RISK MANAGEMENT FOR THE INTERNATIONAL SPACE STATION

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INTRODUCTION

The International Space Station (ISS) is an extremely complex system, both technically and programmatically. The Space Station must support a wide range of payloads and missions. It must be launched in numerous launch packages and be safely assembled and operated in the harsh environment of space. It is being designed and manufactured by many organizations, including the prime contractor, Boeing, the NASA institutions, and international partners and their contractors. Finally, the ISS has multiple customers, (e.g., the Administration, Congress, users, public, international partners, etc.) with contrasting needs and constraints. It is the ISS Risk Management Office strategy to proactively and systematically manages risks to help ensure ISS Program success.

ISS CONTINOUS RISK MANAGEMENT STRATEGY

The purpose of risk management is to identify risks and threats in the program early so that appropriate mitigation plans can be developed and implemented to reduce the consequences of the risk or likelihood that the risk will occur. This Continuous Risk Management (CRM) process will provide systematic methods for identifying, analyzing, abating, and communicating risks on a continual basis.

The strategy of the ISS Program to manage risk includes:

a. Embed risk management processes into normal day-to-day activities to identify and help manage all risks and potential threats.
b. Delegate risk-management responsibility to the lowest possible organization with the allocated resources to mitigate or accept the risk.
c. Dedicate a Program Risk Management organization to lead program-level risk-management activities, facilitate the risk-management processes, and provide analytical support and tools including Probabilistic Risk Assessments (PRAs), ISS Risk Management processes training and other risk-management assistance to managing organizations.
d. Provide the necessary costs analysis and funding to address all risks and potential threats to the ISS. This includes integrating the cost process within one risk system.

All Space Station program management organizations are responsible for performing the following functions under this risk methodology:

a. Manage their ISS managing organizations risks by:
   (1) Routinely identifying and documenting risks.
   (2) Assessing probability and consequences of occurrence of the risk (technical, schedule & cost) and score by using the standardized risk tool.
   (3) Identifying and documenting risk-mitigation options and analyzing their impacts and uncertainties throughout the program.

(4) Manage risks including developing risk-mitigation plan options and ensuring its implementation.

(5) Delegate as much responsibility and authority to manage, track and mitigate risks to the lowest level.

b. Report risk-management status and issues to the Managing Organization control board or panel, and monitor the risk-management activity of all levels of the Managing Organization. Communicate throughout the program so that inputs and consequences can be better managed.

c. Integrate consideration of risk into all major decisions and throughout the entire development cycle. The continuous risk management process is depicted in Figure 1.

Figure 1 ISS Continuous Risk Management Process

The ISS Program Risk Management office develops and implements standard risk-management processes and tools that encompass both qualitative and quantative risk methodologies. This is supported by integrated user training on the process and supporting infrastructure (e.g., databases and quantative and qualitative analysis tools). Several types of industry accepted tools and techniques for risk management are shown in Figure 2.
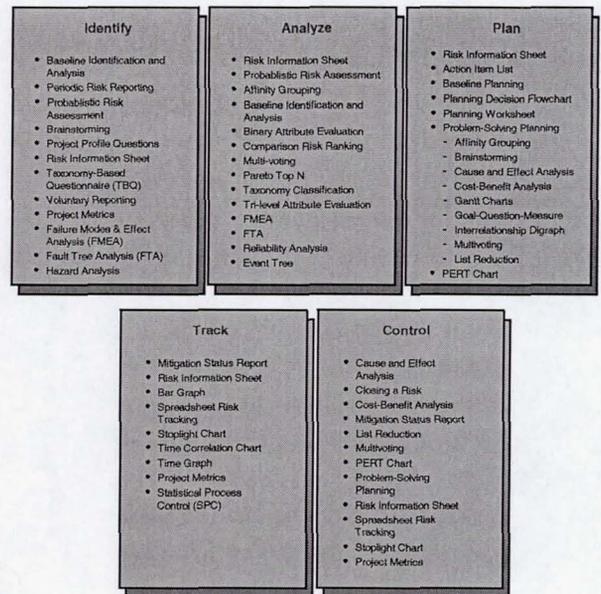

Figure 2 Tools and Techniques for Continuous Risk Management

PROGRAM RISK MANAGEMENT PROCESS

The purpose of risk management is to identify risks early in the program so that appropriate mitigation plans can be put into place to effectively reduce the risk or prevent the risk from occurring. The ISS risk management process provides systematic methods for identifying, analyzing, mitigating, and communicating risks.

The risk management process promotes the use of risk management techniques and tools in making decisions. The process must require all associated personnel to bring risk information within the risk management infrastructure. Specifically, the risk process should assess continually what could go wrong (risks), determine which risks are important to deal with, implement strategies to deal with those risks, and measure effectiveness of the implemented strategies. The benefits of

implementing an effective risk management process include increasing the likelihood of mission success, assisting the program in understanding what can go wrong, enabling better use of resources through prioritization, and promoting teamwork, communication, and smart decision making. Risk management should permeate throughout all facets of project management as seen in Figure 3.

Figure 3 Risk Management Coverage

ISS Risk Data Application (IRMA)

The ISS program office uses an integrated risk management database called IRMA to manage risks and communicate risk data throughout all ISS managing organizations. A characterization of each risk, its matrix location (severity), and the mitigation tasks are entered into this database. Managing organizations use this database application to effectively manage and track each risk and to gain insight into impacts from other managing organization risks. All cost issues are tracked in detail through this database.

Items in the database are tiered. Low level items that lack definition or are too far "over the horizon" are labeled "Concerns." More detailed/defined items are known as "Watch

Items". Top level issues are defined as "Risks." Each level requires higher levels of authorizations and scrutiny, see Figure 4.
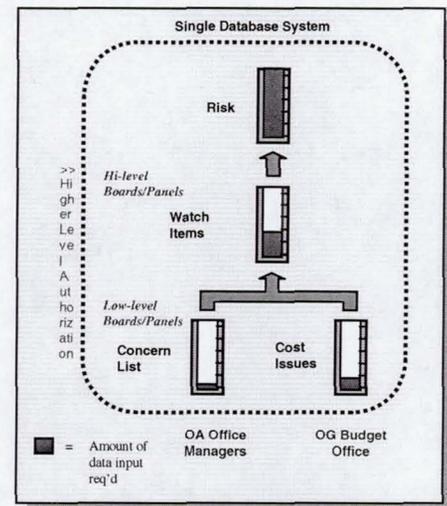

Figure 4 Risk DB Tiered Levels

IRMA facilitates each ISS managing organization's review of sub-organization risks. When a managing organization reviews its sub-organization risks, it records whether it agrees with the data and whether it chooses to elevate that risk. Risks at that level will be reviewed by the Program Risk Advisory Board and may be given resources to mitigate the risk. At each level of elevation, managing organizations can assign their own score and rank after considering the more global aspects of the risk.

IRMA is intended as a day-to-day tool for managing organizations and their risks. Managing organizations should review their risks at their respective organization's board/panel on a bi-weekly basis (at all levels of boards and panels).

The managing organization generates mitigation plans for risks as appropriate. Each mitigation plan includes the specific tasks that will be conducted to either decrease the likelihood of the risk occurring or lessen the severity of the consequences. As each mitigation task is completed, the responsible managing

organization records the completion of the task in IRMA and re-scores the risk considering the task's results (the effects on the risk). By keeping scores updated, a managing organization's current top risks can be readily identified or the status of any risk in the system.

A number of metrics measure program risk-management trends using data contained in the IRMA. This allows for trend analysis to further identify new potential risks and assist in the management of all risks. The metrics will also scutinized the effectiveness and compliance in the ISS Risk Management Process by individual organizations.

Program Risk Advisory Board

The top-level program risk board is the Program Risk Advisory Board (PRAB). The objective of the PRAB is to assist the ISS Program Manager in managing the top risks of the ISS Program. The PRAB has representatives from each managing organization, prime contractor, other NASA centers and international partners.

At each PRAB, the IRMA is utilized to review the top ranked risks of each managing organization. The PRAB reviews the risk magnitudes from the Program Manager's perspective. The ISS Program Manager scrutinizes the management of all risks and assigns resources and actions as appropriate. Mitigation plans and status are reviewed and recommended actions for additional risk-mitigation activities and resources are formulated.

Risk Summary Card

The ISS Risk Summary Card is a management tool used to assist in the identification and scoring of all risks. It provide a quick overview of the risk management process and the risk-scoring tool. There are guidelines and checklists for all steps in the risk management process with definitions and standardized scoring (likelihood & consequence) for risks. This tool

provides a way all program-managing organizations can measure risk likelihood, consequence, and magnitude (in a program-wide consistent manner). It allows risks to be ranked relative to other risks to help determine risk mitigation priority in a consistent manner. Individual risks can be plotted on the matrix itself to provide a visual representation of their relative magnitudes and importance.

Decision Trees

Decision trees are used within the risk management process for structuring complex decisions and identifying the best available option. Decision trees capture the logical, sequential progression of events that will occur during the decision process. The decision tree decomposes complex problems into a series of smaller, solvable sub-problems. This tool provides the decision maker an avenue to illustrate the options available in a graphical manner.

Probabilistic Risk Assessment

Probabilistic Risk Assessment (PRA) is a multi-disciplinary method employed to assess factors contributing to determine their relative significance within a system. The PRA results can be used as a powerful decision-making tool in support of design, operations, and upgrade alternative decisions. The process helps both identify potential new risks and analyze existing risks. The ISS PRA captures possible accident scenarios that lead to several undesired consequences called end states. The ISS PRA goals are to examine those scenarios that can lead to:

- Catastrophic loss of the Station
- Loss of a crewmember
- Loss of a vital Station system
- Loss or shutdown of a pressurized module
- Situations requiring evacuation

Cost & Schedule Risk Coordination

In identifying and assessing risks, managing organizations can use probabilistic cost and schedule to deal more effectively with inherent cost and scheduling uncertainty. These models will also allow managing organizations to more effectively consider cost and schedule in decisions.

The cost/budget threats must be coordinated effectively with program risks. Cost issues and risks must all be tracked and managed together in an efficient process. This integrated approach should document, rank, review and manage all risks including all cost and schedule impacts to the program.
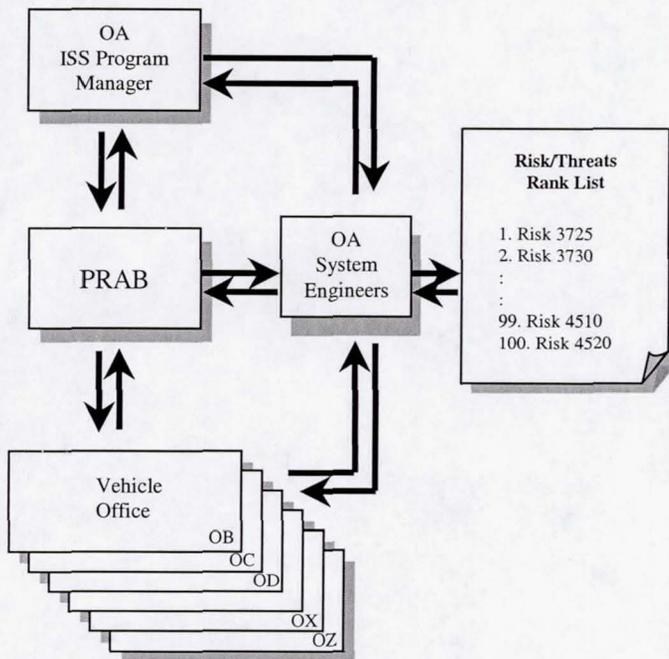

Figure 5 Force Rank Process

A "force ranking" system is used which prioritizes all risks/threats relative to program importance. This will facilitate a more organized and timely review of the risks in the program, which may require financial reserves to resolve. In addition, this will assist in making management decisions that span multiple years by ensuring reserves are allocated based on multi-year prioritizations. An independent system-engineering group within the ISS Program Office will develop a "forced ranking" of all risks considering technical aspects, cost and schedule, see Figure 5.

This team looks at all facets of the risks/threats including schedule, technical and costs impacts and develop a prioritization list of all threats/risk after consulting with ISS Program management and all managing organizations.

CONCLUSION

ISS program follows integrated risk management process (both quantitative and qualitative) and is integrated into ISS project management. The process and tools are simple and seamless and permeate to the lowest levels (at a level where effective management can be realized) and follows the continuous risk management methodology. The risk process assesses continually what could go wrong (risks), determine which risks need to be managed, implement strategies to deal with those risks, and measure effectiveness of the implemented strategies. The process integrates all facets of risk including cost, schedule and technical aspects. Support analysis risk tools like PRA are used to support programatic decisions and assist in analyzing risks.

APPENDIX A: Abbreviations and Acronyms

CRM   Continuous Risk Management
ISS   International Space Station
IRMA   ISS Risk Management Application
L x C   Likelihood Times Consequence
MO   Managing Organization
NASA   National Aeronautics and Space Administration
OA   Mailcode for International Space Station Program Office
PRA   Probabilistic Risk Assessment
PRAB   Program Risk Advisory Board
PRM   Program Risk Management
PRMO   Program Risk Management Office
RM   Risk Management
TPR   Top Program Risk
WI   Watch Item