Navigator Program Risk Management

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Introduction

Program management is a relatively new discipline at Jet Propulsion Laboratory (JPL) brought about by the proliferation of robotic space missions. In the early 1990's robotic exploration began a metamorphosis from individual spacecraft that were launched once per decade to multiple spacecraft with numerous launches every year. Today at JPL, there are seventeen space missions in operations and another eighteen under development. These missions are organized into programs to provide a coordinated effort towards accomplishing NASA's strategic objectives and to share technological developments and scientific results across groups of missions with related goals. Therefore, program risk management is the management of risk across a set of projects in order to achieve the overall goals of a program.

Program risk management relies heavily on risk management techniques and processes developed for projects. It requires a Risk Management Plan to document the program risk management process; a Program Risk Working Group (PRWG) to identify, assess, handle, track and control all program risk items across the program's mission set; and programmatic support to provide the resources necessary to take the appropriate actions to improve the risk posture of the program. However, program's objectives and their types of risk vary from program to program. As an example, NASA's New Millenium Program has the objective to develop and transition new technologies and capabilities from the laboratory to flight acceptance. This program has a very different set of risks than NASA's Mars Exploration Program whose objective is to increase our understanding of Mars with the eventual retrieval of samples from the planet's surface.

In this paper, program risk management as applied to the Navigator Program: *In Search of New Worlds* will be discussed. The Navigator Program's goals are to learn how planetary systems form and to search for those worlds that could or do harbor life. There are five projects in the Navigator Program:

- Two optical interferometers mounted on telescopes (i.e., The Keck Interferometer (KI) to be mounted on the twin Keck Telescopes in Hawaii and the Large Binocular Telescope Interferometer (LBTI) to be mounted on the Large Binocular Telescopes operated by the University of Arizona Steward Observatory).
- Two spacecraft designed to search for planets (i.e., the Space Interferometry Mission (SIM) and the Terrestrial Planet Finder (TPF) Mission), and
- One science center known as the Michelson Science Center (MSC) which will provide science planning and be the repository of science data from the previous four missions and other planet finding endeavors outside of the program.

Unlike a flight project, the Navigator Program does not build hardware or write software. The Navigator Program oversight provides an environment where spacecraft missions can benefit

from one another to reduce risk, shrink schedules, decrease costs and to increase the overall science return of the program.

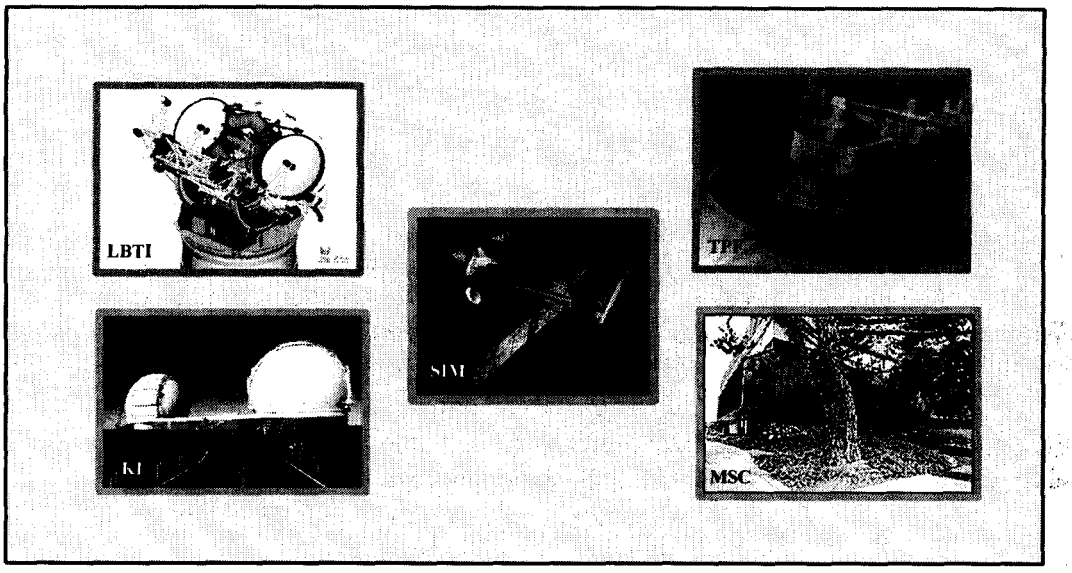

Figure 1. The Navigator Program is composed of the Keck Interferometer (KI), the Large Binocular Telescope Interferometer (LBTI), the Michelson Science Center (MSC), The Space Interferometry Mission (SIM) and the Terrestrial Planet Finder (TPF) missions.

Program Risk Posture

A program's risk posture is clearly not just the sum of the high-risk items from all of the projects internal to a program. Some project high-risk items do not impact program goals as much as others. In the case of the Navigator Program, the KI will provide exo-zodiacal disk information (i.e., the warm dust surrounding a proto-star) for upcoming missions (e.g., TPF). This will allow future Navigator missions to determine the best instrument architecture for peering through the surrounding dust disk to directly observe planets around other stars. As such, the KI nulling mode, which will capture a significant amount of the dust disk information, is much more critical to the success of the program than some of the other KI observing modes.

On the other hand, some program risk items may not even appear at the project level without some direction from the program office. When such risks are identified, the program office must levy new requirements on to their projects to mitigate or reduce program risk. These program requirements may become project risk items themselves since they were not considered part of the initial scope of the project. Such program requirements may have a positive effect on the program but may also have a negative impact to the project burdened with the new requirements. As an example of the consequence of not levying program requirements on to a project to reduce overall program risk, one can review the 1998 Mars Polar Lander mission. Here, the project determined that telecommunications was not necessary during entry, descent and landing (EDL) due to the binary nature of landings. That is either the spacecraft landed successfully or it didn't. As such, due to mass and costs constraints, the project decided not to add an EDL telecommunications capability. The eventual loss of the mission during EDL

resulted in not only the loss of the spacecraft but also produced fear among mission planners about using precision landing techniques for upcoming missions. Thus, the 2001 Mars Lander, using precision landing techniques, was canceled in favor of using parachutes, solid rocket motors, and airbags for the 2003 Mars Exploration Rovers. It would take eight years from the loss of the Mars Polar Lander for the 2001 Mars Lander to be given another launch opportunity as the Phoenix Mission to Mars. In our opinion, the Mars Program failed to identify a program risk item in a formalized manner that would serve to evaluate the issue and the resulting requirements needed to mitigate it. As a result, near-term future Mars lander designs were adversely affected.

Thus, a program's risk posture is the sum of those project risk items (from current and future projects internal to the program) coupled with program risk items that can adversely affect the program from reaching its goals. As such, Program Managers and Program Engineers must constantly be looking toward the future to determine how science information and technology capability flow between projects internal to a program. Any dependencies between projects must be assessed for likelihood of being met and the consequence to program's goals if not. Dependencies that produce medium-level program risk items must have resources earmarked to reduce or mitigate the risk to improve the overall risk posture of the program.

Program Risk Management Process

The standard risk management process established for flight projects heavily influenced the basic approach adopted by the Navigator Program for risk management. The first step taken by the program was the creation of a Navigator Program Risk Management Plan to document the entire risk management process. The main difference between project and program risk management is the process by which risk items are identified. In the case of a project, risk items are identified by Project Element Mangers who identify those items within their element that have a non-negligible probability of not being able to meet their performance, schedule or cost commitments. From a program point of view, risk items are identified through brainstorming and the assessment of the following project level documents: 1) Project Risk Lists, 2) Program Level Requirements Appendices, 3) Precursor Science Documents, and 4) Technology Plans.

The guiding mantra for brainstorming is, "What keeps Project Managers up at night?" Brainstorming with project representatives (i.e., Project Mangers, Mission Assurance Managers, Project Engineers, etc.) and representatives from the Navigator Program Office (i.e., Program Engineer, Program Resource Administrator, etc.) were used to capture non-project specific risk items. All risk items identified during the PRWG brainstorming sessions were recorded. Future steps in the Navigator Program risk management process would filter out those suggestions that had little impact to the success of the program or had a negligible chance of occurring. The PRWG evaluated such areas as:

- Unplanned NASA events (e.g., launch slips, other astrophysics mission cost overruns, etc.).
- Changing government priorities (e.g., decrease to NASA's budget, decrease in the priority of NASA's Origins Theme, etc.).

- Industry dependencies (e.g., contractor companies' cost growths, suppliers going out of business, etc.).

Risk items identified during the brainstorming sessions ranged from those dictated by nature (e.g., Exo-zodiacal dust (found around other stars) is so optically thick that exo-planet detection becomes virtually impossible with proposed techniques) to those based on economics (e.g., Contractor resources are spread too thin to complete their commitments).

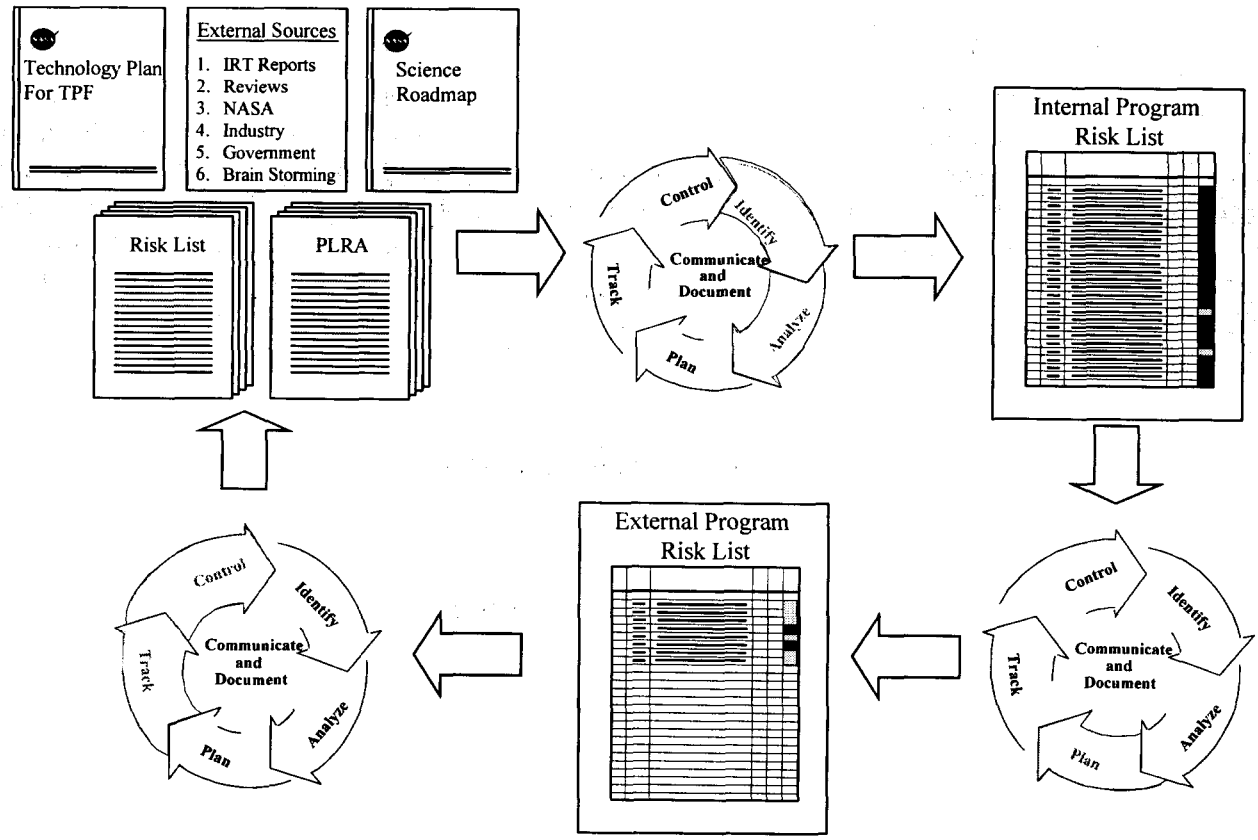

Figure 2. The Navigator Program Risk Management Process flowchart. The process begins with brainstorming and the evaluation of project documents to identify and assess risk items. The process is continuous since risk items are continually being retired as new one are identified.

As can be seen from the previous exo-zodiacal dust disk risk item, some cannot have a direct mitigation plan. If nature makes exo-zodical dust clouds too optically thick that no currently proposed technique can discern planets then no current technology will suffice. If this risk were to be realized the program focus would change to support those missions that can improve our understanding of exo-zodical dust disks and funding redirected to an alternate future technology that may be able to perform at the required levels. In the mean time certain assumptions must be made to allow progress to move forward until new information is obtained.

Many Navigator Program and project documents were reviewed for potential risk items. One natural source for these risk items is the project risk lists. Only those project risk items that could impact the success of the program were incorporated on to the Navigator Program's Risk List. One difficulty with this approach is that not all projects in the Navigator Program have formal risk lists. This is particularly the case for the ground facilities whose requirements are not as demanding as the flight projects. After much deliberation, the PRWG felt that the risk items presented to NASA Headquarters personnel by the Navigator Program projects during the Program Quarterly Reviews would suffice as Project Risk Lists for those projects without formal lists. The consensus was that project risk items that did not make it on to the project's Quarterly Review presentations where of a sufficiently low nature as to have very little impact to the overall goals of the program. As such, the PRWG evaluated the project Quarterly Review presentations and incorporated that subset of risk items that could impact the goals of the Navigator Program.

The next set of project documents assessed by the PRWG was the Project Level Requirements Appendices (PLRA). These documents, written by the projects, are appendices to the Navigator's Program Plan and include all of the level-1 requirements the projects have negotiated with NASA Headquarters for mission success. One by one each requirement in each PLRA was assessed from the point of view of, "If the requirement was not met, would it impact the goals of the program?" If the answer was yes, then the likelihood of occurring was addressed. This was accomplished by determining what triggering event(s) would cause the requirement to not be met. If the triggering event was exceedingly unlikely (e.g. The Earth impacted by an asteroid), the requirement was removed as a possible program risk item. Some triggering events could also be grouped together to form a risk class. The particular requirement to store scientific data at the Michelson Science Center for 5-years, could have a number of triggering events that would prevent this requirement from being met. As an example, an earthquake or fire at the MSC could both prevent this requirement from being realized. Since the mitigation is the same for both triggering events (e.g., store the scientific data in a second remote location), the risk items were grouped into a single risk item that then could be assessed and handled.

All risk items identified were compiled on to a single list. This list contained all risk items that could degrade or prevent the program from reaching its desired goals. This list, known as the Navigator Program's Risk List, was then scrubbed to remove those risk items that were not viable. Viable in this context meant that the triggering event required to realize the risk was so unlikely as to approach a negligible chance of occurring. The risk items that fell into this category were removed. The resulting risk list was used to determine a course of action for each risk item and to continually track their individual status.

Program Risk List

The Program Risk List contains a unique numerical identifier, the project associated with the source of the risk, the requirement at risk (i.e., the risk item), an assessment of its likelihood, and potential consequences to the program if it occurred (see Figure 3). However, from the program's sponsor perspective, not all risks with the same likelihood and consequence are equal.

Some risk items can be handled at the project level and don't require outside mitigation. Removing some risk items from the risk list allows the sponsor, in this case NASA, to focus on those risk items that may require a commitment change and not those that are being handled at the project level. As an example compare, "NASA's Space Science Enterprise redirects (Navigator Program) funds for SIRTF launch delays" and "Failure to achieve interferometric performance objectives prevents LBTI from having an instrument stable null depth of 10,000:1 over a minimum of 30% of on science observing time." Both risks were assessed with the same likelihood and consequence for impacting the program goals but the LBTI risk can be handled by project, the repayment of Navigator Program funds requires sponsor attention.

No.	Project	Risk Item	Likelihood	Consequence	Risk
1	LBTI	LBTI shall survey 50 nearby stars down to a level of zodiacal dust corresponding to 3 times the zodiacal dust in our own planetary system (the NIREST program).	2	3	Low
2	LBTI	LBTI instrument shall have a photometric (5s) sensitivity over 3 hours of observing time in the mid-infrared, 8-13 um wavelength, of 100 uJy; and	1	3	Low
3	LBTI	LBTI instrument shall have a stable null depth of 10E-4 (10,000:1) over minimum of 30% of on science object observing time.	2	3	Low

Figure 3. First page of the Navigator Program Internal Risk List.

The dual nature of the risk list (i.e., notifying sponsor of a possible change in commitments and tracking all program risk items) forced the PRWG to generate two program risk lists, one internal the other external. The internal program risk list had every risk item identified and assessed by the PRWG. The PRWG project representative most closely related to the low-level program risk items continually tracked the status of their risk items. These representatives report back to the PRWG anytime one of their low-level risk items is retired (i.e., the risk could no longer occur) or when a low-level risk item becomes a medium-level concern. The medium and high-level risk items on the internal program risk list have Action Plans generated which documented the mitigation plans for those risk item and are tracked by the Program Engineer. The Action Plans for the medium and high-level risk items required approval by the Program Manager.

The external program risk list is a subset of the internal program risk list and contains those risk items that could not be handled by the project itself and might require a commitment change by NASA Headquarters. As can be seen in Figure 4, by the end of December 2003, the Navigator Program Internal Risk Assessment Guide (RAG) was tracking 75 risk items where as

A future challenge for the Navigator Program will be the mitigation of those risk items that represent medium or high-level risks (e.g., Vacuum chamber availability for SIM integration & test, obtaining permits for the KI Outrigger Telescopes, recruitment of individuals with the appropriate skill mix, etc.). Currently, funding reserves are held at the project level with minimal reserves at the program level. As such, very little program funding is available to directly mitigate those risk items that are not viewed as medium or high-level risks by the projects. However, the lack of program reserves does not release the Program Manager, who is ultimately responsible for achieving the goals of the program, from program risk management. The Program Manager may propose program operating plan changes These changes may be short-term (current funding year) or long-term (current NASA operating plan) and shift funding priorities across the program. In this way, with concurrence from the sponsor, the Program Manager can influence project performance, schedule and costs requirements to mitigate or retire program level risks.

Space explorations missions can succeed without program management. This clearly has been the case since the birth of the space program in 1957. However, as the number of space missions continues to grow, a long-term perspective is required for managing this ever-increasing fleet of space explorers. With vibrant program management and a thorough risk management approach, these missions will produce more science, greater engineering advances, while reducing overall project costs.

Acknowledgment

The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

References

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the External RAG only three. Communicating the appropriate level of program risk to the sponsor requires the Program Engineer to work closely with the Program Manager to avoid the appearance of misrepresentation. As such, the Program Engineer made the initial external program risk list, which was then endorsed by the PRWG and approved by the Program Manager. The approved external program risk list is presented to NASA Headquarters personnel at each Program Quarterly Review.

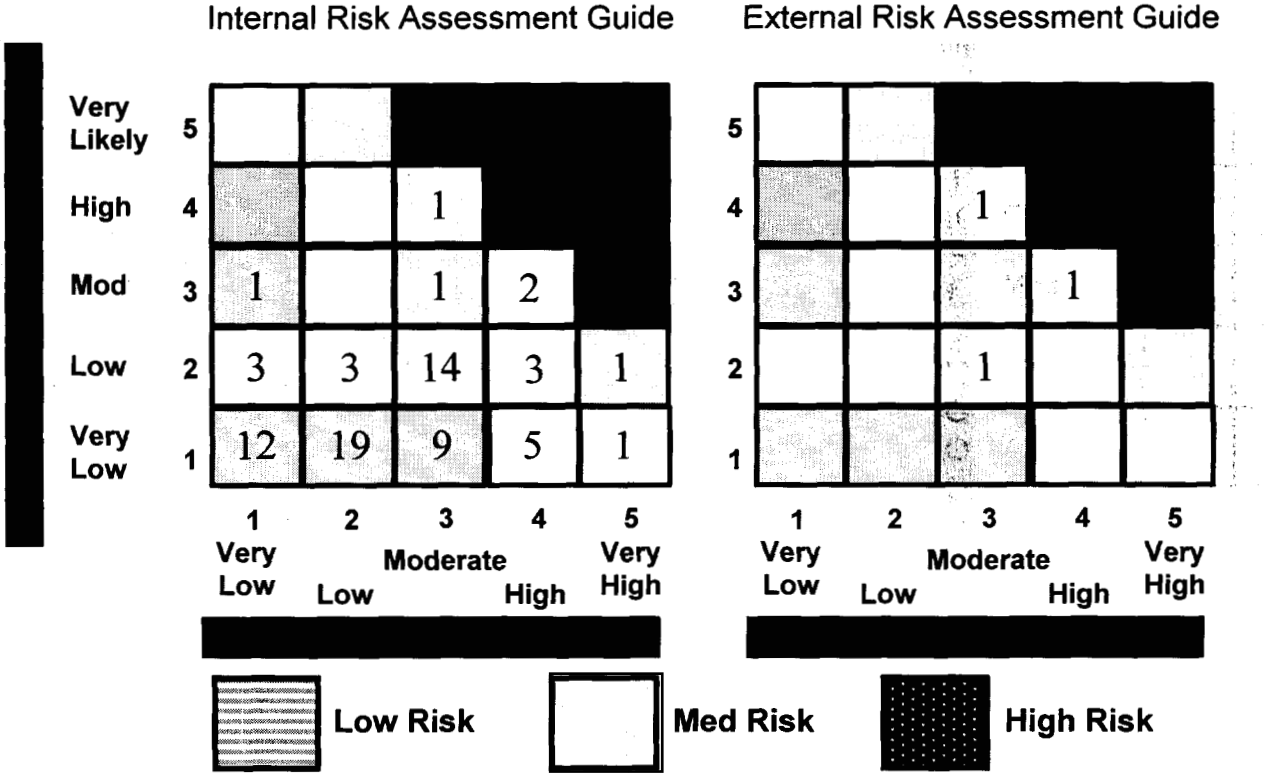

Figure 4. The Navigator Program Risk Assessment Guides as of 2003 December. The external Risk Assessment Guide (right) is a subset of the internal Risk Assessment Guide (left).

Concluding Remarks

The Navigator Program and its PRWG have been working to establish the program's risk posture for slightly more than one year. To date, progress has been made on the definition of program risk management, the execution of the process, and sponsor feedback has been very positive. The program has completed the identification and assessment of risk items from the project Risk Lists, PLRAs , and brainstorming. The PRWG is currently looking for other potential risk items from the Terrestrial Planet Finder Technology Plan and its Science Roadmap. In addition, the PRWG will assess reports generated by the Independent Review Team (IRT) for additional risk items. The IRT is an independent group of experts chartered by NASA Headquarters with providing NASA an unbiased evaluation of the program's scientific, technical, schedule and cost information as compared to the program's commitments.