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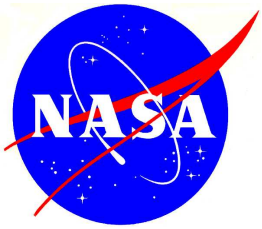
Global Precipitation Measurement (GPM)

Project Risk Management Plan

October 8, 2002



National Aeronautics and
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October 2002

Global Precipitation Measurement (GPM)

Project Risk Management Plan

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Global Precipitation Measurement (GPM)
Project Risk Management Plan

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1. INTRODUCTION

The Global Precipitation Measurement (GPM) mission is not a typical single-spacecraft, Earth Science mission in that it is composed of a non-traditional constellation of satellites, as well as several ground elements. These ground elements encompass the mission operations and data delivery services, as well as the ground validation and calibration sites, data processing, and other terrestrial science data sources. The configuration of this system will evolve over time with new constellation missions and precipitation data sources contributing data streams, while others reach the end of mission life, no longer contributing to the global precipitation data. GPM is a complex system of systems, space-based and terrestrial, but is focused on being a low risk mission, especially with respect to technology implementation.

NASA GSFC has embraced a continuous risk management philosophy and has placed expectations on projects to incorporate this practice in all elements and across their entire life cycle. The risk management approach contained in this document is based upon the Continuous Risk Management Practices defined by the Software Assurance Technology Center at NASA GSFC and is consistent with NASA NPG 7120.5A, NASA Program and Project Management Processes and Requirements and NPG 8000.4, Risk Management Procedures and Guidelines. Figure 1-1 shows the basic Continuous Risk Management process utilized.

Figure 1-1. Continuous Risk Management Process

NASA's Continuous Risk Management Practices have historically been applied to single spacecraft missions, which differs somewhat from the unique multi-element system of which GPM is composed. The risk management approach has been tailored to GPM to best fulfill the project's risk and problem management needs. GPM has developed a custom risk escalation process that fits the needs of the various project elements. The process is unique in that it places responsibility for risks and their disposition in the hands of the organizational level in which it impacts, while still communicating these risks up through project management. This process is described in Section 4.5 in detail. Given the multi-element and potentially dynamic nature of GPM, certain risks may not be resolved as portions of the system are transitioned to operations (e.g., various ground system components will come on-line prior to the launch of the Core spacecraft). All flight system risks will be dispositioned upon launch and any residual risks on the ground elements will be prepared for the Flight Readiness Review.

The purpose of the GPM Risk Management Plan is to provide a guideline for the GPM Project to identify, analyze, monitor, and control all levels of project risks. GPM Risk Management is

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integrated into the GPM Systems Engineering and Management Processes with the objective of incorporating Risk Management into the daily activities of the project and staff. All GPM staff members are encouraged to participate in risk management by identifying risks. Responsibility for the risks will also belong to GPM staff members. The GPM Risk Management Tools are integrated into SLATE (System Level Automation Tool for Enterprises), which includes capturing risks, problems, decisions, anomalies, and failures.

The GPM Risk Manager is integral to the success of GPM Risk Management. The Risk Manager provides a unique intersection of engineering and programmatic risk management support. Programmatically, the Risk Manager maintains ownership of this risk management process and is responsible for its overall implementation. He establishes the means for risk communication and reporting and oversees and maintains the SLATE risk database. The Risk Manager also plays an important engineering role in the GPM project. He actively participates in and across the element and mission teams to assist in and perform risk identification and analysis.

The Risk Management Process will continue to evolve as the GPM project matures. For example, the Formulation/Project Manager and Mission Systems Engineer will be involved in detailed risk management activities early in formulation. As the Element Teams grow, much of the detailed Risk Management will be handled at the Element Level and lower. The same basic risk management approach will be utilized, but the responsibilities and communication mechanisms will evolve. Risk ownership and responsibility will belong to the appropriate members of the team who assess the risks and ensure that the appropriate actions are taken.

1.1. APPLICABLE DOCUMENTS

Formulation Authorization Document for the Global Precipitation Measurement, Draft Revision 8, November 9, 2001

Global Precipitation Measurement (GPM) Project Formulation Plan, 420-10-01, November 15, 2001

NASA Program and Project Management Processes and Requirements, NPG 7120.5A, NASA Procedures and Guidelines, April 3, 1998

Risk Management Procedures and Guidelines, NPG 800.4, NASA Procedures and Guidelines, April 25, 2002

NASA Safety Manual, NPG 8715.3, NASA Procedures and Guidelines, January 24, 2000

GSFC Project Formulation, 700-PG-7120.2.2A, NASA Procedures and Guidelines, August 6, 1999

Risk Management, GPG 7120.4, Goddard Procedures and Guidelines, December 7, 2001

Systems Engineering, GPG TBD, Goddard Procedures and Guidelines, TBD

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GPM Systems Engineering Management Plan, GSFC 420.2-02-001-01, Original, February 1, 2002

Earth Observing Systems & Earth Explorers Programs Risk Management Plan, Draft

Continuous Risk Management, Revision 6, Software Assurance Technology Center (SATC), June 2001

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2. GPM RISK AND PROBLEM MANAGEMENT PROCESS OVERVIEW

GPM utilizes a Continuous Risk Management approach that considers risk management as well as problem management and escalation.

2.1. TERMS AND DEFINITIONS

A **risk** is defined as an event that may occur that will have a negative impact on the GPM Project objectives if it occurs. A risk has three components which factor into the severity of the risk:

1. A probability of the event occurringAn impact on the project resulting in a negative consequenceA timeframe in which action must be taken.

A risk is deemed a **Primary Risk** if the risk severity is determined to be High per Section 4.4.

A **problem** is also an event that has a negative impact on GPM project objectives, but a problem has a 100% certainty of occurrence.

The **Risk Identifier** is the person (most likely a GPM staff member) who first identifies and documents the risk.

The **Risk Owner** is the GPM staff member assigned to and responsible for analyzing, tracking, or mitigating an identified risk. The risk owner must have the appropriate knowledge, experience, and area of responsibility within the project to fully address the risk.

Risks can be identified and analyzed for impact at five **Assembly Levels** within the GPM Organization. Figure 2-1 illustrates those hierarchical levels and their associated scope. The table provides guidance to the element managers who are responsible for defining the assembly level responsibilities within their organization. Team members at each level are responsible for assessing risk impact as they apply to that person's realm of control within the hierarchy.

Level	Impact Scope
Mission	Risks are assessed for their impact to overall GPM Project success
Element	Risks are assessed for this impact on the ability of that particular element to achieve its operational or scientific objectives
Subsystem	Risks are assessed for their impact to the performance of that subsystem
Component	Risks are assessed for their impact to the functional effectiveness of that particular component. Examples include the spacecraft Box level or software program level
Subcomponent	Risks are assessed for their impact to the function performance of that particular subcomponent. Example includes the spacecraft card level or software module level.

Figure 2-1. Assembly Levels

Risk escalation is the process of characterizing the impacts of a risk at the appropriate GPM assembly level beyond where the risk is identified. Risk Escalation does not automatically result in a change of ownership or responsibility for the risk. Responsibility remains with the assigned risk owner throughout any needed escalation unless the higher level manager deems it necessary to reassign the risk to a new owner at a higher assembly level.

Risk notification is the process of communicating a risk to the team but does not require detailed analysis beyond that of the original assembly level.

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Risk disposition is the process of deeming a risk closed, acceptable, or out of scope, including the appropriate rationale when necessary.

2.2. RISK MANAGEMENT PROCESS

The Risk Management Process set forth in this document is illustrated in Figure 2-3 and consists of five steps:

- Risk Identification
- Risk Analysis
- Risk Planning
- Risk Tracking and Control
- Risk Communication and Documentation.

As risks are analyzed and addressed throughout the Risk Management Process, they are assigned a risk status within the SLATE risk database at the various stages per Figure 2-2. The risk status is intended to facilitate the review and reporting of GPM Risks.

Risk Status	Activities Performed During This Risk Status
New	• Identify and enter risk into the SLATE risk database
Open	• Perform risk severity assessment and escalate risk as necessary • Identify risk approach and owner
Tracking	• Monitor and review risk regularly • Implement mitigation and contingency plans as required
Closed	• Risk dispositioned (i.e. deemed resolved or allocated to a new risk, risk assessed to have zero impact or probability) • Close risk in the SLATE risk database • Enter lessons learned into the SLATE risk database
Out of Scope	• Risk not within the scope of the project • No actions performed

Figure 2-2. Risk Status Options

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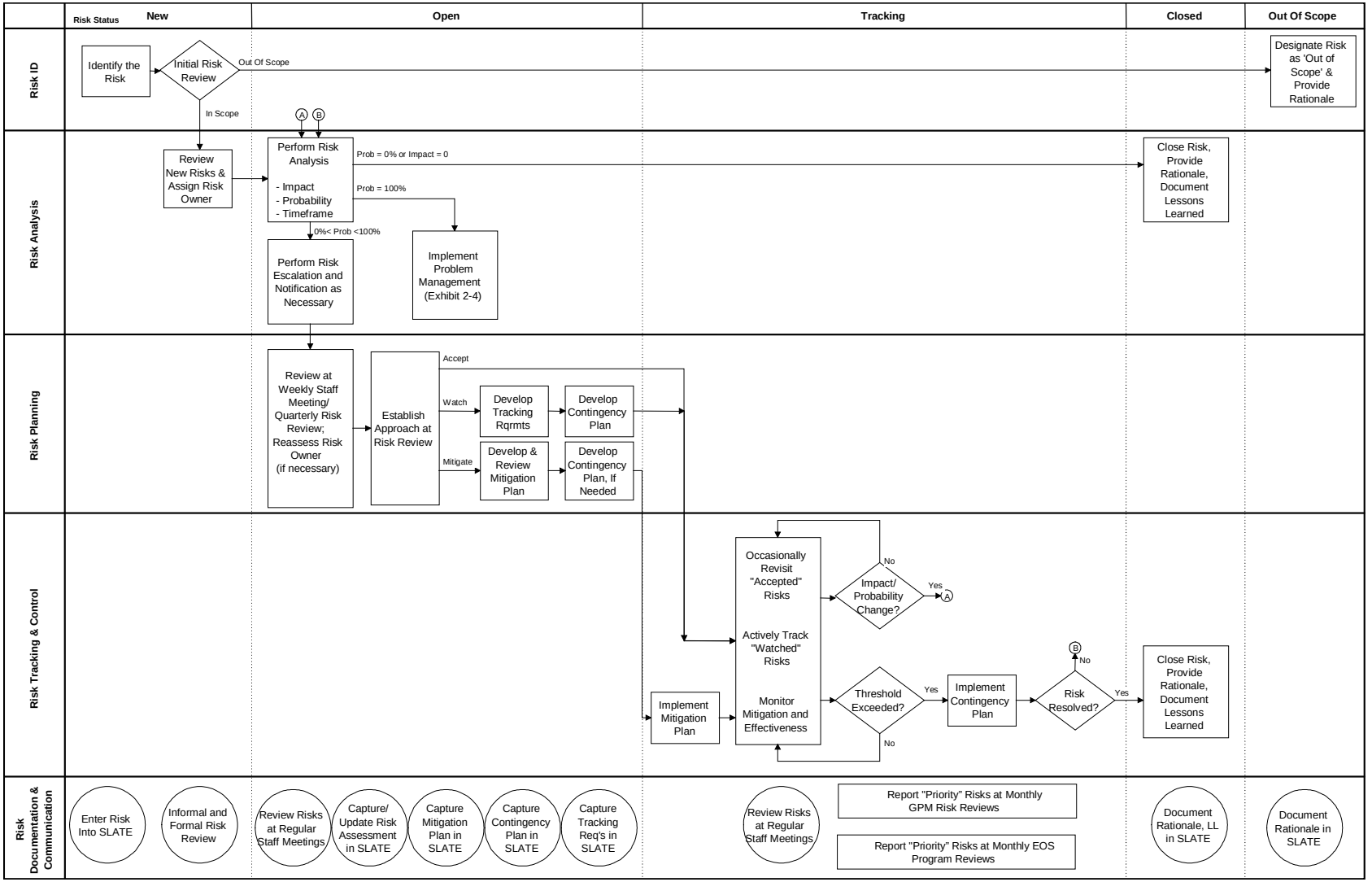

Figure 2-3. GPM Risk Management Process

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2.3. PROBLEM MANAGEMENT AND ESCALATION

Problem Management and Risk Management occupy slightly different areas in the spectrum of program management activities, similar to fire fighting and fire prevention in the world of fire protection. However, the GPM program is handling each under the same umbrella since the SLATE tool will be used for documenting and tracking risks and problems, with both processes having the potential to populate the program "lessons learned."

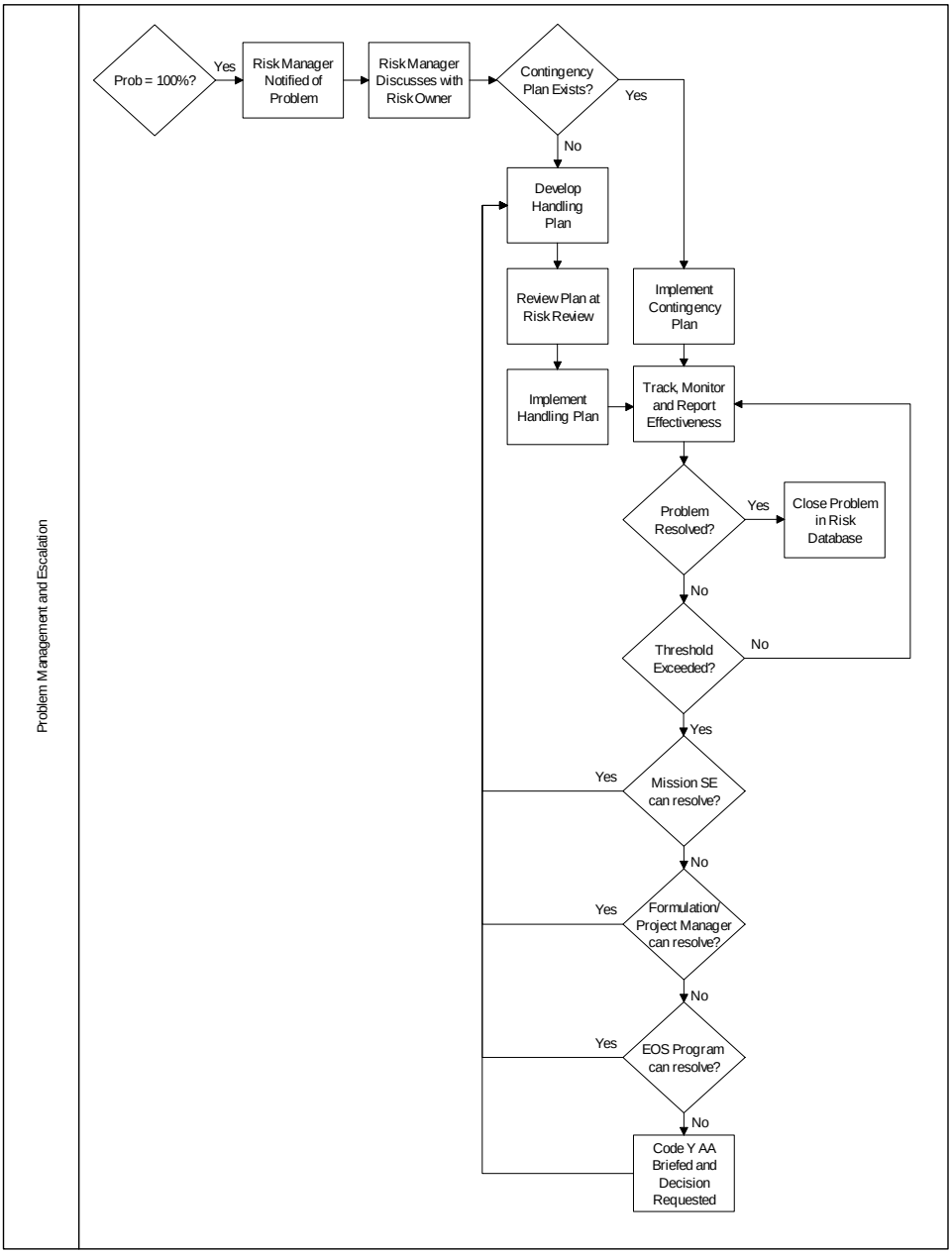

Figure 2-4. GPM Problem Management and Escalation Process

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As previously stated, a problem is defined as a risk with a probability of occurrence of 100%. Note that “anticipated problems,” such as software trouble reports or integration test findings/failures, will be handled under their own resolution systems. Problem Management in this context is reserved for those risk items that manifest themselves or for unforeseen budget, schedule, or technical issues that arise without warning and threaten program success (e.g., a mid-fiscal year budget reduction).

The Problem Management and Escalation process is illustrated in Figure 2-4. Once a risk becomes a problem, the contingency plan for that risk is implemented. If a contingency plan does not exist, a problem handling plan is developed and implemented. Problems are escalated, as needed, by the risk/problem owner if the contingency or handling plan does not adequately mitigate the problem.

2.4. ROLES AND RESPONSIBILITIES

Program risk management is a responsibility shared by the GPM Formulation/Project Manager, Risk Manager, and Project Staff. Specific roles and responsibilities are explained in Figure 2-5.

2.5. ALLOCATION OF RISK MANAGEMENT RESOURCES

Resources for risk management activities have been included in the GPM budget. The project also maintains a contingency budget to accommodate special circumstance that may arise, which may include mitigation of risks if needed. Each Element Manager is responsible for managing the mitigation budget for their respective elements. Any requests for additional mitigation resources must be made to the Project Manager.

Resources spent to address any given risk will depend on the attributes of that risk. Risks that have a high severity assessment are more likely to receive resources; however, other factors such as cost / benefit assessment of feasible mitigation activities, required timeframe for mitigation activities and programmatic factors (e.g., ability to influence international partner activity) will also play a large part in resource allocation. Ultimately, the GPM manager(s) responsible for any given risk will need to make risk resource decisions on a case-by-case basis.

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Role	Responsibility
GPM Formulation/ Project Manager	• Responsible for overall project risk management • Ultimate Project Authority for risk definition, planning, monitoring, control, and resolution • Reviews escalated risks brought forth from the GPM Mission Systems Engineer, Element Managers, Business Manager, and other GPM Staff • Assists in and performs risk identification and analysis for Mission Level risks especially programmatic, schedule, and cost risks • Escalates risks to the EOS Program or Code Y if necessary
GPM Mission Systems Engineer	• Responsible for all technical Mission Level risks • Reviews and/or analyzes escalated risks brought forth from the Element Systems Engineers (SE) • Assists in and performs risk identification and analysis for Mission Level risks especially technical/performance and safety risks • Escalates risks to the GPM Formulation/Project Manager to evaluate if necessary
GPM Risk Manager	• Responsible for ensuring that all Assembly Levels are following the Risk Management Process • Manage and oversees the SLATE risk database • Coordinates and leads the quarterly project risk meetings • Regularly reports any risk issues to the Mission SE • Facilitates the development and implementation of Risk Mitigation Plans • Performs or assists team in performance of Risk Analysis • Performs special risk trade studies and engineering analyses
GPM Element Managers	• Responsible for ensuring that the Subsystem, Component, and Sub-Component Assembly Levels are following the Risk Management Process • Define risk management responsibilities and risk impact definitions within their element • Review and/or analyze risks escalated from the Subsystem Level • Responsible for identifying and analyzing Element Level risks for their respective element • Escalate risks, as necessary, to the Mission SE and/or Formulation/Project Manager
GPM Project Staff	• Responsible for identifying and analyzing risks at their respective levels • Escalate the risks to the appropriate Assembly Levels
GPM Customers and Suppliers	• Recommend/Identify new risks to be analyzed and addressed • Provide input and insight into the identified risks as pertaining to their involvement with GPM • Risk management requirements may be levied on suppliers on a case-by-case basis based on scope of work and level of involvement with the project
External Reviewers and Assessors	• Invited to attend the quarterly project risk reviews • Provide input and insight into the identified risks being reviewed • Recommend/Identify new risks to be analyzed and addressed

Figure 2-5. Risk Management Roles and Responsibilities

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3. RISK IDENTIFICATION

The first step in the Risk Management Process, as outlined in Figure 2-3, is to identify potential risks. An environment of continuous risk identification will begin early in the GPM formulation phase to enable both appropriate risk planning as well as responsive engineering design.

Risk identification can be initiated in several ways. Lessons learned from previous projects and experiences can provide valuable insights for identifying potential risks. Analysis of requirements development may also provide insight into risks. The following is a list of methods or sources that may assist in the identification of risks:

- Failure Mode, Effects, and Criticality Analysis (FMECA)
- Reliability analysis
- Fault Tree Analysis
- Trade studies
- GPM Project Staff
- External Reviewers/Assessors
- Project and Element Team Meetings

All GPM staff members participate in the Risk Management Process and are encouraged to complete a Risk Input Form in the SLATE risk database for any risks that are identified. All GPM staff members should be trained in NASA Continuous Risk Management (CRM), which is taught by the Systems Management Office, NASA Goddard Space Flight Center. This training will assist in educating the GPM project staff to understand why risks need to be identified early and how to properly identify risks and formulate risk statements.

Once a risk has been identified, the Risk Identifier completes a Risk Input Form as shown in Appendix A. A title and risk statement is created for each new risk that is identified. The Risk Identifier should attempt to complete the form as completely as practical by providing as much information about the risk as possible, including the condition and consequences, the context of the risk (e.g. what, when, where, why, and how), any technical insight, and suggested contingencies or mitigations. The Risk Identifier should review the risk with the Assembly Level lead/team or the Risk Manager, if necessary, to verify that the risk is within the scope of the project.

All newly identified risks are submitted into the SLATE risk database and given a status of New. A project risk list can be reported from SLATE at any time. Section 7.4 provides a summary of risk reports that can be created using SLATE, including overall project risk list as well element specific lists.

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4. RISK ANALYSIS

Following identification of a candidate risk, a Risk Owner is initially assigned to the risk based on knowledge of the risk subject, relevant experience, and area of responsibility within GPM. Assignment of a Risk Owner must be approved by the relevant Assembly Level Manager, and, if needed, by the Mission Systems Engineer or Formulation/Project Manager depending upon the level of risk impact. The Risk Owner, in consultation with the Risk Manager and other relevant GPM staff members, performs an analysis of risk impact, probability, and timeframe to determine the priority and severity as related to their respective Assembly Level. The Risk Owner uses the SLATE risk database to calculate the risk severity as well as to note any additional useful information known or identified when the risk was initially reviewed. The Assembly Level Lead and the Risk Manager should provide guidance to the Risk Owner throughout the analysis process if needed. The risk status is designated as Open throughout the risk analysis.

The Risk Owner is responsible for maintaining the input form and database entry for the respective risk throughout the analysis process. If needed, the Risk Owner should make any appropriate changes or modifications to the Risk Statement. The context of the risk should be updated as needed throughout the analysis process. The context of the risk should include the primary causes and contributors to the risk, any actions that may have been previously taken by the project to reduce or control the risk, and potential consequences should the undesired event occur. Consequences may include significant cost impacts, significant schedule impacts, and potential impacts to other elements or architecture levels.

If a risk is escalated, the Risk Owner should work with the higher level Assembly to ensure that the proper inputs and changes are made to the Risk Form. [Note that during the escalation process, a higher level manager may assume closure authority for the risk and may also elect to reassign risk ownership (see Section 4.5), if it is deemed out of the realm of the original Risk Owner's control.] The Risk Owner should also capture any 'Lessons Learned' throughout the life of the risk.

4.1. IMPACT ASSESSMENT

4.1.1. Impact Categories

To help assess the impact of a risk, several Impact Categories have been identified. Figure 4-1 lists the Impact Categories and example indicators. The indicators are meant to provide guidance to the Risk Owner in assessing the risk impact for each category.

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Impact Category	Example Indicators
Technical/Performance	Mass
	Physical Dimensions
	Memory Utilization
	Power Requirements
	Design Maturity
	Failure Rate Does Not Support Design Life
	Design Complexity
	Environmental Conditions
Programmatic	Technical Type that is not GPM Project Responsibility
	Schedule Type that is not GPM Project Responsibility
	Cost Type that is not GPM Project Responsibility
	Level 1 Requirements Drivers
	NASA Constraints
	Partner Contributions/Shortfalls
	Budget Restrictions from HQ
	Resource Adequacy/Availability
Schedule	Component Availability
	Launch Windows
	Instrument Delivery Schedules
	Development Schedule
Cost	Actual Cost Beyond Budget Allocation
	Replacement Impacts due to Cost (e.g., alternate LV)
	Independent Cost Estimate Inputs
Safety	Personnel Related Safety (e.g., electrical shock)
	Environmental considerations (e.g., the use of such materials as beryllium, volatile fuels, or water contaminates)

Figure 4-1. Impact Categories and Indicators

4.1.2. Impact Definitions

An impact rating is determined for each Impact Category based on the predefined impact definitions. Impact definitions are specific to each Assembly Level. Figure 4-2 provides the impact definitions for the Mission Level, which have been assigned by the GPM Project Office. Figure 4-3 provides impact definitions for the mission elements. Impact definitions for Assembly Levels below the Element Level are also the responsibility of the Element SEs. The Element SEs utilize their team's expertise at each Assembly Level to provide the appropriate impact definitions. The Risk Manager will provide guidance to the Element SEs to ensure that the definitions are documented and are consistent with the GPM Risk Management approach. The Risk Owner determines the Impact Rating for each impact category. The Impact Category with the highest Impact Rating is then entered in the Risk Input Form or updated in the SLATE risk database.

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Impact Rating	Technical / Performance	Programmatic	Schedule	Cost	Safety
A	Minimal Performance Margin Reduction; Exceeds Level 1 Req.	Requires GPM Element Manager Decision	Minimal or none	Minimal or none	Meets Safety Requirements
B	Some Performance Margin reduction; Exceeds Level 1 Req.	Requires GPM Formulation/ Project Manager Notification	Additional resources required to meet need date	< 5% of affected Element	Negligible, No Adverse Affect to Personal Safety or Health
C	Significant Performance Margin Reduction; One or More Level 1 Req Barely Met	Requires GPM Formulation/ Project Manager Decision	Minor slip in need date	5 to 7% of affected Element	Moderate, May Cause Minor Injury or Occupational Illness
D	Fails to meet a Level 2 Req., Level 1 Req. Met	Requires EOS Program Office & GSFC PMC Decision	Major slip in key milestone	7 to 10% of affected Element	Critical, May Cause Severe Injury or Occupational Illness
E	Fails to Meet a Level 1 Req	Requires NASA Associate Administrator Decision	Unrecoverable project delay	>10% of affected Element	Catastrophic, May Cause Death or Permanently Disabling Injury

Note: These definitions are for the establishment of impact level only and do not preclude or redefine standard reporting/reviews of cost, schedule, performance, or safety status and issues.

Figure 4-2. Mission Level Impact Definitions

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Impact Rating	Technical / Performance	Programmatic	Schedule	Cost	Safety
A	Minimal Performance Margin Reduction; Exceeds Level 2 Req.	Requires Subsystem Manager Decision	Minimal or none	Minimal or none	Meets Safety Requirements
B	Some Performance. Margin reduction; Exceeds Level 2 Req.	Requires GPM Element Manager Notification	Additional resources required to meet need date	< 5% of affected subsystem	Negligible, No Adverse Affect to Personal Safety or Health
C	Significant Performance Margin Reduction; One or More Level 2 Req Barely Met	Requires GPM Formulation/ Element Manager Decision	Minor slip in need date	5 to 7% subsystem	Moderate, May Cause Minor Injury or Occupational Illness
D	Fails to meet a Level 3 Req., Level 2 Req. Met	Requires GPM Formulation/ Project Manager Decision	Major slip in key milestone	7 to 10% subsystem	Critical, May Cause Severe Injury or Occupational Illness
E	Fails to Meet a Level 2 Req	Requires GPM Formulation/ Project Manager Decision	Unrecoverable project delay	>10% subsystem	Catastrophic, May Cause Death or Permanently Disabling Injury

Note: These definitions are for the establishment of impact level only and do not preclude or redefine standard reporting/reviews of cost, schedule, performance, or safety status and issues.

Figure 4-3. Element Level Impact Definitions

4.2. PROBABILITY ASSESSMENT

A probability of risk occurrence must also be determined to define the overall risk severity. Figure 4-4 provides the probability rating definitions. Note that the definitions of probability of occurrence for safety vary from the other Impact Categories (per the NASA Safety Manual, NPG 8715.3). The probability is determined through analysis, experience, knowledge of the risk, and understanding of how the risk fits into the Assembly Level and project as a whole. The determined probability rating is specified in the Risk Input Form or updated in the SLATE database. If the probability of occurrence is 0%, then the risk is considered Closed and is designated as such. For any risks deemed closed, rationale and justification for the designation is required and is entered into input form or the SLATE database. If the probability is 100%, then the risk has become a problem and the problem management process is implemented; otherwise, the risk continues through the risk analysis process.

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Probability Rating	Probability of Occurrence	Safety Probability of Occurrence
A	0-20%	$10^{-6} \geq P$
B	21-40%	$10^{-3} \geq P > 10^{-6}$
C	41-60%	$10^{-2} \geq P > 10^{-3}$
D	61-80%	$10^{-1} \geq P > 10^{-2}$
E	81-100%	$P > 10^{-1}$

Figure 4-4. Probability Rating Definitions

4.3. TIMEFRAME ASSESSMENT

A timeframe in which actions need to be taken for the risk needs to be determined. It is anticipated that most timeframe selections will be anchored to one of the key project milestones (e.g., PDR, CDR, Launch). The selected timeframe is not accounted for in the risk prioritization rating calculation but is considered when performing risk planning and better enables management to focus on actions required in the immediate future. The timeframe is entered into the Risk Input Form or updated in the SLATE Risk Database as a date code.

4.4. RISK PRIORITIZATION AND SEVERITY ASSESSMENT

Using the impact and probability ratings, a risk prioritization rating is automatically determined in the SLATE database according to Figure 4-5. This rating then maps to Risk Severity listed in Figure 4-6. The Risk Owner then begins the notification and escalation process set forth in Section 4.5.

		Impact Level				
		A	B	C	D	E
Probability of Occurrence	E	5	10	15	20	25
	D	4	8	12	16	20
	C	3	6	9	12	15
	B	2	4	6	8	10
	A	1	2	3	4	5

Figure 4-5. Risk Prioritization Table

Severity Level	Definition
High	Impact * Probability ≥ 15
Medium	14 ≥ Impact * Probability ≥ 4
Low	3 ≥ Impact * Probability ≥ 1

Figure 4-6. Risk Severity Definitions

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4.5. RISK ANALYSIS NOTIFICATION AND ESCALATION

4.5.1. Notification and Escalation Philosophy

GPM has adopted the philosophy that once risks are assessed at the level at which they are identified, some will need to be communicated up through the GPM organization to ensure that they are handled at the appropriate management level. The expectation is that this method will allow risks to be addressed at the GPM organization level that will best understand the risk's severity and will be most able to handle its mitigation and determine the point of appropriate closure. This will allow for effective risk management while not diluting any manager's risk list with items that will be addressed elsewhere in the organization, are of low severity, or are not a risk to their respective element or assembly level.

Primary risks (high severity) are required to be escalated to the next higher level of the organization (e.g., from component manager to sub-system manager), where the risk is re-assessed and the higher level of management has the option to assume the closure authority for the risk. If the risk again has a high severity it is re-escalated to the next higher level. High risks at the Mission (i.e., GPM Project Manager) level are briefed to the next higher level, but re-assessment is not required at the Program level.

Risks that are assessed to have a Medium Severity must be briefed to the next level of management to ensure that the risks receive appropriate visibility and to provide management at that level with the option to assume closure authority for the risk and/or escalate the risk further (at their discretion). In addition, any Low Severity risks that the originator either believes has an impact on other GPM Elements or Assembly Levels (e.g., a component schedule slip that would impact an overall sub-system integration schedule) or requires urgent action (i.e., see Section 4.3) should be briefed to the next higher Assembly Level management. Closure authority for Low Severity risks will remain at the level last assessed regardless of whether they are briefed to a higher level of management.

[Note that for purposes of being assigned closure authority, the Mission System Engineer and System Assurance Manager may each be considered an "Assembly Level."]

4.5.2. Notification and Escalation Process

With the Risk Severity determined, the Risk Owner begins the risk analysis notification and escalation process. Figure 4-7 contains the Risk Notification and Escalation Rules, which explain the actions that need to be taken given a Risk Severity. Risk escalation is necessary to characterize the impacts of a risk at the appropriate GPM assembly level, beyond where the risk is identified.

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Severity Level	Notification and Escalation Rules
High	▪ Escalation of the risk to the next higher Assembly Level is required. ▪ The manager at the next higher assembly level has the option to assume closure authority for this risk. ▪ Once escalated, the Risk Owner and Risk Manager work with the Assembly Level team to re-assess the risk impact and probability as related to that level ▪ As long as the severity remains high, the risk continues to be escalated to the next higher assembly level. ▪ The Risk Owner is responsible for following the risk through the complete escalation process.
Medium	▪ Notification and discussion of the risk to the Assembly Level Manager at the next higher level is required. ▪ The next higher layer of management has the option to assume closure authority (to be decided at the point when the risk is first briefed up to that level). ▪ Escalation and detailed analysis at that level is not required unless deemed so within team discussions. ▪ If reassessment of the risk is necessary, the impact and probability should be evaluated to accurately represent severity at the respective assembly level.
Low	▪ Escalation or notification of the risk to the next higher level is not required. ▪ Closure authority for the risk remains at this layer of management.

Figure 4-7. Risk Notification and Escalation Rules

Risk escalation does not imply a change in risk ownership, but if the risk is deemed out of the realm of the original owner, a new risk owner can be identified to better address the risk. The process is structured such that the notification and escalation process highlights those risks that are of greater significance to higher levels within the organization, to ensure appropriate action is taken.

Figure 4-8 illustrates one example of the how the GPM Risk Management Database facilitates this escalation process. This simple example shows a risk that was identified by an engineer at the Card Level. This particular engineer was assigned as the Risk Owner and assessed the impact of the risk to be High to his card development. As this risk was a High Severity Level, the engineer escalated the risk to the responsible engineer or manager at the Box Level. That individual coordinated with the Risk Owner and assessed the impact of the risk at the Box Level, which automatically calculates a Box Level Severity. In this case, that Severity Level was also High. Again, as this risk was a High Severity Level, the risk is escalated to the responsible engineer or manager at the Subsystem Level. The impact of the risk is also assessed at the Subsystem Level, which automatically calculates a Subsystem Level Severity. In this case, that Severity Level was Medium. The Subsystem Manager notifies the Element Manager of the risk, and they determine that reassessment is desirable. The reassessment shows that it is a low severity risk at the Element level and no further escalation is required.

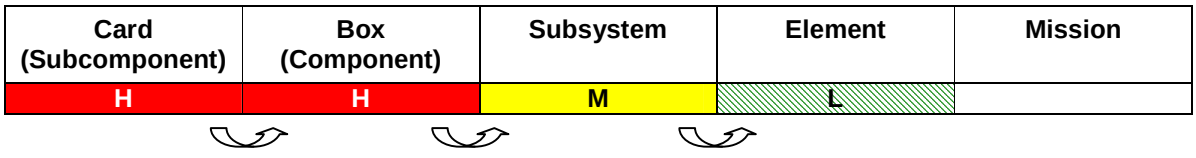

Figure 4-8. GPM Risk Escalation Example

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5. RISK PLANNING

Once the appropriate levels of risk analyses and escalation are complete, risk planning occurs to develop an approach (per Figure 5-1) to appropriately handle the risk. This approach is developed by the Risk Owner in consultation with other GPM staff, as necessary. The Risk Owner and Risk Manager present the risk and recommended approach to the team for input and concurrence. The response option and determined approach are captured in the Risk Input Form or are updated in the SLATE Database by the Risk Owner. If a contingency plan is developed for the selected response option, a summary of the contingency plan and any determined metrics that are established to initiate the implementation of the contingency plan should be included in the Risk Input Form or updated in the SLATE database.

The Risk Owner is then responsible for seeing that the response option actions are implemented and for following/managing the risk. If a response option is not specifically determined by risk severity, the risk review team and Risk Owner will assign a response option. The GPM manager with risk closure authority (see Section 4.5) must approve the response option.

Response Option	Response Option Actions
Accept	Prepare written rationale and maintain record of risk in SLATE; development of mitigation strategies not necessary
Watch	Monitor risk attributes; establish risk tracking requirements; develop contingency plan if needed
Mitigate	Develop and execute a mitigation plan to eliminate or reduce likelihood of occurrence or impact; develop contingency plan if needed

Figure 5-1. Risk Response Options

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6. RISK TRACKING AND CONTROL

6.1. TRACKING RISKS

Following the completion of the risk analysis and the definition of the risk response option, the risk enters Tracking status. Tracking activities vary based on the Risk Response Option that is assigned to the risk.

6.1.1. Accept

Accepted risks are maintained in the SLATE risk database and reviewed occasionally for any changes that could affect the status of the risk. Rationale as to why the risk is acceptable will be provided for all accepted risks. No other actions are taken, and the accepted risk will be handled as a problem if it occurs. The GPM Risk Manager is responsible for monitoring all accepted risks.

6.1.2. Watch

Risks with the Watch response are reviewed regularly at GPM staff meetings and are monitored by the Risk Owner per the tracking requirements established in the approach. If the metrics reach a threshold defined by the tracking requirements, then the Risk Owner notifies the Element Manager, Mission Systems Engineer, and the Formulation/Project Manager as appropriate and implements the contingency plan. In the case where a contingency plan does not exist, the Risk Owner reanalyzes the risk to determine further action and submits a plan to the team for approval. If the threshold is not exceeded, the risk continues to be watched and reviewed. The Risk Owner is responsible for tracking the risk while under Watch, and the Risk Manager is responsible for monitoring all risks with the Watch response.

6.1.3. Mitigate

The mitigation plan is implemented for risks assigned the Mitigate Response Option. The Risk Owner initiates the mitigation and is responsible for notifying the team of the mitigation status and effectiveness at subsequent risk meetings.. The Risk Owner and Risk Manager are responsible for monitoring the mitigation and its effectiveness. If the mitigation is effective and eliminates the risk, rationale and justification is provided and the risk is assigned a Closed status.

In the case that mitigation is not effective, the contingency plan is implemented if the metrics have reached the predetermined threshold limits. If the contingency plan does not resolve the risk, then the risk will be reassessed and escalated as necessary. If a contingency plan does not exist, the Risk Owner reanalyzes the risk, addresses the risk at the next meeting, and develops a new mitigation plan.

Should a re-scaling of the project mission be required as a result of mitigation of the risk or as a consequence of the risk manifesting itself, GPM management will follow the appropriate descope process as detailed in the Project Management Plan.

6.2. CLOSING RISKS

A risk can be closed when the product of the probability of risk occurrence and the impact of the risk is assessed as being of so little concern as to not warrant further attention from the program. Alternately, a risk may be closed when the program phase has passed such that the risk can no longer materialize (e.g., the risk to the FY03 budget disappears in FY04 and should be closed).

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The risk owner must provide sufficient rationale for a closure determination. A risk is officially closed via signatures of the GPM Project Manager (or appropriate closure authority per the escalation process defined in section 4.5), the risk owner and risk identifier (if still with the GPM project). The Risk Manager reports all newly closed risks at the next risk meeting where risk status is briefed (Note that this means the GPM Project Manager will be informed of the closure of all risks, even if the closure authority was delegated per Section 4.5 to a lower level of management within GPM). All closed risks will be designated as "closed" and their records maintained within SLATE.

If any GPM staff member or reviewer outside of the GPM project is not in agreement with the disposition of a given risk, they are encouraged to bring their concerns to the Risk Manager, Formulation/Project Manager, Mission SE, or the GPM Safety Assurance Manager (SAM). Section 7.3 provides further detail on possible recourse options.

6.3. TRACKING PROBLEMS

A risk becomes a problem when the probability of occurrence becomes 100%. Problems are tracked in the SLATE risk database similarly to risks. If a contingency plan exists but has not yet been triggered, it is implemented. If a contingency plan does not exist or has already been implemented, then a problem handling plan is developed and implemented. The problem status is regularly reviewed at GPM team meetings. If the contingency or handling plan is not effective in mitigating the problem, it is then escalated per Figure 2-4. The problem is closed after it has been effectively resolved. It is important to note new risks can result when a risk becomes a problem.

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7. RISK DOCUMENTATION AND COMMUNICATION

Risk documentation and communication are key elements in GPM Risk Management. All risks are documented and tracked within the risk management database. The Risk Manager is responsible for ensuring that all appropriate communication related to risks and problems takes place.

7.1. RISK REPORTS AND REPORTING MILESTONES

Regular risk reports are produced from the SLATE risk database and distributed appropriately to the GPM team. These reports include but are not limited to:

- Mission Level Primary risk list
- Element Level Primary risk lists
- List of all project risks sorted by assembly level or element
- Accepted Risks list
- Closed Risks list
- Risk escalation reports
- Risk activity reports
- Problem reports

Weekly staff meetings are used for internal reporting where Risk will be a regular agenda item. These weekly meetings are used as a forum to report Element Level Primary risks to GPM Project Management and to assess the effectiveness of the Risk Management Process. The Senior Staff meeting reviews the Primary risk list at the Mission Level. Element Staff meetings cover Primary risks at the Element Level and lower. As required, subsystem risk meetings cover subsystem and lower risks. Quarterly Project Risk Meetings will be coordinated with GSFC and NASA HQ organizational entities to review and communicate GPM risks and status. Summary reports of risk activity are generated quarterly through CDR and then monthly through launch. The Risk Manager, with assistance from Risk Owners, will facilitate generation of the appropriate risk materials for various meetings where discussion of risk is featured.

7.2. RISK AWARENESS AND EDUCATION

The GPM project is dedicated to the swift identification of risks, impacts, and the necessary course of action for all risks. All GPM staff members are encouraged to participate in the identification of risks and will be trained in continuous risk management, consistent with the Continuous Risk Management Practices defined by the Software Assurance Technology Center at NASA GSFC. GPM staff members are immediately notified of updates or changes to the risk management process or procedures. Weekly staff meetings utilized for risk discussion and review provide the opportunity for continuous improvement of the GPM Risk Management Process. The Risk Manager will track and document all changes instituted by the team and make recommendations for improvement where possible. These modifications will be communicated to the GPM team as necessary. Additionally, the Risk Manager will review and, if needed, update the Risk Management Plan annually.

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7.3. RECOURSE

If any member of the GPM team feels that a risk has been improperly handled or addressed, that team member may address those concerns with the Risk Manager, Formulation/Project Manager, Mission SE, or the GPM Safety Assurance Manager (SAM). The concerns can be brought to the Risk Manager who provides assistance in identifying how the risk was improperly handled and any recourse or action that needs to be taken. The Risk Manager documents the concerns and addresses them with the Formulation/Project Manager and Mission Systems Engineer as appropriate. Status and resolution of the concerns are then reported back to the original team member. The GPM SAM is an independent alternate resource in the event the Risk Identifier feels insufficient action may have been taken to address the concerns. Based on the SAM's opinion of the severity of the item, he may choose to facilitate resolution with the Formulation/Project Manager or elevate the issue to GSFC Management. The GPM Formulation/Project Manager and Mission Systems Engineer also maintain an 'open door' policy to any team member desiring reconsideration of specific risks or resolution of their concerns.

7.4. PROJECT TOOLS

The risk management tools and database are integrated into SLATE, the GPM Project Knowledge Management tool. SLATE is distributed software client built on a shared database and work environment that is already being utilized for a number of project functions in addition to risk management, including requirements and documentation management. By having one tool serve multiple purposes, including risk management, training of project staff will be minimized and communication and sharing of information will be easier and more efficient. Risks are entered into an external Risk Input Form that is imported into SLATE for tracking and analysis. The form has been developed in Microsoft EXCEL and is available for any GPM staff members or external parties to the project who do not have direct access to SLATE but who wish to participate in identifying risks.

The SLATE tool is expandable to support a growing GPM team and administration of risks from the Project Level to the Subcomponent Level. In the future, SLATE will be expanded to incorporate problems, decisions, anomalies, and failures. The objective of the risk management tools are to provide a user-friendly method of reporting, analyzing, addressing, and reporting risks. All information related to the risk is maintained in the SLATE risk database and correlated to the respective risk. Various reports can be produced from the database, including top risk lists, risk action lists, risk status reports, etc (See Section 7.1 Risk Reporting for a detailed list of regular risk reports). SLATE can be also used to track selected metrics as related to the overall Risk Management process (e.g. number of risks for a given status, number of risks successfully mitigated, etc.). The database is also a repository for lessons learned through the course of continuous risk management. The GPM lessons learned are shared with the NASA Lessons Learned Database for the benefit of future missions and the NASA community in general.

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APPENDIX A – RISK INPUT TEMPLATE

ID		Title				
Status	New				Date Entered	
Statement					Date Updated	
Originator				Assigned To		
Probability	None Assi	Timeframe	None Assi	Severity		
Impact by Assy Level	Sub Component	Component	Subsystem	Element	Mission	Program
Assembly						
Impact	None Assi	None Assi	None Assi	None Assi	None Assi	None Assi
Context						
Approach	None Assigned					
Contingency Plan and Trigger						
Lessons Learned						
Closed by					Date Closed	
Closing Rationale						

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APPENDIX B – GPM "PRIORITY" RISK LIST PHILOSOPHY / CRITERIA

Objective:

Give the GPM Project Manager a condensed list of the most important / urgent issues potentially impacting the success of the GPM mission in preparation for monthly Project Status Reviews.

Guiding Principles:

- The number of risks on the GPM Project Manager "Priority" list will be flexible to the given risk situation at the time. No minimum or maximum number of risk is required to be on the list.
- The "Priority List" will cover both risks and problems, since the Risk Management Plan and SLATE handle both. A subset of the "Priority List" will be a "Hot List" of extremely high severity or urgent issues.
- Obviously, risk severity will be a major player in landing a risk on the "Priority List", but timeframe of required mitigation actions (for risks of some minimum level of severity) will also be a factor. In addition, the GPM Project Manager, Mission System Engineer, and Risk Manager will have some discretion to include risks of special programmatic importance that do not otherwise automatically qualify to be on the list.
- Target audience for the "Priority List" would be the attendees at the Monthly Project Status Review

"Priority / Hot List" Criteria:

- Hot List Items (sub-set of Priority List)
  - High Severity Problems
  - Project-level High Risks with Mitigation Timeframe <= 3 months
  - Project-level Medium Risks with Mitigation Timeframe <= 1 month
  - Element-level High Risks with Mitigation Timeframe <= 1 month
  - Other Risks of Programmatic importance, at the discretion of the GPM Project Manager, Mission System Engineer, and/or Risk Manager.
- Priority List (non-Hot List portion of the Priority List)
  - Medium Severity Problems
  - Project-level High Risks with Mitigation Timeframe > 3 months [Note: the GPM Project Manager may omit certain High risks from the Priority List that have been previously briefed at PSR if the risk status is "watch" or if the mitigation timeframe is very far off in the future (i.e., years).]
  - Project-level Medium Risks with Mitigation Timeframe > 1 month and <= 3 months
  - Element-level High Risks with Mitigation Timeframe > 1 month and <= 3 months
  - Other Risks of Programmatic importance, at the discretion of the GPM Project Manager, Mission System Engineer, and/or Risk Manager.

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- GPM Element / Sub-element managers would be expected to include any needed elaboration on the status of a Priority / Hot List item that they "own" in their respective materials for PSR. They also have the discretion to include materials for other risks not automatically included on the Priority List in their PSR materials, if they feel additional visibility is needed and/or desirable.

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APPENDIX C – ACRONYM LIST

CDR	Critical Design Review
EOS	Earth Observing System
FMECA	Failure Mode, Effects and Criticality Analysis
GPM	Global Precipitation Measurement
GSFC	Goddard Space Flight Center
HQ	Headquarters
NASA	National Aeronautics and Space Administration
NPG	NASA Procedures and Guidelines
PDR	Preliminary Design Review
PMC	Program Management Council
PSR	Project Status Review
SE	System Engineer
SLATE	System Level Automation Tool for Enterprises