefore, risks should be elevated only, if additional resources are required to mitigate, if integration with other organizations will be necessary or if general visibility by the next level is needed including the need for programmatic risk decisions. By elevating risks to higher levels of management, cross-functional and cross-program implications of risk decision-making can be better handled.

The risk system should capture every program team member's concerns and have a formalized method for evaluation and disposition. Rationale for closure should be documented for those risks that are deemed unfounded. More mature risk processes should include multiple paths for reporting issues from project personnel to avoid premature closure. There also should be a mechanism to document dissenting opinions based on the coarse of action seletced.

4.0 The Inception of a New Risk Database

Principal considerations for a risk management software database tool should be the consistent, concise, and thorough documentation of the risk description and characterization (probability and impact), and the details of the mitigation plans. Common and convenient accessibility and visibility to all project team members and stakeholders must be insured. This management information tool must be able to assist in the decision making process and proactively manage risk. The database must provide a comprehensive portal for identifying, assessing and managing risk through integrated program-wide input.

At the time when the ISS risk system was being re-engineered, a market survey into existing risk databases was conducted. However, there were no risk databases that met the program's specific needs. Therefore, the program approved the development of a new customized database.

Specific requirements were elicited from users at all levels including the program manager. After the risk office designed a new comprehensive risk process for the ISS office, additional risk database requirements were added. Since funding was limited and a quick turn around was mandated, a prototype database was created quickly using a rapid software development environment. After demonstrating the prototype risk database, program personnel were given an opportunity to revise their initial requirements. Much resources and time were saved by this rapid prototyping approach. In addition, having a working prototype eliminated most of the confusion over requirements by both the users and the development contractor. Using this technique, design, development, testing and deployment were rapidly performed and at a lower cost. Additionally, the software development was phased; basic core requirements were only developed for the first release. As program personnel and management utilized the system and could provide more concrete inputs, the necessary adjustments in the requirements were made. This insured viability of the system and reduced the training requirements for the program over time. The resulting application was given the name, IRMA for Integrated Risk Management Application (see Figure 4 for a screen capture from IRMA).

Every member of the organization is a user of the software and may identify a risk to one or more of the organization's goals. The user enters pertinent information about the risk that allows appropriate personnel to understand and evaluate the details to qualify and then quantify the risk. The application provides for the documentation of the handling strategy and any mitigation plans that may be developed. Electronic change notification is provided to the management chain throughout the risk's life cycle.

Another important aspect of the application is the ability to select, filter, and report on the information contained within the risks. Contents of the system are presented in several formats such as: location, project, and functional organization affected.

Another key feature of the application is the emphasis placed on data integrity. The database assigns varying degrees of permission to users, which ensures that only necessary risks are escalated through the system (tiered-management process so that program management only deals with those issues that require it – risks are only managed at the necessary level). Once a risk is admitted and assigned to a responsible party, the risk owner assumes primary responsibility for their risk. To aid the risk owner as they prepare for presentations at control boards, the system will provide many output reports and charts in native PowerPoint, Excel and Word formats. This insured that as long as risk owners updated the system constantly with current data, developing reports or charts are only a click away. This feature alone forces risk owners to constantly feed the system and reduces many of the configuration management issues with personnel updating presentation charts instead of the risk database.

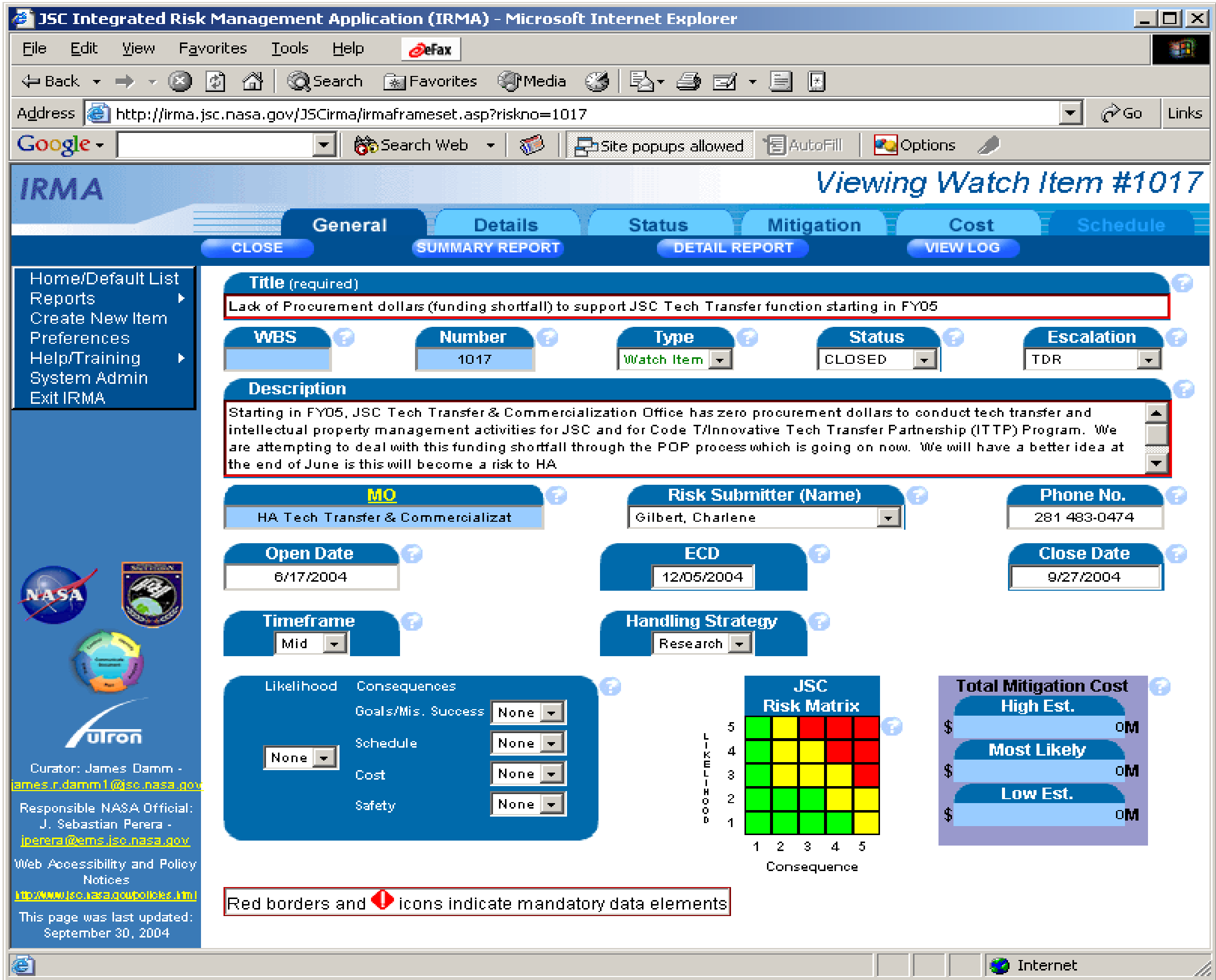

Figure 4, A Risk Record within IRMA

5.0 MEASURING RM EFFECTIVENESS

Normally the focus on risk management within NASA has been assuring programs and projects comply with risk management standards set by NASA headquarters. As mentioned previously, NASA has adopted the Continuous Risk Management methodology developed by Carnegie-Mellon University. However, compliance in a risk management model does not in itself ensure that an effective risk management system will actually occur. One significant measure of effectiveness is whether the right risk information gets to the right decision maker at the right time. Even when someone in the organization becomes aware of a risk item that may be serious, will that information get into the risk database and will it get to the right decision-maker? Will it get there quickly and accurately? Will the decision-maker understand its relevance and will it be synthesized with all the other risks in the system?

In Continuous Risk Management, it is recognized that communication is the "hub" of the paradigm wheel, and is a key enabler for effective risk management. This element of Continuous Risk Management focuses on getting people to communicate effectively about risks. Risk management effectiveness is determined by the participation of people in an organization, and by the speed and fidelity of communications between those people, and not necessarily by compliance in risk management requirements.

What has been found to be true is that there are four areas of this communication throughput that are important in measuring effectiveness:

Input: Is there anything slowing risks from being documented once they are recognized, or keeping from them being documented at all?

- Frequency of input from each source/organization
- Participation of sources/organizations
- Input delay (time from recognition to documentation)

- Number of unidentified risks that materialized

Speed: How long does it take for a risk to get from its source to the right destination (i.e., appropriate decision-maker)?

- Time from input to the right decision-maker

- Frequency of "data dropping" along the way

- Rate at which risk items are being refreshed, reviewed, and maintained

Fidelity: Does the risk input arrive at the decision-maker still true to its original intent (i.e., without distortion)?

- Clarity of risk item description and context at input (true to perception)

- Content change from source to destination (true to input)

- Parts of organization that are over- or under-represented (true to the "big picture")

Synthesis: Does the decision-maker get a view of risks that considers and correlates input from multiple sources?

- Percentage of correlation (# of risk items that have been related to others)

- Number of populated perspectives

- Percentage of risk items that are covered by some active mitigation strategy

Metrics from the database have been designed to track and manage these four areas. The risk office actively uses these measures to monitor and control how the risk process is implemented and working and to indicate where improvements are needed.

6.0 CONCLUSION

Risk management begins early in program/project formulation and must continue in a disciplined manner throughout all program/project life cycle phases. A long-range view of the program/project and its mission success criteria, and open communication among all members of the program/project team (including stakeholders), are essential elements for successful risk management.

Effective project management depends on a thorough understanding of the concept of risk, the principles of risk management, and the establishment of a disciplined risk management process. Although the benefits of a well-thought-out risk management plan are substantial, implementation is not an exact science; rather it is more of an art. This is due to the fact that success of risk management is reliant on organizational culture and the interactions of personnel involved. The project team is responsible for identifying, analyzing, planning, tracking, controlling, and effectively communicating the risks, both within the team and with management and stakeholders

In many complex space projects, the root cause of risk is from designs engineered near the leading edge of achievable performance for a given level of cost and schedule. Therefore, with performance, cost and schedule all just within "the fringes of reality", effective risk management is usually the key determinate of which projects succeed and which projects fail. This paper outlined some of the key enablers for effective risk management and some of the lessons learned from designing and developing a risk database to meet specific program needs.

REFERENCES

[1] NPR 8000.4, Risk Management Procedures and Guidelines, 2002.

[2] Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing, 2002.

[3] NPR 71xx.x (document number not yet assigned), NASA Systems Engineering Processes and Requirements.

[4] NPR 7120.5B, NASA Program and Project Management Processes and Requirements, 2002.

[5] Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners, Version 1.1, http://www.hq.nasa.gov/office/doeq/doctree/praguide.pdf

BIOGRAPHY

Jeevan Perera's work involves leading a risk management team implementing tools and process for NASA's Johnson Space Center in Houston, Texas. In this capacity, he oversees both quantitative and qualitative risk analysis processes. Dr. Perera has designed, developed, implemented and improved the International Space Station risk management process using a phased approach including providing the necessary supporting tools, applications and corresponding training. In addition, Dr. Perera has overseen risk management assessments of ISS Program systems and procedures through Probabilistic Risk Assessments (PRA) and other quantitative methods for strategic & logistics planning and real-time operational support.

Prior to his work in risk management, he has worked in different technical fields in support of many NASA programs and projects. These duties have included management responsibility for versions of the primary and back-up flight software for the Space Shuttle and development responsibility for software used aboard Space Shuttle and International Space Station missions. He has a bachelor's degree in Aerospace Engineering, a master's degree in Industrial Engineering, a Doctorate in Jurisprudence, and a Doctorate in Industrial Engineering.