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Risk Management Handbook for JPL Projects

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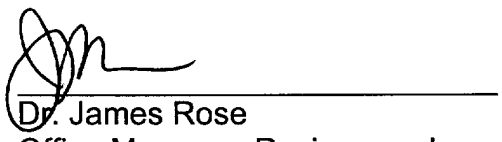

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HANDBOOK FOR RISK MANAGEMENT ON JPL PROJECTS

1 INTRODUCTION

1.1 Purpose of Risk Management at JPL

1.1.1 Knowing and Controlling Risks to Project Assets

The formal process of Risk Management at JPL is instituted to provide JPL Flight Projects with knowledge and control over the risk position of the project.

In the past, JPL project implementation emphasized the maximizing of project success, and thus the risk management strategy was to drive any known risks to achieving the expected mission return to negligible levels. This resulted in extremely successful implementations, with achieved results often far surpassing requirements, and with associated high cost and high cost uncertainty. In the present environment of accomplishing NASA=s space exploration objectives, cost and cost control is an overriding project driver. Not all identified risks can be removed. The likelihood of surpassing mission requirements can be traded off against the risk of surpassing the budget constraints. Risk Management is a process used to balance the project risk position across all project resource areas (mission success, technical reserves, schedule and cost reserves), controlling the distribution and magnitude of the identified risks against the cost constraints while obtaining the best possible confidence in achieving high mission return.

The JPL Risk Management is fully consistent with the JPL Risk Management Policy (reference 1).

1.1.2 Risk Management as a NASA Requirement

NASA has identified Risk Management as a specific project management and systems engineering activity, and has outlined guidelines for the conduct of this activity. In NPD 7120.4A, "NASA Policy Directive for Program/Project Management" (reference 2) and NPG 7120.5A, "NASA Program and Project Management Processes and Requirements" (reference 3), the requirements and guidelines are established for implementing Risk Management on NASA Programs and Projects. These requirements encompass categories of risks to be considered, project life-cycle RM objectives, and reporting approaches. The JPL Risk Management (RM)

Process is consistent with these requirements and guidelines.

1.1.3 Risk Management and the Governing Program Management Council (GPMC)

The NASA document NPG 7120.5A (reference 3) requires risk assessment and a Risk Management process on projects. It also requires that the assessed risks and the projects response to them be reviewed at appropriate milestones by an independent body, the GPMC, which makes recommendations for approval and/or continuance of the project through appropriate authorities to the NASA Associate Administrator. The JPL Risk Management process has in place the necessary elements to comply with these requirements.

1.2 Risk Management is a Project Team Effort

1.2.1 Integral Part of Project Implementation

It is intended that Risk Management be an integral element of a Project Manager's tool kit. Risk considerations can then be significant in the systems design development. This involves *considering risk* at the very beginning of the project conceptualization. The key features of RM activity within the project are:

1) Managed risks are essential elements of the project management control process
2) Cognizant personnel accept the time imposed to develop the risk list
3) Project plans the effort and takes ownership of the plan
4) Risk status reports are integral to project review process
5) Effective metrics are identified and delivered per the plan

These activities require some work-force expenditures that must be recognized in the project planning process, and accounted for in the budget. They also require commitment from the project management, and the Risk Engineer.

1.2.2 A Team Effort

Risk Management is a team effort. The project **Risk Engineer** is the coordinator of the risk management activity. All systems within the project, and all parts of the systems, have important roles in identifying, assessing, and tracking risk, and in identifying the possible approaches to dealing with risks that are necessary for the project to make good risk decisions. Risk decisions are supported by analyses and recommendations from the project team, but are ultimately made by the Project Manager in the same manner as all cost, schedule and performance

impact decisions are made.

1.3 The JPL Risk Management (RM) Team

The JPL Office of Reviews and Risk Management (517) is the element of the JPL organization responsible for (owning) the Risk Management Process. The JPL Risk Management (RM) Team is supported in this organization. The RM Team has developed and documented this Risk Management (RM) Process, which has been adapted and utilized by the Mars Global Surveyor (MGS) project, and the Shuttle Radar Topography Mission. Elements of the RM process are also derived from the SIRTF RM approach, including the adaptation of web-based data management techniques developed in that program. The RM Team will continue to update and improve the process as we find out what is effective and what additional features could be useful. The JPL RM Team is established to assist projects in installing a Risk Management process tailored to their needs, to consult with them in the ongoing application of risk management in their project, and to audit the compliance with the defined JPL process.

2 OBJECTIVES

2.1 Objectives of Risk Management

The overall objective of Risk Management is identify and assess the risks to achieving project success, and to balance the mitigation of these risks (and hence the additional cost) against the acceptance and control of these risks (and hence a possible higher degree of technical achievement). To further these objectives, the JPL Risk Management process involves **identifying risks** to the success of a flight project, **understanding the nature of these risks**, individually and in total, and **acting to control their impact on the success of the project**.

2.2 Objectives of the Risk Management (RM) Handbook

The JPL RM Handbook is intended to provide:

1) a description of the overall Risk Management methodology, and
2) a description of the techniques being used and evaluated at JPL for implementing the methodology

These descriptions are complementary to and consistent with the on-line JPL Risk Management (RM) Guide, which is currently under development. This Guide (the URL is given

on the document front page) will be an on-line interactive tool to provide access of Project personnel to identification, assessment, decision making and tracking tools available at JPL and at other NASA centers in support of risk management.

This JPL Risk Management Handbook will provide paper templates and formats for the planned RM Tools. Future versions of the Handbook will provide introductions to and guidance in the use of the integrated on-line RM Guide.

3 RISK MANAGEMENT DESCRIPTION

3.1 Overview

3.1.1 Definitions of Risk

In the context of the JPL Risk Management Process, **risk** is defined as:

> the combination of the likelihood of occurrence of an undesirable event and the severity of the consequences of the occurrence.

A specific risk to a project, identified in this process as a **risk item,** therefore has three components, namely

- the undesirable event
- the likelihood of occurrence
- the severity of the consequences of the occurrence

The project **risk position** is defined as:

> the **aggregate** of the assessments of the individual risk items for the project, including the decisions made to mitigate, accept and control, or take additional risk. It is a goal that this risk position be **measurable** relative to project reserves.

In this context, **risk management** is defined as:

> an organized means of planning the risk management activity (Planning), identifying and measuring risks relevant to a Flight Project (Identification and Assessment), identifying, selecting and implementing measures for controlling these risks so as to control the project risk position (Decision-Making), and tracking the decisions made and the evolving risk status (Tracking).

Project reserves can be identified in different ways and are managed by a number of effective tools and methods. Two that the JPL Risk Management methodology looks at as

aspects of the Project risk position are the budget reserves and the measure of expected mission return relative to mission requirements (project success criteria).

The Risk Management methodology is based on the project risk position, which is the understanding of the "knowable" risk, while acknowledging that there are inherent Aunknown-unknown≅ risk possibilities in any project, and must be acknowledged when judging adequacy of the reserves.

3.1.2 Aspects of Risk

Each risk item has two aspects

1) threats to achieving launch and operational capability within cost and schedule constraints **(implementation risk)**, and
2) threats to achieving mission success **(mission risk)**, that is loss of some or all of the expected achievement of scientific data return or demonstration of new technology capability, or some combination of these project objectives.

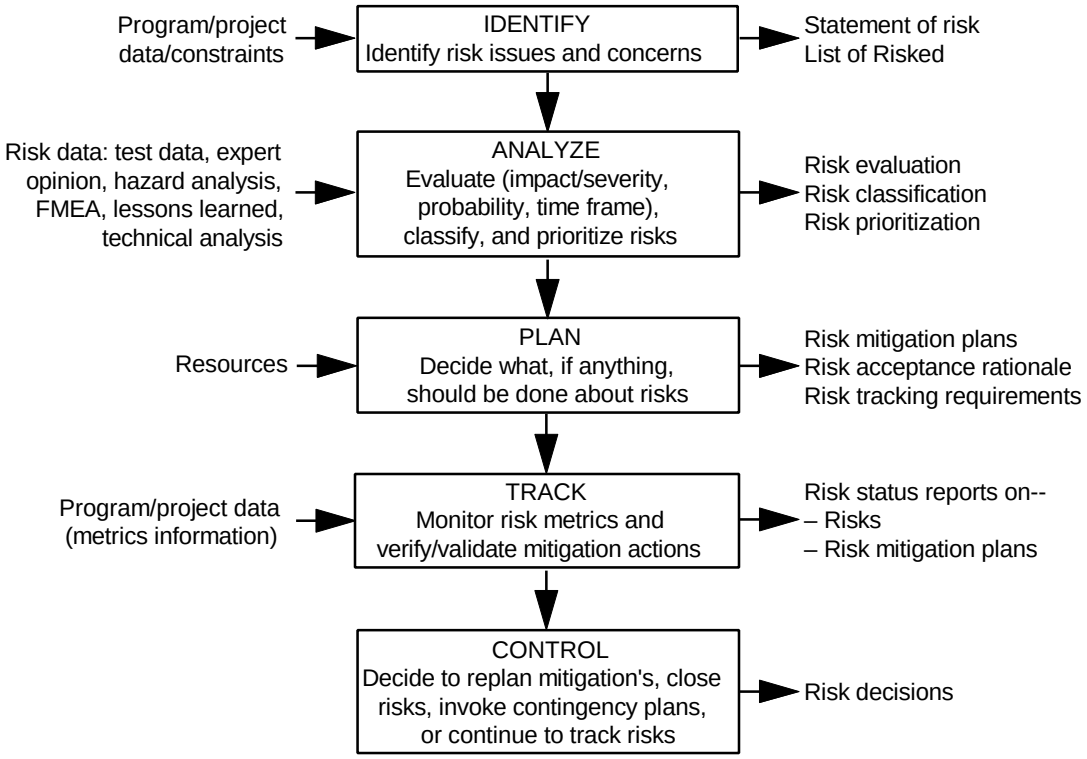
(Note: It is **not** an intention of risk management to allow increased likelihood of catastrophic loss of a mission - this must be maintained to be very unlikely, just as has been done in the past. Risk Management **is** intended to allow likelihood of achieving greater than the required mission return to be balanced relative to likelihood of remaining within the budget constraints in implementing the mission.)

3.1.3 The Elements of the JPL Risk Management Process

Every Risk Management process in today=s aerospace industry have a common set of activities, even though they may be organized in different ways.

1 Identifying and Characterizing Risks
2 Prioritizing or Ranking Risks
3 Developing potential project responses to risks
4 Making decisions utilizing existing resources to restructure the program to reduce the potential effect of the risks
5 Track the evolving risk exposure and iterate the above actions as needed
6 Develop a plan for the above activities throughout the project life-cycle

The NASA Continuous Risk Management process defined in reference 3 defines these activities as shown in the figure below, **excerpted from reference 3**:



NOTE: Communication and documentation extend throughout all of the functions.

These activities are embedded in the JPL Risk Management Process in **four elements**, namely **Risk Planning, Risk Identification and Assessment, Risk Decision-Making, and Risk Tracking.** Each of these elements is described in separate sections in this document.

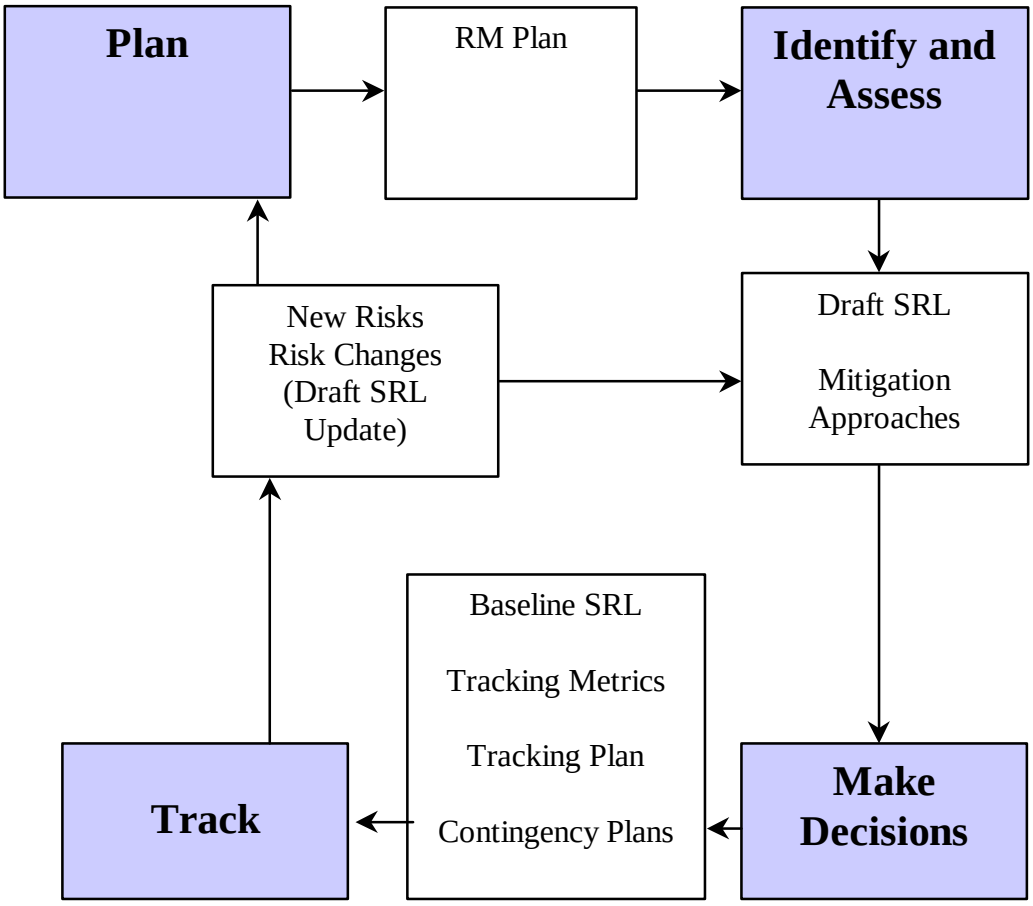
The table below shows how the elements of the JPL RM process aligns with the activities of the NASA Continuous RM process.

Activity	JPL RM Element	NASA Continuous RM Element
1	Identify and Assess	Identify/Analyze
2	Identify and Assess	Analyze
3	Make Decisions	Plan
4	Make Decisions	Plan
5	Track	Track/Control
6	Plan	Develop RM Plan (a separate requirement)

Each element of the Risk Management process requires interactions among the project team, and the JPL process provides methodology and tools to enable effective communication and documentation.

Figure 3.1 shows a process flow for the activity of risk management in the JPL process. The four elements are identified (shaded), and their relationships and interactions with each other are indicated. The details of each of these activities will be described in this Handbook.

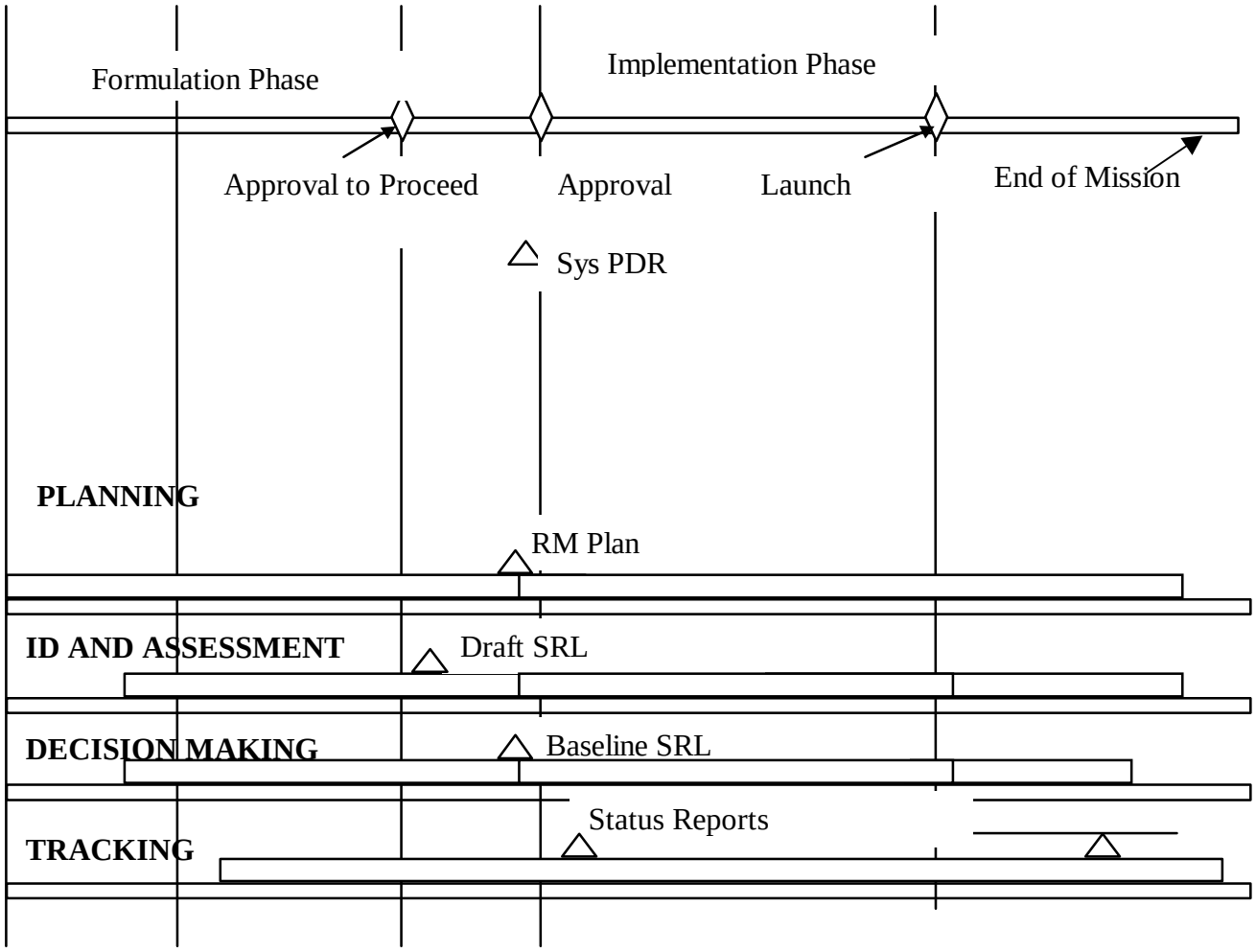
Fig 3.1 Risk Management Process Flow Chart



3.1.4 Risk Management in the Project Life-Cycle

Figure 3.2 shows the periods of activity, and generally the times of inputs/outputs of the Risk Management Process, within the project life-cycle frame of reference. Each Risk Management element extends through the entire life-cycle, and the preponderance of effort shifts from planning through identification and assessment, decision making, to tracking as the project risk position changes and evolves.

Figure 3.2
Risk Management in the Project Life-Cycle



While the risk management process is serial, there is significant iteration and updating as the project progresses and matures and thus the identified risks change, are realized or retired, and new risks arise. As risk matures, probability of occurrence or impact will change. Risks can reduce to the level of insignificance, where they are retired, or can increase to point of occurrence, or realization. Also, new risks can and will be identified throughout the project life-cycle. The Risk Management process considers and responds to all of these outcomes by returning to earlier activities for reconsideration and update.

3.1.5 Receivables and Deliverables

The table below lists appropriate external receivables/ deliverables of the Risk Management Process, and describes when they are produced as a function of time in the life-cycle.

Item	Receivable	Deliverable	Project Milestone
Project Documents			
Project Context	X		Approval to Proceed
-Project and Mission Objectives			(Pre-project product)
-Project and Mission Success Criteria			
-Programmatic Relationships			
-Organizational Relationships			
Project Implementation Approach	X		Approval to Proceed
- Requirements Prioritization			(Pre-project product)
- Systems Architectures			
- Design Concept			
- Concept of Operations			
Pre-project RM Plan		X	w/proposal
Project RM Plan		X	Project Implementation Approval
Descope Plan		X	Project Implementation Approval
Data Bases			
Draft SRL		X	Approval to Proceed
Baseline SRL		X	Project Implementation Approval
Tracking Metric	X		Implementation
Reports			
Metric Data Reports	X		Implementation
Risk Status Reports		X	Maj Reviews, MMRs
Analyses			
Risk Assessments		X	As agreed in plan
Interfaces			
NASA Lessons Learned	X		Usage - on request as needed
		X	Contributions - as they occur
NASA Alerts	X		on request, as issued

3.2 Risk Planning

Risk Planning defines the Project's specific approach to Risk Management - how each of the activities described here will be accomplished. The product of the planning activity is the project Risk Management Plan. The plan may be a stand-alone product or a section of the Project Plan document, which is approved by the GPMC.

3.2.1 Planning Requirements

A Risk Management Plan is required by NASA for all projects (reference 2)**.** Planning is sometimes done in two parts. In the initial pre-project or proposal activity, planning is often required and usually helpful. This **pre-project plan** documents the risk policy, and identifies the significant risk drivers to be understood and controlled. The **Risk Management Plan**, developed in the formulation activity, will be required for project approval for implementation, and will be the working plan which defines how the Identification and Assessment, Decision-Making, and Tracking elements are to be carried out.

The Risk Management Plan must include the following information (reference 3):

(1) Purpose, scope, assumptions, constraints, and policies pertaining to risk management on the project.
(2) Overview of the process and a description of how risk management is integrated into the project management processes
(3) Organization, roles and responsibilities for risk management
(4) Methods and tools to be used, metrics to be produced for each activity (element) of the process
(5) Schedule and milestones for risk management activities. Resources required to implement risk management
(6) How will risks be documented and maintained?
(7) Descope strategy, related to Program objectives and Project objectives, including defining the minimum expected achievement (limit of project viability)

Section 3.2.3.1 discusses the possible content of a Risk Management Plan, in response to these requirements.

3.2.2 Inputs

To develop a Risk Management Plan, the following **inputs** are needed. In general, these inputs will be documented in the Project Plan, and are needed for review by the GPMC for

approval, as described in Reference 3.

3.2.2.1 Project Context

3.2.2.1.1 Project and Mission Objectives

Science objectives (e.g. return sample, perform a),b), and c), in that priority, etc.), programmatic objectives (e.g. technology demonstration, telemetry relay for other programs), and institutional objectives (e.g. developing an expertise, establishing new partnerships), are defined, assessed and prioritized to enable risk ranking, and impact quantification

3.2.2.1.2 Project Success Criteria

This is the prioritization and or relative weighting of the objectives. These provide the bases upon which specific scales for assessing risk impact can be constructed, and also form criteria for trade-off decisions concerning risk disposition. They should be directly derived from the Project and Mission Objectives, and the Mission Requirements, and should be approved by the customer.

3.2.2.1.3 Programmatic Relationships and Organizational Relationships

These identify the partners, customers, suppliers, governmental, and international interfaces within which the project will be implemented. This information enables the identification and assessment of programmatic risk items, such uncertainty in the launch vehicle to be supplied, complicated interfaces with industrial partners, uncertain customer needs, etc.

3.2.2.2 Project Implementation Approach

3.2.2.2.1 Allocation and Prioritization of Requirements

This may assist in establishing descope options, and follows from analyzing the project context

3.2.2.2.2 System Architecture, Design Concept, Concept of Operations

These are required to enable the risk identification process for both technical and programmatic risk categories, and establish candidate scenarios for more detailed risk analysis

3.2.2.2.3 Budget Allocation, WBS, Reserve Distribution, Master schedules, Receivables/ Deliverables Plan

These are required to enable identification and assessment of cost and schedule risks, interface deliverable risks, critical path risks, etc.

3.2.3 Risk Management Planning Activities

3.2.3.1 Risk Management Plan Contents

The following subjects should be treated in a Risk Management Plan. As indicated by the numbers in parentheses, these address the NASA requirements identified in section 3.2.1.

- **Project Risk Policy and Strategy (1,7)**

This section should map the project success criteria and project objectives into an overall approach to risk. The plan communicates this approach to the project team and to the customer. The basic policy reflects the prioritization of performance and programmatic objectives and constraints, and weights the emphasis on the following:

> **avoiding risk**, by minimizing risk through redesign, alternative developments, parallel developments, large margins, etc.;
>
> **accepting risk**, by developing contingency plans and margin management criteria for exercising those plans, and/or allowing descope/ reduction in Mission return to trade against cost, schedule, and other resources; or
>
> **taking risk**, by finding and incorporating high potential performance/cost/schedule benefits with acceptable additional risk to reserves or margins.

A project in which the nominal performance requirement is highest priority, and cost relief is potentially available might favor the risk avoidance approach. A hard cost ceiling and some agreed-to performance reduction options might favor the risk-accepting or balancing (moving risk from cost risk to performance risk, for instance) approach. An example of a project for which risk-taking may be appealing is a technology validation project where the possibility that significantly more technologies may be investigated with judicious use of less expensive, less proven quality parts would imply a payoff for taking increased risks.

- **Risk Management Responsibilities (3)**

Key responsibilities include the Risk Engineer, who can be the project manager, sometimes is the Mission Assurance Manager, but usually is the Project Engineer. In addition, if the RM assessment is tiered, with a project level, and system level assessments and risk lists, then in each system the coordinating RM responsibilities must be identified.

The table below lists possible roles for project members in support of Risk Management. The Risk Engineer should be identified by the Project Manager. Others on the project will also contribute, especially to the identification of risks and mitigation options, trade-off studies, and tracking.

	Team Roles in Risk Management of a JPL Project
Risk Engineer	-Staffed at a Position of broad project oversight -Project Systems Engineer, Mission Assurance Manager leading candidates
Decision Maker	-Project Manager
Risk Identification and Assessment	-Spread across project. At least every PEM, and every partnering system. Desirable to assign responsibilities lower, integrate up risk assessments.
Risk Trade-Offs	-Coordinated by Risk Manager and Project Systems Engineer -Assign analyses at least to all those assigned to identify risks
Tracking	-Selected project engineers and administrators cognizant of the required data -Coordinated by the Risk Engineer

- **Risk Concerns on the Project**
  (This is not currently required by reference 3, but is encouraged, and often required in RFPs,)

Describe the major areas of risk and the measures incorporated in the baseline plan to reduce the risk exposure of the project. Include here areas that have not been reduced to minimal risk, and how the Risk Management approach will deal with them.

- **Contingency Planning (7)**

The descopes available, and the approach to using them as risk mitigators should be discussed. Other contingency approaches, such as mitigation of new technology risk, should be addressed as needed. The approaches defined here will be the basis of mitigation decisions made later, and may be later formalized in contingency plans (described in detail in section 3.4, the Decision Making element.)

- **Overall Risk Management Process (2,6)**

Describe here the methodology used to accomplish Risk Management on the Project. Generally a Flow-Chart of activities can effectively describe this methodology, and the role project personnel, teams, and organizations play in the process. An example is shown in figure 3.3 for a qualitative process. Describe how risks will be identified, reviewed for appropriateness, categorized for consideration in the aggregates of the project risks, and dispositioned as they mature.

Describe the nature of the project architecture with other organizations and how Risk Management in their elements of the project will be integrated into the overall Risk Management process, and the overall assessment of the Project risk position.

- **Risk Identification and Assessment Processes (4)**

Risk Identification approaches may include methods outlined in this handbook in section 3.3, and/or any number of other effective project-unique methods. Describe the methods to be used.

The assessment methodology chosen to identify and rank risks must be clearly described. Both qualitative and quantitative methods are described in section 3.3. There may be more than one methodology chosen, depending on the strategy adopted. Categorizing risks may be useful for tracking classes of risk, or risks associated with elements of the system. These should be defined in the plan.

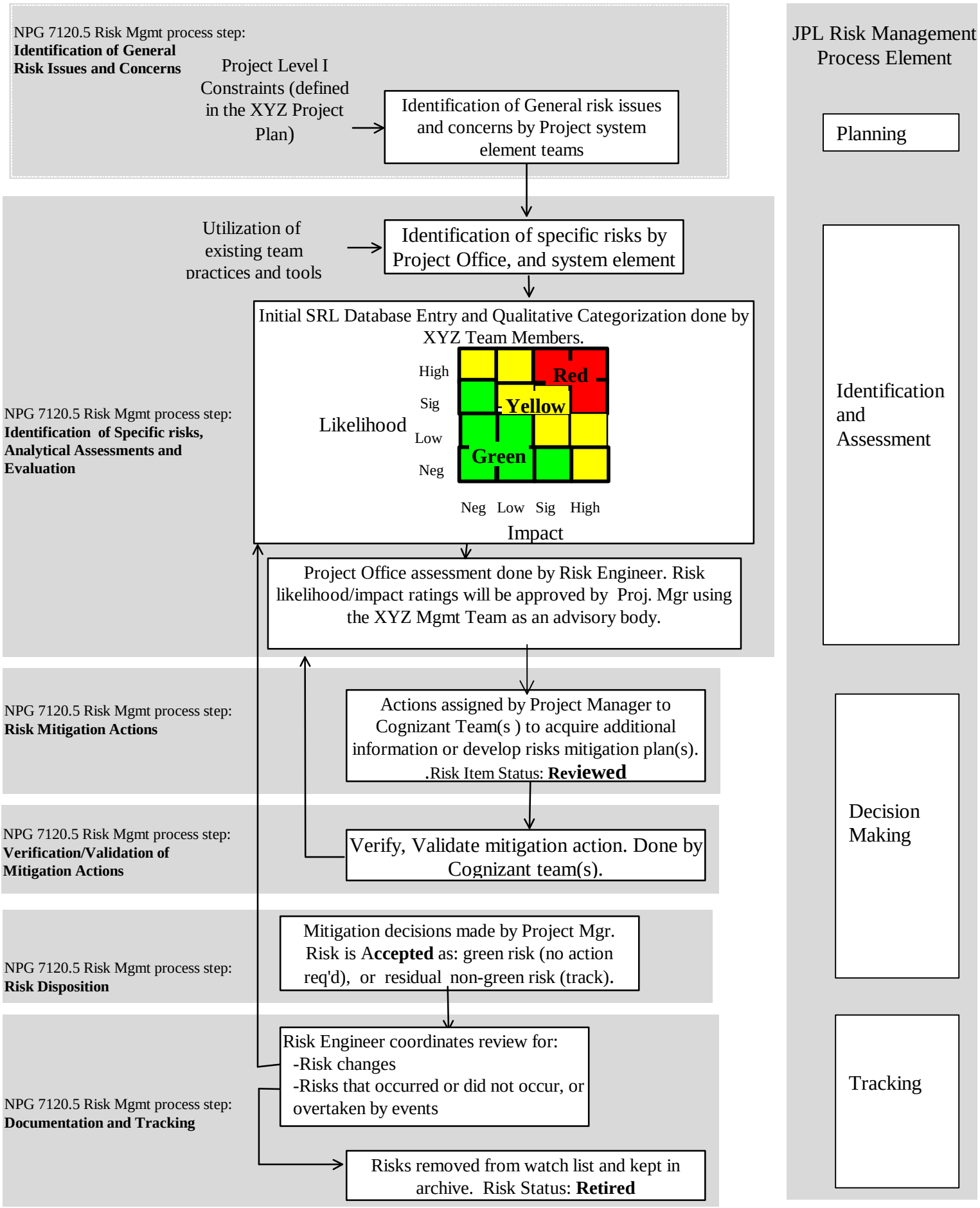


Figure 3.3: XYZ Project Risk Management Process Flow and Responsibilities

- **Risk Documenting Process and Tools (4,6)**

The Significant Risk List, with definitions of the entries in the data base, milestones for updates or decisions, criteria for decisions, etc, should be described. The JPL RM Team provides a web-based SRL tool which can be tailored for a user project, and provides qualitative risk aggregation and display capability. Also available is an EXCEL-based tool that may be used to do quantitative assessment and is easily adapted to the specific needs of the project. (The goal of the JPL Risk Management Team is to integrate these tools for maximum user convenience.) At present, data is manually transferred as needed.

- **Decision Process (2,7)**

Describe how the assembled data will be assessed and grouped for decisions. Describe how trade-offs will be performed, and, if appropriate, what forums will be used to present recommendations and obtain direction.

- **Risk Tracking Responsibilities (6)**

The cognizant personnel who will provide analyses of the risks and updates of the status of the risks should be identified, along with the key parameters used to assess the changing risk magnitude as the project progresses. Describe plan for updating status (frequency, reporting forums, etc.). Identify any status reports, requirements for reporting in reviews, etc.

- **Schedules, Milestones, and Allocated Resources (5)**

Provide a schedule for risk management activities, either as part of the master schedule, or separate. Include an overview in the RM Plan. Indicated significant milestones for status review, decisions, etc. Describe resources allocated for Risk Management.

- **Metrics (4)**

Identify metrics that will be used to assess the Project Risk Position, and also metrics which will be used to improve the effectiveness of the Risk Management process.

Appendix A provides a template of a Risk Management Plan. Examples of Project Risk Management Plans can be found at the Risk Management On-line Guide Home Page. The current URL is noted on the Cover Page.

3.2.3.2 Planning for Proposals

In some project opportunities in the Better-Faster-Cheaper era, competitive proposals are needed in the pre-project or pre-phase-A time frame. Such proposals dictate or are enhanced by Risk Management Plans. These plans should include high-level discussions of the areas discussed above. In addition they should include description of anticipated risk areas, and candidate responses, such as descope and alternative technology plans approaches. This risk environment should be related cost-wise and life-cycle wise to the budget reserves requested and the schedule proposed. Appendix B is a template for proposal-level risk management plan generation. There are two versions. One version reflects the general requirements for a very short (<1 page) discussion of the risk management approach, for the Step 1 proposal. The more definitive (but still short and therefore high level) version is for Step 2 proposals, which are constrained to be 4-5 pages in length.

3.2.4 Outputs

The major **output** of the planning element is the project Risk Management Plan.

3.2.5 Reference Risk Management Plans

Current references for risk planning include references 4-8, which are applicable risk management plans from recent Flight Projects. These are available on-line from the RM On-Line Guide (see URL on cover of this document).

3.3 Risk Identification and Assessment

3.3.1 Identification and Assessment Requirements

The requirements in identification and assessment are to identify the risk items, to describe them sufficiently to allow assessment and decision-making, to identify practical mitigation approaches, and to develop the Draft Significant Risk List (SRL), which is a list of the identified risks to the project and their decision-enabling data

3.3.2 Inputs

When the pre-formulation or early formulation phase feasibility demonstration and scope definition results have been approved, the required inputs for Risk Identification can be assembled. The information needed for identifying and assessing risk include at least preliminary

versions of:

- Project Plan and/or Project Implementation Plan
- Project and Mission Requirements
- RM Plan
- System Design Approach
- Technology utilization and descope approaches
- Preliminary Concept of Operations
- Staffing Plan/ key personnel
- Schedule/ Schedule drivers
- Budget/ budget drivers

3.3.3 Identifying Risk Items

3.3.3.1 Resources for Identifying Potential Risks

3.3.3.1.1 External Resources

Risks to the project may be identified through experiences of other projects, or the Aerospace industry in general. Some resources of current information outside of the project are:

X NASA and JPL Lessons Learned Files
X NASA Alert Files

3.3.3.1.2 Internal Resources

Sources and resources available within JPL and within the project which are used to develop inputs to the Risk Identification and Assessment element include:

X **Expert Judgement**
The JPL RM risk identification and assessment process relies heavily on the expert judgement of the project implementers and their peers

X **Reliability Assessments**
Risk Identification is facilitated in part by performing analyses and planning assessments of the systems designs and the design validation approaches to be implemented in the project. Failure mode effects analysis (FMEA), Failure mode effects criticality analysis (FMECA), fault tree analyses, and Defect Detection and Prevention (DDP), are examples of design and product validation activities. which can enhance risk identification, either in the

definition phase of the project, when the risk list is developed, or throughout the life-cycle as the risk tracking progresses and risks are reevaluated, and/or deleted or added.

X **Schedule, WBS Uncertainty Analyses**
These capabilities can systematically examine the planned work and identify uncertainties to which the project has high sensitivity, which can result in risk items to be assessed.

X **RM Categorized Check Lists, Risk Item Templates**
These tools provide checks on the comprehensiveness of the identification process. They will be provided as attachments in future updates this document, and will also be available in an on-line Risk Management Guide.

3.3.3.2 Categories of Risk

Categorization can be used to allow the aggregation of **subsets of risks**, and so provide insight into major risk areas in the project. A useful set of categories distinguishes **technical, cost, schedule, programmatic, or supportability** categories to be considered. A check list for these categories can be found in Appendix C. Other categorizations which might provide insight include:

- The project systems or subsystem area in which the risk is manifested,
- The WBS element primarily involved,
- Technology areas (such as laser communications, solar electric propulsion)
- Design Disciplines (such as software, electrical design, radiation tolerance)

Appendix C lists and describes various categories that could be considered for either or both purposes.

3.3.4 Risk Item Descriptors

The draft SRL should list each identified risk item, and for each item should include as a minimum:

- Description of the adverse event
- Categorization in the categories chosen
- Implementation Risk
    - Impact - what will it take to fix it
    - Likelihood of occurrence
- Mission Risk

    - Impact - if you don=t/can=t fix it what reduction in mission return
    - Likelihood of occurrence
- Probable time of occurrence - if applicable
- Description of potential mitigation for consideration
- Costs of identified mitigation options
- Resulting reductions in risk likelihood and impact if mitigation option is implemented

Project personnel who are identifying risk items will record as much of this as is available at the time a risk is input to the project. Recording the likelihood and consequence descriptors require that the thought processes of risk assessment (described below) be gone through, and in general a first cut at each can be entered with the other data.

3.3.5 Risk Item Assessment

3.3.5.1 Risk Identification Methodology

The first step in developing the risk list is generally a brain-storming activity where potential risk items are identified by the key project personnel. These risks are characterized by two parameters - the **likelihood** of an adverse event and the **consequences** of that event. Whenever a potential risk is submitted for consideration, it is accompanied by estimates of these two parameters. The risks are identified by the Aexperts" in the specific subject of the risk item - that is, the key personnel submit candidate risks in their project areas of expertise. Risks may be suggested in areas outside their expertise, but they should be then presented to the expert in that area for concurrence. As these risk items are characterized, other data are needed which are described below.

The mechanism for obtaining these submissions will vary. The brain-storming may occur as a group, or by e-mail, or separately. The submissions should be Astandardized≅ to remove very disparate interpretations of the rules before the first group consideration takes place. The following characteristics should be observed in the process.

- The candidate risks submitted by the team should be inclusive - if the item might be a risk, input it. The Risk Engineer will work with the submitter to delete inappropriate risks or modify the assessment as needed.
- They should have a common basis for interpretations. This is accomplished by the Risk Engineer iterating with the specific group members
- The team should assess the risk list , and remove differences of understanding through discussion.

3.3.5.2 Risk Identification Data Base

Also accompanying the risk item submission is a description of optional mitigation options. These data will be sorted by the Risk Engineer and entered into the data base (the candidate SRL). An example of a data base input form is shown in figure 3.4. Accompanying this form, is an example of a risk appraisal form (figure 3.5). These may be distributed to the participants as the medium by which the risks and risk assessments are submitted. These two examples are extracted from the MGS Risk identification and assessment approach. The JPL Risk Management Team has developed a web-based data entry tool can be used in lieu of forms to explain the assessment criteria and allow entry of these data. These examples will be augmented to include other approaches to measuring risk, and the SRL tool will accommodate semi quantitative and quantitative assessment criteria as well.

The project must establish the metrics and algorithms for assessing the risk likelihoods and consequences, and for aggregating and the risk items to determine the project risk position. Several approaches are described below. The chief differentiation is whether the assessment is to qualitative or quantitative, or a combination of both

3.3.5.3 Qualitative vs. Quantitative Assessment

3.3.5.3.1 Qualitative Assessment

Qualitative Risk Assessment is the assignment of adjective ratings to the degree of significance of either likelihood or consequence of occurrence. Criteria like "High, Medium, and Low≅ are generally used. Scales can have fewer gradations (i.e. high and low) or more (e.g. high, significant, moderate, and low). **Definition of these levels** is essential, and some iteration and discussion will be needed before the team understands a common distinction between assessed levels. The advantage of this qualitative approach is that numerical assignment of degree is difficult, or not believable, by the assessors. The disadvantage is that the system does not straightforwardly allow Aadding-up≅ or otherwise aggregating the total risk. Rather, a risk distribution is used to display the project risk position, as will be seen below.

3.3.5.3.2 Qualitative Risk Assessment Criteria- Example

3.3.5.3.2.1 Pure Qualitative Criteria Example

The following three-level scales illustrate the qualitative approach. Scales are required for both likelihood and consequence for the implementation risk aspect and the mission risk aspect of a risk item.

Figure 3.4
RISK IDENTIFICATION AND ASSESSMENT DATA BASE

Risk Number	Risk Description	Probability of occurrence	Impact (action to recover)	Cost to recover ($)	Risk Cost ($)	Mission Risk - Impact	Mission Risk - Probability	Mitigation Options

1. Risk Number: Identification number
2. Risk Description: Description of risk event, cause of occurrence, and effect of occurrence
   (Can add columns categorizing types of risk; areas impacted; elements of the system involved; etc..)
3. Probability of Occurrence: Estimate of the probability ($0<p<1$) that the event will occur
4. Impact of Occurrence: Description of action required to recover plan to launch
   (This effort can be described relative to the Fiscal Years action would be required)
5. Cost to Recover: This defines in dollars the cost of the recovery actions
   (Can add columns to account for cost per FY)
6. Risk Cost: Estimate of the most likely cost to recover ($). This is calculated by multiplying (3.)X(5.)
7. Mission Risk - Impact: Estimate of the loss of capability to achieve mission success if event occurs and is not/cannot be fixed
8. Mission Risk - Probability: Likelihood that the risk event occurs and cannot be fixed
9. Mitigation Options: Description of the possible actions which can be taken (immediately or at some predefined milestone) to reduce or remove the risk. This is accompanied by a cost to mitigate, and a residual mission risk impact. These data might be kept in separate data records correlated to the involved risk item

Figure 3.5
RISK APPRAISAL FORM - Quantitative Discrete Scales

REF NO. _____ DATE:_____
(for project use only)

RISK NUMBER	PROB-ABILITY	COST IMPACT	DESCRIBE RISK OR SOURCE OF RISK Describe event, consequence, time of occurrence
1			
2			
3			
4			
5			

PROBABILITY (CHOSE ONE):

10% Low -risk will in all likelihood not occur
30% Medium - risk may occur despite normal care
50% High - risk may occur even with special management
90% Very High - risk is nearly certain to occur

COST IMPACT:

Estimate the extra cost to the program if the risk occurs;
express all schedule and technical risk in terms of cost.
Choose a cost impact value only from the following:
$10K, $20K, $50K, $100K, $200K, $500K, $1M, $2M, $5M

Implementation and Mission Risk Likelihood

High: Occurrence is likely
Medium: Occurrence is unlikely
Low: Occurrence is very unlikely

Implementation Risk Consequence Consequence

High: The impact would not be reparable within planned resources
Medium: The impact would require all planned resources
Low: The impact would be reparable within planned resources

Mission Risk Consequence

High: Major impact to primary objectives
Medium: Impact may degrade satisfaction of primary objectives
Low: Primary Objectives are not impacted

3.3.5.3.2.2 Semi-Quantitative Adjectival Criteria Example

This approach, while still a qualitative assessment using adjectival ratings, sets the criteria for the adjective rating through numerical ranges, based on the significant project resources selected to measure risk, in this case budget reserves and mission success objectives. This can further clarify the adjectival ratings.

Implementation Risk and Mission Risk Likelihood

Low (L)	Probability of occurrence < 1%
Moderate(M)	Probability of occurrence between 1% and 10%
Significant(S)	Probability of occurrence between 10% and 50%
High(H)	Probability of Occurrence >50%

Implementation Risk Consequence

Low(L)	Potential Draw on Budget Reserves to Fix < 1%
Moderate(M)	Potential Draw on Budget Reserves to Fix between 1% and 10%
Significant(S)	Potential Draw on Budget Reserves to Fix between 10% and 50%
High(H)	Potential Draw on Budget Reserves to Fix >50%

Mission Risk Consequence

Low(L)	Potential Reduction in expected Mission Success < 1%
Moderate(M)	Potential Reduction in expected Mission Success between 1% and 10%
Significant(S)	Potential Reduction in expected Mission Success between 10% and 50%
High(H)	Potential Reduction in expected Mission Success >50%

3.3.5.3.3 Quantitative Risk Assessment Methods

Quantitative Risk Assessment uses numerical assessments according to a pre-defined scale. The scales can be whatever is most important to measure against, and the precision can be set depending on the confidence in the Aassessability≅ of the risks. Likelihood is generally assessed in a probability of occurrence as a percent. As will be seen, common quantitative scales for the impact of the risk include cost to fix it if it occurs when it can be and would be fixed, or reduction in mission return if it occurs when it can=t or won=t be fixed.

3.3.5.3.3.1 Quantitative Assessment Criteria

Implementation and Mission Risk Likelihood

Implementation risk likelihood is measured as a probability of occurrence

Implementation Risk Consequence

The measure of implementation risk consequence is the cost to fix it. This is assessed in the context of the current project baseline plan. The point at which the cost is incurred should be assessed so that the fiscal year impact to budget reserves can be understood. The description of the consequence (e.g., buy another part, schedule delayed for two months while hardware is fixed, etc.) must be sufficiently detailed to allow the costs to be assessed.

Example: If a perceived propulsion system risk is the possible occurrence of stress cracks, when would these be detected and what would the correction be such that the cost to repair ($, schedule, alternative design, etc) can be estimated and spread by year?

Note: If an effective mitigation effort is identified which can be implemented immediately, the decision is often made at this point to make that change, thereby modifying the project baseline. Then the candidate risk would be modified, reduced or retired. If the decision is not made now, then the risk is carried as is.

Mission Risk Consequence

The metric of mission risk consequence is the likely percentage of achievement of mission success. At this time, this risk assessment methodology is not as mature as the assessment of implementation risk. The goal is to develop credible quantitative assessment techniques for this parameter - first on a risk item basis, and ultimately to develop a project mission risk position.

The metric scales can be as finely drawn in the numerical range as desired. The example shows 4 levels of distinction in both likelihood and consequence. Some translation to percentage levels, or "high - medium - low≅ scales is important.

3.3.5.3.3.2 Continuous vs. Discrete Scales

Either likelihood or consequence or both scales may be continuous or discrete. The desire is to provide the most objective and consistent assessments in these scales across the team of assessors. No single scale or assessment approach is given as a requirement here. The JPL Risk Management Team is suggested as a consulting source to help select the approach for a specific project. The general advantages and disadvantages of the continuous and discrete metric scales are noted below.

Continuous Scales

Assessing likelihood of occurrence on a continuous scale can be and is most often modeled by estimating the probability of occurrence "p", where $0<p<1$, and $p=1$ means certain to occur, $p=0$ means will not occur. A continuous scale for assessing implementation risk consequence is the estimation of the cost to fix the problem or otherwise recover to the implementation plan, should the risk event occur, in K$. For Mission Risk, the scale could be a percentage "s", ($0<s<100$) of the degradation of expected mission return relative to a norm or nominal mission success goal.

Establishing a continuous scale allows the assessors the maximum flexibility in establishing their expert judgment. The disadvantage of this approach is that the inherent optimism vs. conservatism of the evaluators will vary widely, and some means to normalize or objectivize the assessments is desirable. Techniques for accomplishing this are available, but require some rigor and some training of the assessors.

Discrete Scales

Discrete scales, which can have the same metrics as the continuous scale, but allowing estimates only from a finite set of choices. The objective is to give some bounds for the assessors to self-normalize their assessments. The assessors are forced to choose between two significantly different levels near where they have judged the measure to be, and the achievement of some consistency with their peers is perhaps possible with less training. Figure 3.5 gives an example of

discrete metric scales that can be used for assessing these risk parameters.

3.3.5.3.3.3 Magnitude of the Risk Item

The resulting product of the assessed probability and consequence of occurrence is called the **risk magnitude** for a quantitatively assessed risk. For the implementation risk aspect of a risk item, this is measured in dollars (**risk dollars**). For the mission risk aspect, this magnitude could be viewed as the likely reduction in mission return.

These assessed magnitudes should be added to the data fields of risk items in the Significant Risk List, and allow their relative ranking.

3.3.6 Aggregating Risk - The Project Risk Position

The Significant Risk List is the accumulation of the identified risks with which the project must make decisions. In order to see the effect of all of these individual risks, it is useful to develop aggregates of the risks, and these we use to characterize the project total risk, which is called here the **project risk position.**

3.3.6.1 Qualitative Aggregate

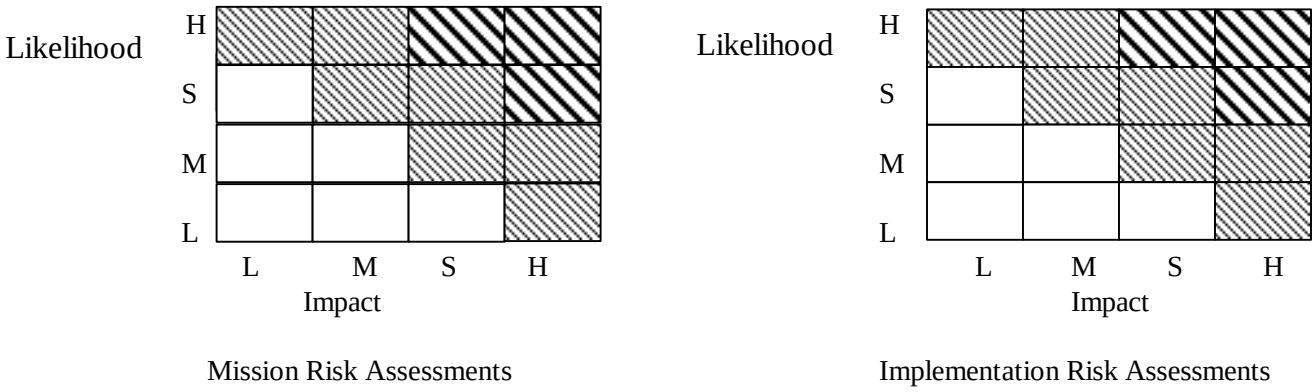
A graphical method for aggregating qualitatively assessed risks, and summarizing the project risk position, is shown in Figure 3.6. Each risk item, which has been assessed in likelihood and consequence for both implementation and mission risk aspects, can be plotted in a bin of each of the two matrices shown in the figure. The significance of the bin groups reflects the risk magnitude, and should be established a priori by the project management team. Example criteria are shown below the matrices. In general risks to the upper right are most significant, and need the most attention.

The project risk position is a subjective judgement based on the number and distribution of risks in the matrix. Criteria for how to deal with each region of the matrix in terms of deciding on mitigation actions, etc, should also be considered before the actual data are in hand.

Figure 3.6 - Qualitative Aggregation Matrix

(The assessment criteria described in section 3.3.5.3.2.2 are the basis for this example)

Risk Item Aggregation



Criteria for Significance of Bin Groups

Major concern - acceptance must be justified

Significant concern - review for mitigation

Accept, and track

3.3.6.2 Quantitative Aggregate

Quantitative risk assessment allows numerical aggregation of risk. Each risk aspect of each risk item has a risk magnitude, commonly assessed as the product of the likelihood and the consequence.

3.3.6.2.1 Quantitative Implementation Risk Aggregate

The measure of implementation risk magnitude of a risk item is Arisk cost≅. Risk cost is the combination of the probability of occurrence of a risk and the cost to fix it, in order to be able to get to launch as planned. The **sum** of the risk costs of the risk items is the **aggregate risk cost** for the project. This may be thought of as the expected value of the risk items considered as a set

of random events with the given probabilities of occurrence. If costs are distributed by fiscal year, the risk cost can be defined per fiscal year as well as for the whole project, and these values can be compared to the distribution of budget reserve to determine the level of risk of the project.

It must be remembered that this "risk cost" is assessed on the identified, or known risk. Unknown risk must still be accounted in assessing adequacy of reserves. The success of risk management in a way is the measure of the completeness in identifying extraordinary risks to a project, such that the remaining unknown risk level will be "normal" risk, and may be quantified by experience as a percentage of project cost.

The JPL Risk Management Team provides an EXCEL tool that will calculate this aggregate risk cost and also the probability distribution of risk cost at any confidence level. This provides an estimate of the cost of realized risk that the project could expect not to exceed with any desired probability.

3.3.6.2.2 Quantitative Mission Risk Aggregate

Aggregating Mission Risk depends on the metric used to quantify Mission Risk**. This methodology is still being evaluated for utility**.

A general approach being investigated is to assign a prioritized scale to the specific list of Mission Success criteria. Then each risk item mission risk aspect consequence is assessed as a percent of the mission success lost if the event occurs. By multiplying the likelihood of the event occurring, and the percent loss of mission success, and adding up the results for all mission risk aspects, the result could be interpreted as the expected percent loss of potential total mission success. The mission success criteria (scale) should be established and agreed to with the customer.

3.3.6.3 Role of the Risk Management Team

The JPL Risk Management Team is available to assist the project in accomplishing risk identification and assessment. Some or all of the roles identified below may be applicable.

- Discuss the process with project management and help tailor the process
- Conduct/facilitate/support training or facilitating Workshops
- Provide checklists, risk templates as appropriate. These reference tools will all be available on-line in future version of this capability
- Assist the project personnel in the application of the tools
- Perform probabilistic risk analyses as agreed to and funded by the project

3.3.7 Outputs

The primary **output** of the Risk Identification and Assessment element is the Draft SRL. The draft SRL should be planned to be available such that decision-making can occur and the baseline SRL be agreed-to by PDR.

3.4 Risk Decision-Making

3.4.1 Decision Making Requirements

The requirements from this element are to assemble the risk item and aggregate risk data in order to identify the promising set of mitigation approaches trade-off, to conduct those trade-offs, and to select mitigation approaches for implementation. The last requirement is to update the implementation plan, the reserve profile, and the risk item assessments to correspond to the decisions made. This update list of risks becomes the **Baseline SRL**

In some cases this will result in reserve dollars being allocated to liens against the budget, and corresponding changes to the implementation plan. In other cases, mitigation, down-scoping, or other decision points in the future will be identified and tracked in the SRL.

3.4.2 Inputs

The major **input** to this element is the Draft SRL. Additional inputs include idenitified contingency approaches, specifically descope options.

3.4.3 Risk Decision Making Activities

3.4.3.1 Performing Trade-Offs

The mitigation options identified in the SRL can affect more than one risk item. Thus an inspection of the set of risks will lead to assembling sets of potential risk mitigations, which if exercised will reduce total project risks in different ways. The mitigation costs can be compared to the risk reductions in order to see the cost effectiveness and/or the performance effectiveness of the various options.

Trade-off decision criteria must consider the following:

- balance of risk - minimum of tall tent poles, and minimum of Afat≅
- project view - the impact of the trade-off solution should not be viewed in isolation but in combination with the other required decisions
- bottom line - improvement in the project risk positions, and compatibility with the reserves available

As a result of these assessments, recommendations can be supported to disposition these risks. Disposition could include **accepting** the risks as assessed, **mitigating** the risks immediately (e.g. change the design), and/or identifying mitigation measures for possible implementation at a later date, or even changing the implementation plan to **take additional** risks, for a relatively large potential payoff.

3.4.3.2 Updating the Risk List Based on the Decisions

The decisions to implement mitigations will require budget to be allocated to those new activities. Either work is reallocated from other areas, or budget reserve is committed. In any case, the changes decided upon must be folded into an updated baseline project implementation.

As a result of accepting mitigations, the affected risk items must be reassessed in respect to the changed project baseline, and updated in the SRL. When this is completed and approved, the SRL version becomes the **Baseline SRL**.

3.4.3.3 Developing Contingency Plans

Also as a result of the assessments, plans for responding to future events will include descope approaches to stay within margins or constraints. A Descope Plan may be needed as a result of these decisions. Decisions to implement back-up developments, or institute alternative approaches should be documented as results of the process.

The **Descope Plan** provides the leverage for accepting reasonable risk and maintaining confidence that a meaningful mission is available within the fixed budget even if many of the identified risks are actualized. The plan identifies functional or performance capabilities, which may be dropped at some later point of the project, allowing cost savings to be applied to the area where risks happened. It also describes where risks may be added (through dropping a test, or other activity with resulting cost avoidance) acceptably in order to cover unplanned costs in other areas. Key elements of the descope plan include identifying:

- descope options, with implementation approaches if necessary
- the resulting acceptable **reduced performance or risk position**
- the **schedule milestones** related to the required decisions

- the **budget impact** if the options are exercised at the identified milestones
- the **mission success impact**

Other planning should define contingencies indicated by the risk decisions made. An example is for new technology that has not achieved flight validation.

Finally, a tracking plan and set of metrics required to track the remaining risks needs to be implemented, and the cognizant project elements alerted that metric inputs will be required from them on a specified basis.

3.4.4 Decision-Making Procedure Summary

This decision-making process should include specific approaches for:

- Determining the trade-off options for each risk, and the criteria and constraints applicable to the decisions required
- Evaluating and rating the options relative to the criteria (performing the trade-offs)
- Presenting the recommended approaches to disposing of each risk item to the Project Manager for approval or further direction
- Implementing the approved risk item dispositions, and updating the Draft SRL to the Baseline SRL to reflect the new project baseline.
- Collecting and consolidating the resulting descope decisions and technology alternative actions into the appropriate plans
- Compiling the aggregate project risk position for the new baseline.
- Documenting and requesting the required metrics from the responsible project source.

3.4.5 Outputs

Outputs from this activity include the **Baseline SRL**, which includes the risk ranking modifications/additions resulting from the decisions made, and the aggregate project risk position. Additional outputs include identifying the **tracking metrics** which are needed to keep status on evolving risk items whose potentials were identified in the risk assessments. These metrics include technical, cost and schedule parameters. Further outputs resulting from the decisions made are the contingency plans, which consist of the **Descope Plan**, and the **Technology Alternatives Development Plan**. These plans include milestones for future decisions if necessary to realize the savings from these measures.

Another output which is very important to identify in this activity are any risk management effectiveness metrics, through which the RM methodology applied to the project can be evaluated and improved, both for this project and future applications.

3.5 Risk Tracking

3.5.1 Tracking Requirements

The requirements of this element include periodic re-assessments of the risk items on the Baseline SRL. As the project evolves, risks will be realized or be retired without realization, or be reduced or increased with the increased insight obtained as the life-cycle proceeds. Decisions based on the contingency plans identified in the previous section will need to be made. New risk items will be recognized for which modifications to the SRL will be needed. Status reports and review updates will support overview by the parent program, and the Governing Program Management Council.

3.5.2 Inputs

The **inputs** to this activity include the Baseline SRL, metric reports, and the contingency plans (Descope and Technology Alternatives). Regular reporting from the design processes (technical performance measures (TPMs), design assessments, technology validation status reports, etc) and the administrative processes (Earned value parameters, or other cost and schedule metrics) are used to update the risk assessments. The contingency plans are tracked for milestones at which further evaluation and decisions are required. Risk management effectiveness metrics (costs incurred for realized risks, percent of risk milestones for which mitigation measures were enacted, etc) are provided by the accounting system.

1.1.1 Metrics

Metrics include any aspect of the project technical, cost or schedule implementation that are pertinent to the risk item in question. Typical metrics include the **Technical Performance Metrics (TPMs)** used by Systems Engineering to monitor the quality and status of the designs. These metrics are characterized by:

- an identified commodity (system mass, computer memory, processor throughput, etc)
- a plan for each commodity indicating the absolute resource limit, and the allocated margin versus time in the life-cycle
- a definition of the reporting update frequency vs. time in the life-cycle

Although these metrics may be somewhat specific to the risk items being tracked, in general TPMs such as the following would be needed:

System power margins	System mass margins	Other mass property margins
Control pointing performance	Stability margins	Thermal margins
Data Bandwidth margins	Memory Utilization	Cycle time margins

As an example, if the spacecraft mass is a risk item, regular design reassessments as the design solidifies will indicate total spacecraft mass estimated against an allocated margin. If the actual mass estimate plus uncertainty reflects less margin than allocated, and this negative margin is not resolved, or increases in consecutive estimates, then certain actions (and the expenditure of risk resources) are suggested/required.

Programmatic Metrics are used to track the evolution of schedule and cost-related risk items. Estimated cost to complete, and schedule critical path margin, are examples of applicable metrics. Receivables/Deliverables (Rec/Dels) systems are effective in assessing work falling behind. Earned value metrics allow the WBS and the task planning to be related to budget and schedule. If total program schedule or cost are risk elements, periodic probabilistic analyses on these parameters may be performed.

If needed, or desired, the Risk Management Team will assist projects in performing technical or programmatic risk analyses, using probabilistic analyses tools if needed.

3.5.3 Outputs

This activity provides **outputs** to the project management in the form of Risk Status Reports, and to the other RM elements in the form of risk milestone decision analyses, and new risk item reports. Outputs from Risk Tracking include

- Updated risk assessments
- Updates of the baseline SRL
  - Schedule, Budget Margin Assessment
  - Probability of Mission Success Updates
- Risk Status Reports
  - Frequency
  - Audience
- Recommendations for Decisions

3.6 Risk Management Workshops

Workshops are the vehicles for identifying all participants and their roles, and facilitating their contributions to Risk Management. The workshops should always have a well-defined output as an objective, and a methodology for achieving that output, including homework in preparation for the workshops.

3.6.1 Planning Workshops

The first workshop should involve the core players and should deal with the elements of the RM plan discussed below. Note that the **inputs** are essential to the effective risk management plan. Candidate topics for workshops in the planning element can include:

Topic	Risk Engineer Does	When	Participants Do
Agreed-upon project risk strategy	Distribute project inputs	before	review
	Solicit risk drivers	before	provide
	Identify impacts to project	before	
	Prioritize re success criteria	during	discuss in workshop
	Brainstorm risk approaches	during	contribute
	Collect and organize	after	
	Synthesize project approaches	after	concur

3.6.2 Identification and Assessment Workshop Topics

Candidate output objectives for workshops in the this element can include:

Topic	Risk Engineer Does	When	Participants Do
Candidate risk list	Publish assess. methodology	before	critique
	Solicit risk items and assessments	before	provide
	Review inputs	during	discuss/fix inconsistencies
	Establish update ground-rules		concur
	Publish updated list	after	review/concur

(Note: this may be done twice - once to identify candidate risks via a qualitative ranking scheme, and later to provide the candidate SRL using a quantitative scheme by which project risk cost may be estimated. This quantitative scheme is then used to make decisions within a constrained budget)

3.6.3 Decision-Making Workshop Topics

Candidate output objectives for workshops in the decision-making element can include:

Topic	Risk Engineer Does	When	Participants Do
Establish Decision Trades	Assess candidate SRL items and establish mitigation/ control alternatives	before	review
	Discuss/refine list and		

	establish needed trade-off studies		participate
	Implement trade-off studies	after	participate
Approve Baseline SRL	Update Draft SRL with results of decisions	before	
	Publish Baseline SRL	after	

3.6.4 Role of the JPL RM Team in Workshops

The JPL RM Team is available for coordinating, consulting and/or independent assessment of risk management issues on a project. An initial tutorial for the Project team on what Risk Management is, and how it might be applied is available. Help in installing and using the SRL data base tool and the SRL analysis tool is generally required and helpful. Observing and commenting on team interactions and interpretations of risk data during the meetings are also available. It is very valuable to frequently consult with the Risk Engineer to help that activity and also to learn what is working and what improvement needs to be considered.

3.7 Risk Management Tools

The JPL Risk Management Team has developed and/or acquired tools which facilitate the entering, categorizing, and managing the data which characterize a project's risk items (**SRL Data Entry Tool)**, and another tool which allows quantitative aggregation and analysis of project implementation risk (**SRL Analysis Tool**.) These tools are described below as they currently exist. They are currently under development and paragraph 3.7.3 describes some of the goals for the mature RM Tool suite.

3.7.1 SRL Data Management Tool (DMT)

This tool is a web-based front end tool which provides multiple user access to enter risk data, review risk status and assess the current aggregate qualitative project risk position. It is tailorable to the specific needs of the user in terms of data fields, and the aspects of risk to be assessed (implementation risk, mission risk or both).

DMT Characteristics

- Web-based
- Tailorable data fields - can capture risk item data defined in this handbook and other data as needed.
- Relational data - mitigation options will be related to the risk items for which they are relevant (to be installed)
- Categories identified (related WBS, System element, technology type, etc.) - risks can be sub-aggregated by category

- Risk item status management - risk statistics aggregated on reviewed risks. Draft risks can be entered and updated before review. Retired risks archived. Accepted risks constitute the Baseline SRL. See figure 3.7 for tool flow chart. The risk status levels are described below:

Draft	- Any member of the Project Team can input a risk - Not summarized in project summaries
Review	- Input risk item which has been acknowledged by the project team/ risk engineer as valid and properly described - Can be summarized in the category of risks "in review" or in aggregate with accepted risks
Analyze	- A risk in review which is being assessed in trade-studies and for which decision data are being prepared - Can be summarized in the category of risks "in review" or in aggregate with accepted risks
Accept	- A risk item for which action decisions have been made and the changes in risk assessment have been incorporated - Can be summarized in the category of "accepted" risks or in aggregate with risks "in review"
Reject	- A submitted risk item that is not valid
Retire	- An accepted risk that has been overtaken by events

This tool was developed for the SIRTF Program, is currently hosted on the Office 51 server, and is maintained through the Risk Management Team. Versions have been implemented on Project servers as well, but the maintenance of these is the responsibility of the user Projects.

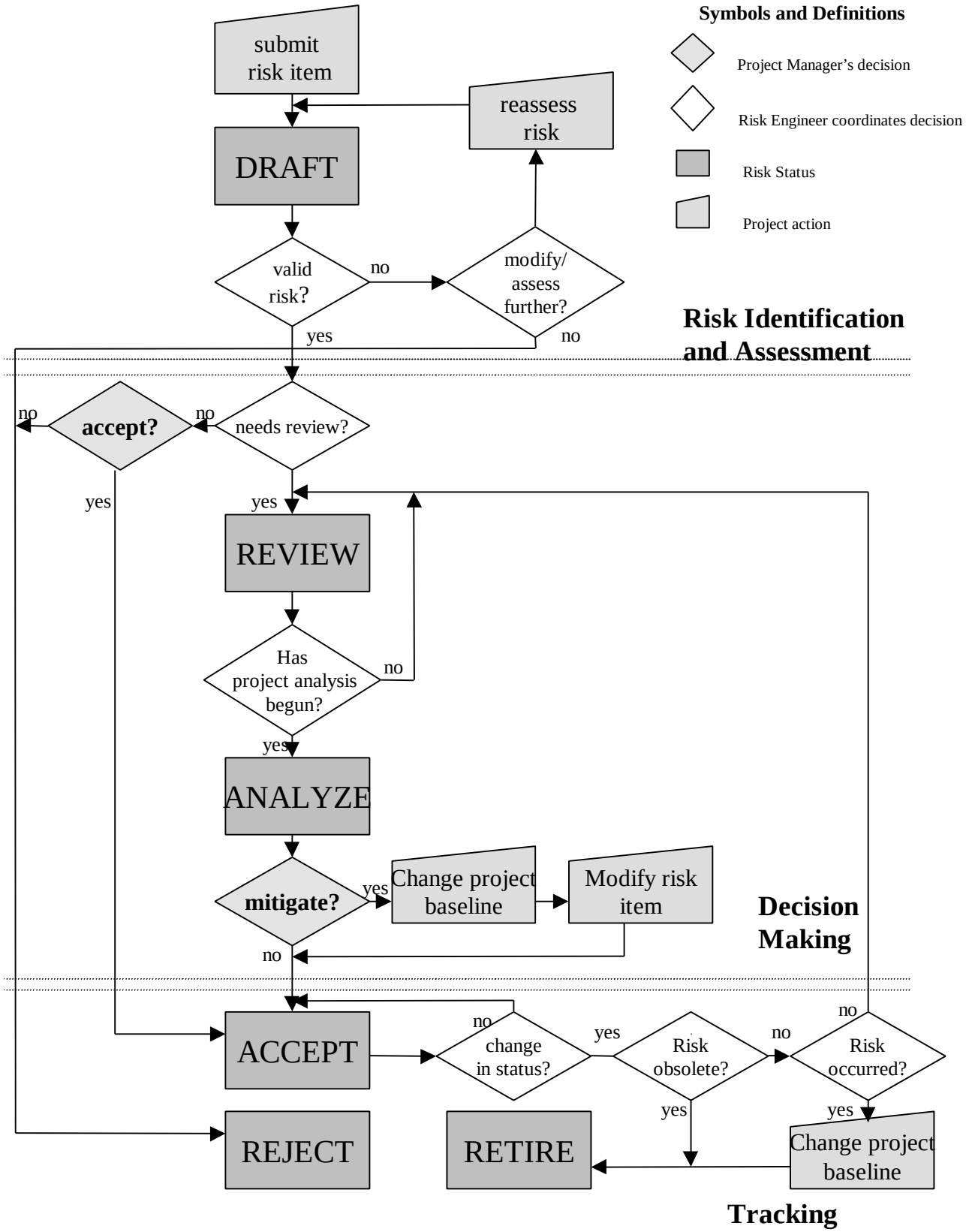
3.7.2 SRL Analysis Tool

This EXCEL Spreadsheet based tool allows for risk item entry, with quantitative estimates of likelihood (probability) of occurrence, and implementation risk consequences (cost to fix) by Fiscal Year if desired. A Monte Carlo program is attached which will run using the probability models represented by the data for each risk item, and produce a cost probability density curve and cumulative probability density curve. These data model the likelihood of cost being within any given range, or the likelihood of the cost exceeding any given value.

3.7.3 Tool Status

Each tool at this time runs independently. Work is in progress to automatically link the tools so that the user can obtain the quantitative assessment using the data base tool user interface. The tools are available from the JPL Risk Management Team.

Figure 3.7 SRL DMT Flow Chart



3.8 Risk Effectiveness Metrics

It is the goal of the Risk Management Process to enable better management of resources, especially budget reserves, by providing comprehensive and effective methodologies and tools to perform the elemental processes of Risk Management as needed for each project. It is desired to identify metrics to allow some estimate of the effectiveness of the Risk Management Process. Each project, along with the Risk Management Team, should identify early in phase A (when the measuring processes tend to be adopted) specific ways of recording budget, schedule and technical decision results throughout the project life-cycle, such that an on-going effectiveness assessment can be made, and an overall assessment made at the end of the project for future modifications of the process.

Candidate metrics include:

- Budget reserve decisions separately identified to compare against risk list assessment
- number of risks realized versus predicted
- percentage of margin utilization for items on the risk list
- $ spent on risk items versus $ predicted

References:

1 JPL Policy, ARisk Management≅
2 NPD 7120.4A, "NASA Policy Directive for Program/Project Management"
3 NPG 7120.5A, "NASA Program and Project Management Processes and Requirements"
4 JPL Document 542-160, AMars Global Surveyor Risk Management Plan≅, September 30, 1994
5 JPL Document 699-015, ACassini Project Risk Management Plan≅, February 28, 1995
6 JPL Document 699-210, ACassini Spacecraft Risk Management Plan≅, June, 1996
7 JPL Document 699-510, ACassini Project Ground System Risk Management Plan≅, 15 September, 1994.
8 JPL D-15473 (SIRTF 674-PM-200), "SIRTF Project Management Plan", January 26, 1998.

Appendix A
JPL D-15951
Risk Management Handbook For
JPL Projects

RISK MANAGEMENT PLAN TEMPLATE

This template contains topics for a Project Risk Management Plan document, based on requirements from NPG7120.5A (indicated by*), and suggested items from the JPL Risk Management and GPMC Processes. It is consistent with the Risk Management Plan section of the SIRTF Project Plan, which was approved by the NASA PMC.

The Risk Management approach for a project should be outlined, discussed and agreed upon by the Project Manager and his/her staff before the plan is written. The RM Handbook for JPL Projects can be used as a source of approaches to stimulate and guide the planning. This plan template can then be tailored to the agreed-upon approach. The General outline can be rearranged as needed to clearly present the tailored plan, and topics can be deleted, modified, or expanded as needed.

Suggested Topics

- Introduction
  - Objectives*
  - Program/Project Success Criteria*
  - Program/Project Risk Drivers*
  - Risk Strategy
  - Satisfying GPMC Requirements (NPG 7120.5A)
- Implementation
  - Responsibilities*
  - Schedules and Milestones*
  - Resources, tools and facility requirements*
- Process Description*
  - Process Flow Chart*
  - Risk Identification and Assessment
    - Methods of identification and categorization
    - Measures for determining likelihood and impact *
    - Aggregating/ Ranking criteria and methods*
    - Other defining identification/ assessment data
  - Risk Decision Making
    - Methods and forums
    - Project mitigation areas available

- •Risk Tracking
  - •Planned utilization of tracking metrics
  - •Risk status reports
- •GPMC Agreements
  - •Include/ point to compliance matrix for NPG 7120.5A for RM compliance
  - •Identify agreed-to list of RM review metrics and reports

•RM Usage in Project Management

- •Consideration of Risk in day-to-day Project Management*
- •Partners', contractors' contributions to Project Risk Management*
- •RM in Project reviews

Expanded Topical Guide

- **Introduction**
  - Objectives

    Two general objectives which can be discussed: 1) Satisfy the requirements of NPG 7120.5A as tailored for this project, and 2) describe the expectations for the selected Risk Management practices in terms of Project usage; e.g. to better understand the mission success sensitivity to project features, to scope the adequacy of the budget reserve, etc.
  - Program/Project Success Criteria

    Summarize or refer elsewhere in the Project Plan to the prioritized, specified success criteria. If necessary, or desirable, describe how these can be compared as a metric for assessing a risk impact to the mission.
  - Program/Project Risk Drivers

    Identify any extraordinary risk features of the project. Use other similar or contemporary projects as "norms" to identify the extreme features that might drive risk. Examples might be that your program has a large dependence on the successful demonstration of a technology, and the uncertainty is larger than the capacity of the schedule to absorb iterative development efforts, or a critical path item has a large cost uncertainty, etc.
  - Risk Strategy

    Based on the risk drivers, the relative priorities of cost control, performance, and perceived technical margins, a risk strategy should be defined which focuses on the achievement of highest priority objectives. This can be discussed as where the balance point is in the balance of risks. A risk averse position has the balance point on the technical side. A risk acceptance position allows some reduction in performance while maintaining control of project resources. A risk-taking position can allow deeper potential performance losses while allowing the possibility of much larger gains, while still managing to an identified budget algorithm.
  - Satisfying GPMC Requirements (NPG 7120.5A)

    Proposed or agreed-to tailoring objectives for the reference document are defined here. The GPMC to which the project will report is identified. Generally the number, kind and life-cycle milestones for the GPMC interactions are identified.

- **Implementation**
  - Responsibilities

    Identify who performs the Risk Management functions by name and/or position. Identify the expectations of the Project team.
  - Schedules and Milestones

    Refer to top level schedules if RM milestones are called out, or provide consistent RM milestones with referenced project schedule. Included should be reviews, assessment milestones, decision points, etc.
  - Resources, tools and facility requirements

What WBS elements fund RM activities? What RM tools are being used? What resources in or outside the project are being provided? How will workshops be used to involve the project team in the activities of RM?

- **Process Description**
  - Process Flow Chart

    Describe overall flow of RM activities. Illustrates in diagram format the flow of activities in the RM elements and between elements. Sample Flow Charts can be found in the MGS and SIRTF Risk Management Plans. These and other sample plans can be found in the JPL RM On-line Guide - References link. URL for the Guide is:

    https://137.78.230.166/rm_index.htm

    Also describe the unique flow of data types and categories of risk, especially if driven by a tool being used.
  - Risk Identification and Assessment
    - Methods of identification and categorization

      What categories of risk are being book-kept? Are you assessing both implementation and mission risk aspects of risk items? What sub-sets/ types of risk are to be aggregated? What checklists/processes are considered for identifying risks? Refer to RM Handbook for both qualitative and quantitative techniques.
    - Measures for determining likelihood and impact

      Describe the measurement scales for measuring likelihood and impact (qualitative or quantitative, continuous or discrete). Identify the criteria for assigning these measures. Refer to the RM handbook for example metrics and scale, and to the RM On-line guide for access to the RM tools and tool descriptions.
    - Aggregating/ Ranking criteria and methods

      How are total project risks to be calculated and described? This should follow from the scales used and the objectives described above. Refer to the RM Handbook for aggregation approaches and the RM tool capabilities to be used. Show sample formats.
    - Other defining identification/ assessment data

      What other data are required to be identified by the risk identifiers? How will the data be used in deciding mitigation actions? Etc.
  - Risk Decision Making
    - Methods and forums

      How will the JPL RM Team be utilized in the process? Will Change Boards, or other similar forums be used to make risk decisions? How will the tools be used to create decision data? How will resource plans be linked to risk management? (e.g. risk cost will be compared to budget reserves, schedule risk will be assessed against schedule uncertainties, etc).

- Project mitigation areas available

  Identify the kinds of mitigation options that may be available - significant scope flexibility, including agreed-to project object descopes, alternative technologies in development, multiple sources for equipment, schedule flexibilities, etc.

- Risk Tracking
  - Planned utilization of tracking metrics

    Describe the sources of metrics available to track risks. How will project produce TPMs?, What programmatic (cost, schedule risk) metrics will be available and how will they be produced?

  - Risk status reports

    What reports are planned, to whom and with what frequency? If partners are included in the project management structure, what reports have they agreed to?

- **GPMC Agreements**
  - Include/ point to compliance matrix for NPG 7120.5A for RM compliance

    Discuss tailored areas (where compliance waivers are being requested)

  - Identify agreed-to list of RM review metrics and reports

    How are risks going to be reported to and statused with the GPMC?

- **RM Usage in Project Management**
  - Consideration of Risk in day-to-day Project Management

    Describe how the project manager intends to use the RM data and process. Is it the single data base for project decisions? Is it integrated with other data (top 10 problem list, fever charts)? Are there related and integrated risk assessment processes like schedule and budget uncertainty assessments, technical assessments like FMECAS, etc which will provide data for the decision?

  - Partners', contractors' contributions to Project Risk Management

    Discuss sharing of data bases, combined or separate risk lists, common or separate criteria, etc.

  - RM in Project reviews

    Discuss how risk will be treated and statused in formal reviews

Appendix B
JPL D-15951
Risk Management Handbook For
JPL Projects

TEMPLATE

RISK MANAGEMENT PLAN FOR PRE-PROJECTS

This template contains topics for a Pre-Project Risk Management planing. Such planning may be required for proposed new projects in a competitive program such as the Discovery program, or in presentations to the appropriate Enterprise advocating a new flight activity. The outline is structured as would be needed to respond to a two-phase proposal, but could be streamlined or integrated as needed.

INITIAL PROPOSAL (STEP 1)

General Guidelines - One-half page

Suggested Topics

Some items should appear in the proposal in other sections, to which the risk aspect discussion may refer: These include:

1. ***Project Success Criteria***
   - ***Minimum Objectives***
   - ***Nominal Objectives***
   - ***Goals***

2. ***Baseline Implementation Approach***
   - ***Mission Concept***
   - ***Trajectory***
   - ***Mission Activity Outline***
   - ***Design Concept***
   - ***Spacecraft design approach***
   - ***Environment***
   - ***New Technology Expectations***

3. ***Project Organizational Approach***
   - ***Participating Organizations and Relationships***

Risk Management Approach

1. ***Highlight Risk Areas -*** *Use Templates/ Checklists (Appendix C)*
   - *Technical*
   - *Cost and Schedule Drivers*
   - *Programmatic Risks*
   - *Operational Risks*

2. *List possible mitigation options*
   - *These are planned activities,* ***but are not in the baseline***
   - *They are future possibilities*
   - ***They mayl need funding identified***
   - *They will need some decision points and criteria*
   - ***They should be accounted in the reserve plan***

3. ***Identify Intention to Apply Risk Management***
   - ***Intention to use a process compatible with NASA NPG7120.5A***

COMMITMENT PROPOSAL (STEP 2)

Typically 2-3 pages of expanded Risk Management Characteristics and Plans. Again, the rest of the proposal must contain sufficient description of the following topics that the Risk Management may refer to that justifies the measures proposed.

1) *Project Objectives and Success Criteria*
2) *Implementation Approach*
   - *Mission*
   - *System Designs*
3) *Programmatic Characteristics*

Risk Management Section

Objectives

1) *Satisfy the requirements of NPG 7120.5A as tailored for this project,*
2) *Identify Risk Management priorities (control cost, control technology risk, etc.)*
3) *Demonstrate sound Risk Management approach*

Program/Project Risk Drivers

Identify unique risk features of the project. Use other similar or contemporary projects as "norms" to identify the extreme features that might drive risk. Examples might be that your program has a large dependence on the successful demonstration of a technology,

and the uncertainty is larger than the capacity of the schedule to absorb iterative development efforts, or a critical path item has a large cost uncertainty, etc.

Risk Strategy

Based on the risk drivers, and the relative priorities of cost control, performance, and perceived technical margins, the risk mitigation approaches should be outlined.

Satisfying GPMC Requirements (NPG 7120.5A)

Describe how this flight project is bound to the rules of NPG 7120.5A. Proposed tailoring objectives are defined here..

Implementation

Identify who performs the Risk Management functions by name and/or position. Identify the expectations of the Project team, and major milestones in assessing, mitigating and reporting risk status.

Process To Be Used

Use a Simplified flow chart to describe overall flow of RM activities. Sample Flow Charts can be found in the MGS and SIRTF Risk Management Plans. These and other sample plans can be found in the JPL RM On-line Guide - References link. URL for the Guide is:

https://137.78.230.166/rm_index.htm

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Risk Identification and Assessment Methodology

What categories of risk are being book-kept? Are you assessing both implementation and mission risk aspects of risk items?

Describe the measurement scales for measuring likelihood and impact (qualitative or quantitative, continuous or discrete). Refer to the RM handbook for example metrics and scale, and to the RM On-line guide for access to the RM tools and tool descriptions.

How are total project risks to be calculated and described? This should follow from the scales used and the objectives described above. Refer to the RM Handbook for aggregation approaches and the RM tool capabilities to be used

RM Usage in Project Management

Describe how the project manager intends to use the RM data and process

Discuss sharing of data bases with Industrial partners, combined or separate risk lists, common or separate criteria, etc.

Discuss how risk will be treated and statused in formal reviews

Appendix C
JPL D-15951
Risk Management Handbook For
JPL Projects

TEMPLATE
RISK IDENTIFICATION CHECKLIST

Risk Categories

Potential Risk Areas

Technical	Cost	Schedule	Programmatic	Supportability
Environment	Margins	Slack	Personnel	Operability
Physical Constraints	Procurement costs	Critical paths	Parts availability	Sensitivity to operator errors
Requirements	Modeling confidence	Estimating confidence	Contractor Stability	Repairqbility
Interfaces	Overhead	Degree of concurrency	Partnerships	Criticality of Commanding
Manufacturing	Inflation		Security	Facility conflicts
Avionics			Communications	Level of Sparing
Data/ Information handling			Multiple Customers	Transportability
Safety			International	Testability
Testing			Multi-Center	Training
Modeling			Multi-Agency	
Existing Design			Funds Availability	
Unproven Technology			Regulatory changes	
Complexity			Political	
Mission duration			Facility Availability	
Software				
Operations				