How can you support RIDM/CRM/RM through the use of PRA

Supply Chain Conference 2011
Panel Session – NASA’s Approach to Integrated Risk Management

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October 19, 2011
Greenbelt, MD - GSFC
Agenda

- Risk Management (RM) Recap
  - What is Continuous Risk Management (CRM)
  - What is Risk Informed Decision Making (RIDM)
  - What is Risk Management (RM)
- What does PRA mean in the context of RIDM
- NASA’s newest PRA requirements
- How does GSFC’s flow down PRA requirements
  - Two Approaches
    - In-House PRA Development
    - Out-of-House PRA Development
  - GSFC’s Standard Mission Assurance Requirements (MAR) Document
- Discussion
What is RIDM?

Risk-Informed Decision Making (RIDM)

Part 1 - Identification of Alternatives
Step 1 - Understand Stakeholder Expectations and Derive Performance Measures
Step 2 - Compile Feasible Alternatives

Part 2 - Risk Analysis of Alternatives
Step 3 - Set the Framework and Choose the Analysis Methodologies
Step 4 - Conduct the Risk Analysis and Document the Results

Part 3 - Risk-Informed Alternative Selection
Step 5 - Develop Risk-Normalized Performance Commitments
Step 6 - Deliberate, Select an Alternative, and Document the Decision Rationale

To Requirements (Re)Baselining

http://www.hq.nasa.gov/office/codeq/doctree/SP2010576.htm
Continuous Risk Management (CRM)

- **IDENTIFY**
  - Identify risk issues and concerns
  - Statements of risk
  - List of risks

- **ANALYZE**
  - Evaluate (impact/severity, probability, time frame), classify, and prioritize risks
  - Risk evaluation
  - Risk classification
  - Risk prioritization

- **PLAN**
  - Decide what, if anything, should be done about risks
  - Risk mitigation plans
  - Risk acceptance rationale
  - Risk tracking requirements

- **TRACK**
  - Monitor risk metrics and verify/validate mitigation actions
  - Risk status reports on:
    - Risks
    - Risk mitigation plans
  - Risk decisions

- **CONTROL**
  - Replan mitigations, close risks, invoke contingency plans, or track risks

Notes:
- Communication and documentation extend throughout all of the functions.

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What is Risk Management?

Diagram taken from Source 7

Legend:
- FMEA - Failure Modes and Effects Analysis
- MLD - Master Logic Diagram
- ESD - Event Sequence Diagram
- ETA - Event Tree Analysis
- FTA - Fault Tree Analysis
- RBD - Reliability Block Diagram
What is PRA?

**Definition:**
Probabilistic Risk Assessment (PRA) is one of key RIDM tools. It is a scenario-based methodology aimed at identifying and assessing Safety and Technical Performance risks in complex technological systems.

PRA characterizes:
1) What can go wrong?
2) How likely is it?
3) What are the consequences

Triplet Concept: Scenario, Likelihood, Impact
What is PRA?

PRA Scenario Concept:

Source of Initiating Event:
- FMEAs
- HazReps
- Failure History
- Master Logic Diagram

Source of Pivotal Events:
- Same as IEs, plus
  - Ground Procedures
  - Crew Procedures
  - Automatic emergency systems, etc.

End State:
Detrimental consequence of interest

Accident Scenario is a string of events that, if it occurs, will lead to an undesired end state.

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What is PRA?

What makes PRA appealing is its ability to integrate several sources of information together that may contribute to Risk.
What is PRA?

The integrated risk scenario model allows for a robust and ordered ranking of the risk contributors that may lead to the undesired states of interest.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description of Scenario (See Figure 1-7)</th>
<th>Cut Set</th>
<th>Symbol</th>
<th>Probability</th>
<th>Total</th>
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<td>Hydrazine Leak, Detection Succeeded but Isolation Fails, Avonics Failure</td>
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<td>Hydrazine Leak, Leak occurs downstream of isolation valves</td>
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<td>1.0E-2</td>
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Total probability: 1.0E-4

Taken from Source 5

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Two-Sets of Requirements governing PRA activity at GSFC

Applicable requirements pulled from:

- NPR 8705.5A PRA Procedures for NASA Programs and Projects (2010)
- NPR 8715.3C NASA General Safety Program Requirements (2012)
Some of the Significant Changes to NPR 8705.5 made in conjunction with RIDM

- Removed language addressing Full, Simplified, and Limited Scope PRA.

- Greater emphasis on PRA Planning/PRA Plan Documentation
  - Formal PRA Plan shall be developed by PRA Lead and approved by Program/Project Manager to:
    - Identify specific end-states (undesirable consequences, performance measures, figures of merit) of interest consistent with PRA objectives
    - Define quantitative performance measures and numerical criteria that are to be evaluated by the PRA consistent with objectives
    - Develop a PRA schedule compatible with objectives, applications, and life cycle phases approved by the Program/Project manager

- Greater tie-in with Program/Project characterization of NASA Space Flight Program and Project Management Requirements
  - Use of Category 1 (i.e., LCC greater than 1 Billion dollars, Nuclear Payloads, Human Spaceflight)
New NPR 8705.5 Requirements for GSFC

- Formal submittal of PRA Decisions – Cat I and Cat II, Class A or Class B.
- Formal submittal of PRA plans, including scope and rationale
- Requires Program Manager approval (note: PRA decision/scope determination is the primary responsibility of the Project subject to OSMA/Center SMA Concurrence)
- Formal coordination of Independent PRA Review with OSMA.
How is GSFC Flowing Down PRA Requirements to Developers/Suppliers

• GSFC’s Mission Assurance Requirements (MAR)

PROBABILISTIC RISK ANALYSIS (PRA) AND RELIABILITY

Tailoring note: The PRA and reliability engineering section requires tailoring per the classification requirements of NPR 8705.4, NPR 8705.5, and project-specific requirements.

RELIABILITY PROGRAM PLAN

Tailoring note: If PRA is being invoked in section 4.2, change section 4.1 to read from “...implement a Reliability Program Plan (RPP)” to “...implement a Reliability Program Plan, including the developer’s approach to PRA requirements in section 4.2, ..”

The developer shall document and implement a Reliability Program Plan (RPP) using both qualitative and quantitative techniques to support decisions regarding mission success and safety throughout system development. The RPP shall include a detailed approach to the analysis of hardware and software for their contributions to system reliability and mission success. The developer shall present the implementation of these plans and related activities at milestone reviews beginning with the System Requirements Review (DID 4-1).

PROBABILISTIC RISK ASSESSMENT

Tailoring note: See paragraph 2.2.1a of NPR 8705.5 for criteria regarding the requirement to perform a PRA. If a PRA is not required, delete this section and the related DIDs. If a PRA will be performed, delete the non-applicable paragraph and related DID.

The developer shall perform a Probabilistic Risk Assessment in accordance with NPR 8705.5, Probabilistic Risk Assessment (PRA) Technical Procedures for Safety and Mission Success for NASA Programs and Projects (DID 4-2).

The developer shall provide the information for a Probabilistic Risk Assessment per NPR 8705.5, Probabilistic Risk Assessment (PRA) Technical Procedures for Safety and Mission Success for NASA Programs and Projects (DID 4-2).
How is GSFC Flowing Down PRA Requirements to Developers/Suppliers

- MAR Data Items Description (DID 4-1)

<table>
<thead>
<tr>
<th>Title: Reliability Program Plan</th>
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<tr>
<td>Use:</td>
<td></td>
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<tr>
<td>Planning and implementation of Probabilistic Risk Assessment (PRA) and reliability activities.</td>
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**Reference Documents:**
- NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy
- NASA-STD-8729.1, Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program
- NPR 8705.4 Risk Classification for NASA Payloads
- NPR 8705.5 PRA Procedures for NASA Programs and Projects

**Place/Time/Purpose of Delivery:**
- Deliver draft plan to the Project Office sixty (60) days after contract award for review.
- Deliver final plan to the Project Office thirty (30) days prior to the Systems Requirements Review for approval.
- Deliver activity reports related to implementation of the plan at milestone reviews beginning with the Systems Requirements Review for review.

**Preparation Information:**
The Reliability Program Plan shall include:
- A discussion of how the developer intends to implement and comply with Reliability program requirements.
- Charts and statements describing organizational responsibilities and functions conducting each task to be performed as part of the Program.
- A summary (matrix or other brief form) that indicates for each requirement, the organization responsible for implementing and generating the necessary documents.
- Identify the approval, oversight, or review authority for each task.
- Narrative descriptions, time or milestone schedules, and supporting documents describing the execution and management plan for each task.
- Documentation, methods, procedures, and reporting specific to each task in the plan.
How is GSFC Flowing Down PRA Requirements to Developers/Suppliers

MAR DID 4-1 -- use this DID if the developer is performing the PRA

<table>
<thead>
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<th>Title: Probabilistic Risk Assessment</th>
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**Use:**
To provide a structured and disciplined approach to: analyzing system risk; supporting management decisions; improving safety, operations, performing maintenance and upgrades; improving performance; reducing costs.

**Reference Documents:**
- NPR 8705.4 Risk Classification for NASA Payloads
- NPR 8705.5 Technical Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects
- NPR 8715.3 NASA General Safety Program Requirements

**Place/Time/Purpose of Delivery:**
- Deliver a PRA plan to the Project office sixty (60) days after contract award for review (Note: PRA may be stand-alone document or included as part of the Reliability Program Plan (RPP), Risk Management Plan (RMP), etc. The PRA Plan shall meet requirements delineated in DID 4-1.).
- Deliver interim PRA to the Project Office thirty (30) days prior to PDR for review.
- Deliver updated interim PRA to the Project Office thirty (30) days prior to CDR for review.
- Deliver updated interim PRA to the Project Office thirty (30) days prior to MOR for review.
- Deliver final PRA to the Project Office thirty (30) days prior to FOR for approval.

**Preparation Information:**
The PRA shall be performed in accordance with NPR 8705.5 and include the following:
- The objective and scope of the PRA
- End-states-of-interest to the decision-maker
- Definition of the mission phases and success criteria
- Initiating event categories
- Top level scenarios
- Initiating and pivotal event models (e.g., fault trees and phenomenological event models), including assessments of common cause failure modes
- Data development for probability calculations
- Integrated model and quantification to obtain risk estimates
- Assessment of uncertainties
- Summary of results and conclusions, including a ranking of the lead contributors to risk.
# How is GSFC Flowing Down PRA Requirements to Developers/Suppliers

## MAR DID 4-2 – use this DID if the GSFC is performing the PRA

<table>
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</table>

**Use:**
- To provide a structured and disciplined approach to: analyzing system risk, supporting management decisions, address safety, operations, maintenance, and upgrades; manage performance; manage costs.

**Reference:**
- NPR 8705.4 Risk Classification for NASA Payloads
- NPR 8705.5 Technical Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects
- NPR 8715.3 NASA General Safety Program Requirements

**Related Documents:**
None

**Place/Time/Purpose of Delivery:**
- Deliver preliminary heritage information, including the percent applicable, to the Project Office sixty (60) days after contract award for information.
- Deliver updated heritage information, including the percent applicable heritage to the subject mission, to the Project Office thirty (30) days to prior major milestone reviews beginning with the SRR for information.
- Deliver product information and process information for elements within the scope of the Mission PRA to the Project Office thirty (90) days prior to the PDR and thirty (30) days prior to subsequent major milestone reviews for information.

**Preparation Information:**
The government will provide a notification to the developer of the scope and/or area of inputs needed to support the risk assessment 30 days prior to needing information in preparation of the PRA. Types of information needed may include heritage information (e.g., current flight history, current operating hours, operational and storage environments, TRLs, etc.), product information (e.g., hardware and/or software configurations, parts lists, schematics), interim analysis (e.g., working-level copies of fault tree analysis, failure modes and effects analysis, reliability predictions, etc) and/or process information (e.g., design documents, manufacturing documents, parts program documents, etc) germane to the element(s) being evaluated within the scope of Mission PRA and Instrument development. The developer and their collaborators will provide access to the information necessary to support the scope of the Mission PRA.
Lessons Learned

• It is important that a clear scope, set of objectives, and milestones be established upfront with the project team to help ensure that needed questions will be answered in a timely manner.

• PRA and other models rely heavily on the degree and fidelity to which they match what will happen in reality. Such modeling requires close coordination with the design team, and a sound system understanding from the modeler.

• Need to establish a framework for developing basic event likelihood distributions upfront.

• Need to clearly communicate results
Discussion

• Comments
• Questions