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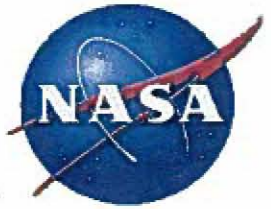

A Proactive and Top-down Approach to Managing Risk at NASA

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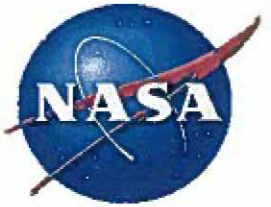
Outline

- Risk Management Overview
- Risk-informed Decision Making Process
- Continuous Risk Management Process
- Summary

Risk Management Policy



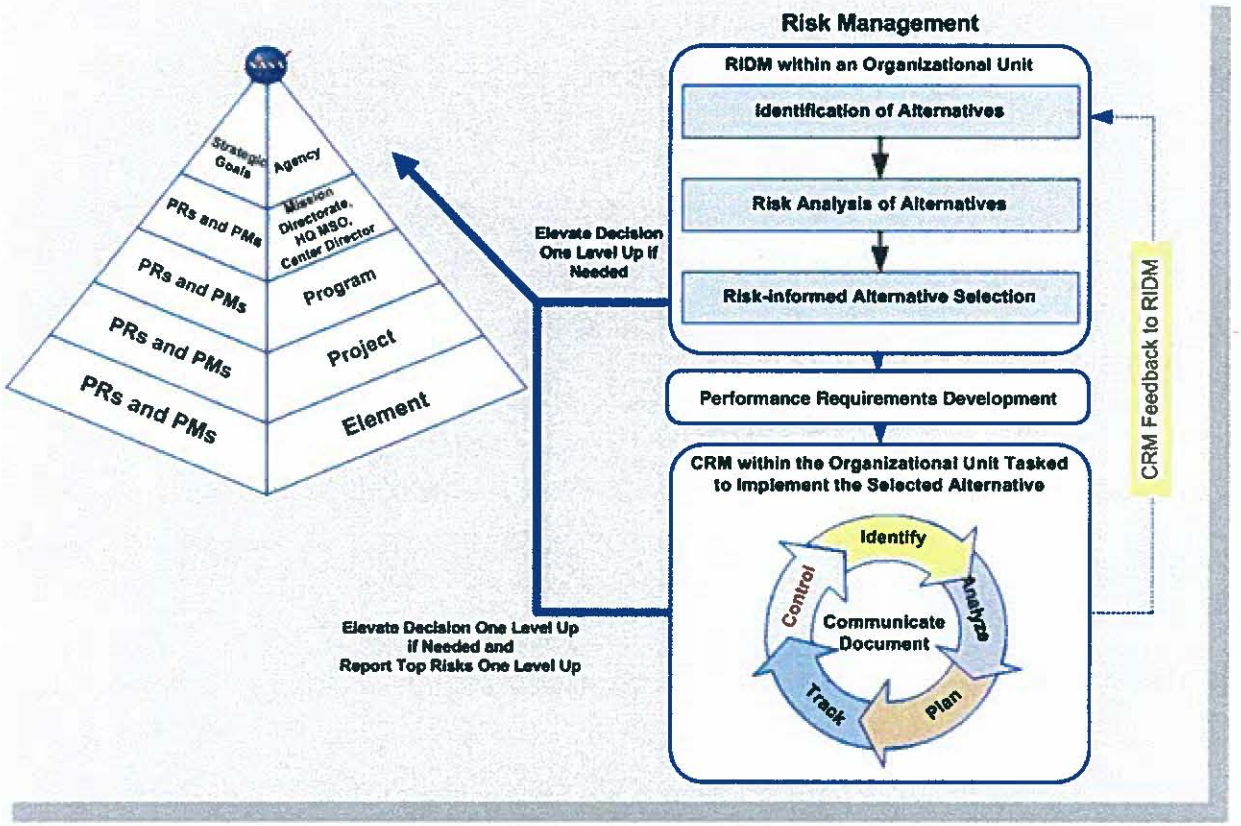
- **NASA Policy Directive (NPD) 1000.5 (2009) states: "*It is NASA policy to incorporate in the overall Agency risk management strategy a risk-informed acquisition process that includes the identification, analysis, and management of programmatic, infrastructure, technical, environmental, safety, cost, schedule, management, industry, and external policy risks that might jeopardize the success with which the Agency executes its acquisition strategies.*"**
- **NPR 8000.4A (2009), Agency Risk Management Procedural Requirements, evolves NASA's risk management (RM) approach to entail two complementary processes:**
  - **Risk-informed Decision Making (RIDM)**
    - To risk-inform direction-setting decisions (e.g., space architecture decisions)
    - To risk-inform the development of credible performance requirements as part of the overall systems engineering process
  - **Continuous Risk Management (CRM)**
    - To manage risk associated with the implementation of baseline performance requirements

What Improvements Are We Looking for?

- To manage risk in a holistic and coherent manner across the Agency
  - Agency strategic goals explicitly drive RM activities at all levels
  - All risk types and their interactions are considered collectively during decision-making
  - Having an integrated perspective of risks when analyzing competing alternatives
  - Implementation of RM in the context of complex institutional relationships (programs, projects, centers, contractors, …)
- To better match the stakeholder expectations and the "true" resources required to address the risks to achieve those expectations
  - Better comprehension of the risk that a decision-maker is accepting when making commitments to stakeholders
- To better establish close ties between the selected alternative and the requirements derived from it
  - Derivation of achievable requirements through systematic characterization of uncertainties

The RM Process Begins with NASA Strategic Goals

- Within NASA's organizational hierarchy, high-level objectives (NASA Strategic Goals) flow down in the form of progressively more detailed performance requirements, whose satisfaction assures that objectives are met
- RIDM is designed to maintain focus on strategic goals as decisions are made throughout the hierarchy
- CRM is designed to manage "risks" in the context of requirements

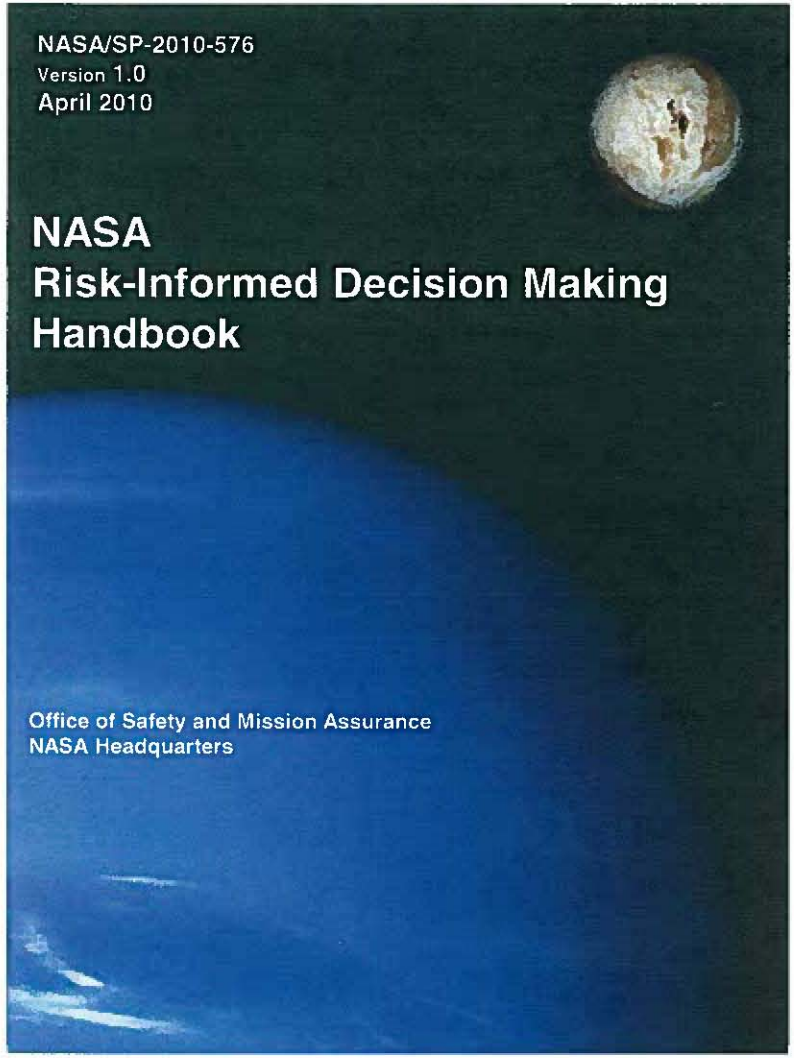


PRs: Performance Requirements
PMs: Performance Measures

Definitions of Risk and RIDM per NPR 8000.4

- **Risk: The expression of the potential for performance shortfalls, which may be realized in the future, with respect to achieving explicitly established and stated performance requirements**
  - **The performance shortfalls may be related to any one or more of the following mission execution domains:**
    - **Safety**
    - **Technical performance**
    - **Cost**
    - **Schedule**
- **RIDM: A risk-informed decision-making process that uses a diverse set of performance measures along with other considerations within a *deliberative* process to inform decision making**
  - **decisions are informed by an integrated risk perspective rather than being informed by a set of individual "risk" contributions**
  - **A decision-making process relying primarily on a narrow set of model-based risk metrics would be considered "risk-based"**

RIDM Process Steps
Based on NASA/SP-2010-576



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

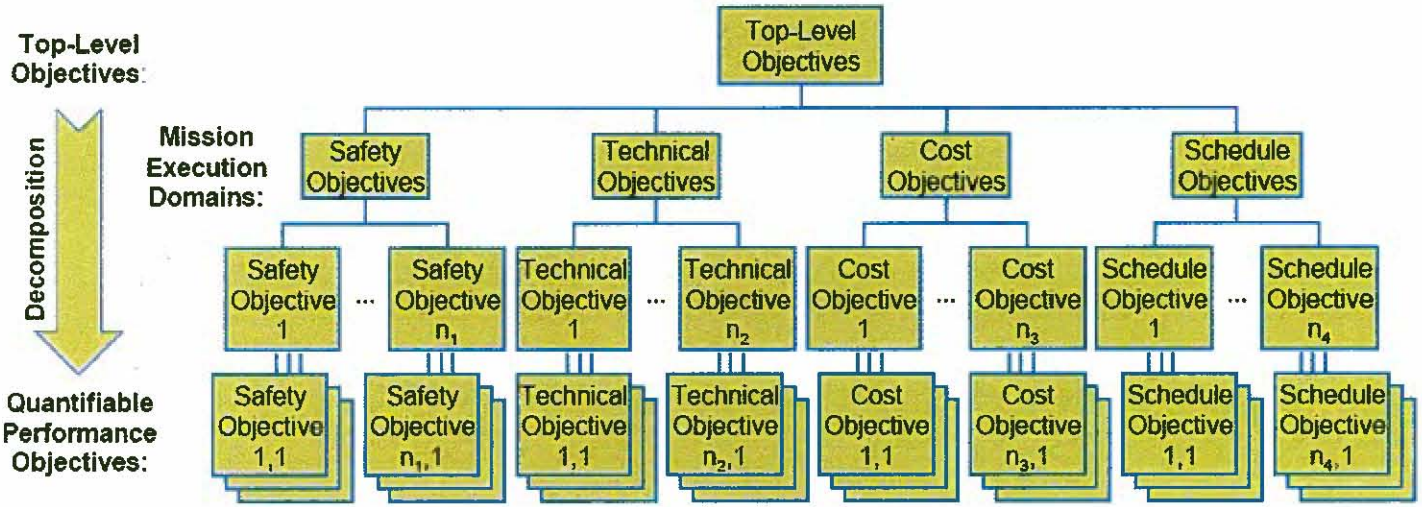
To Requirements (Re)Baselining

http://www.hq.nasa.gov/office/codeq/doctree/SP2010576.htm

RIDM Process – Part 1

Understand Stakeholder Expectations and Derive Performance Measures

- An objectives hierarchy is constructed by subdividing the top-level objectives into more detailed objectives, thereby clarifying the intended meaning.
- At the first level of decomposition, the top-level objective is partitioned into the mission execution domains of Safety, Technical, Cost, and Schedule.
- Within each domain, the objectives are further decomposed until appropriate quantifiable performance objectives are generated.



Notional Objectives Hierarchy

RIDM Process – Part 1

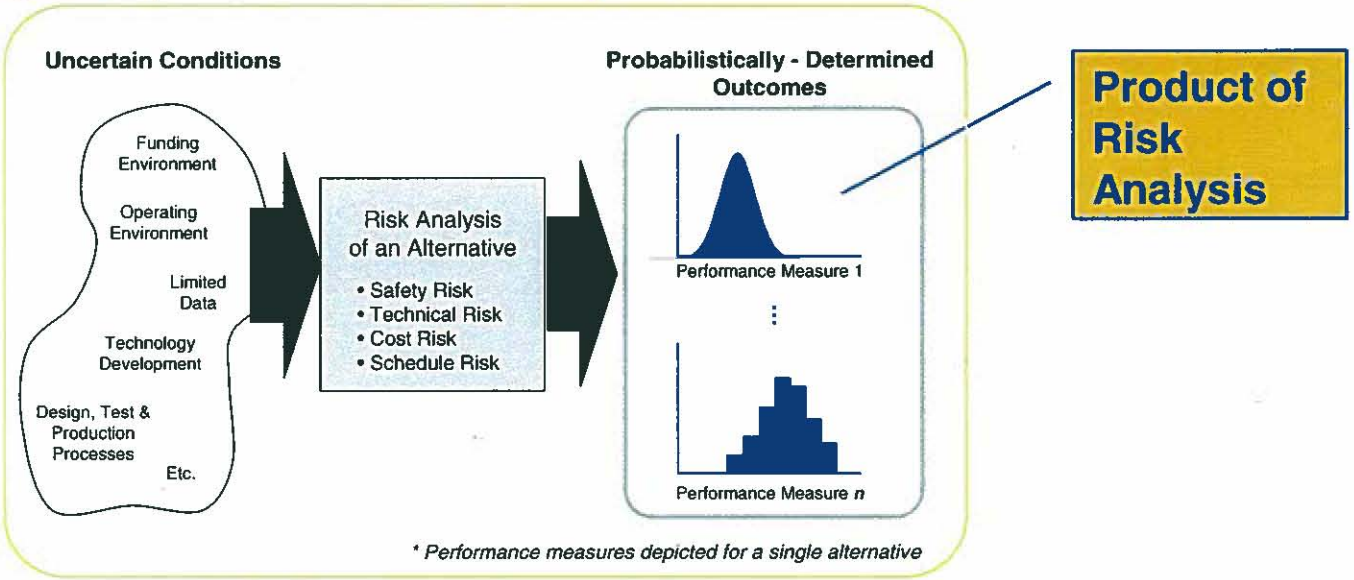
Performance Measures and Performance Requirements

- **A Performance Measure (PM) is a metric used to quantify the extent to which a Performance Objective is fulfilled**
  - **Safety** (e.g., avoidance of injury, fatality, or destruction of key assets)
    - **Maintain Astronaut Safety → Probability of Loss of Crew (P(LOC))**
  - **Technical** (e.g., increase thrust or output, maximize amount of observational data acquired)
    - **Maximize Payload Capability → Payload Capability (kg)**
  - **Cost** (e.g., execution within minimum cost)
    - **Minimize Cost → Cost ($)**
  - **Schedule** (e.g., meeting milestones)
    - **Minimize completion time → Schedule (months)**
- **The PM values imputed to the selected alternative are Performance Requirements**
  - **They essentially define "success"**
  - **Significant shortfalls in performance are "failures"**

RIDM Process – Part 2

Risk Analysis of Alternatives

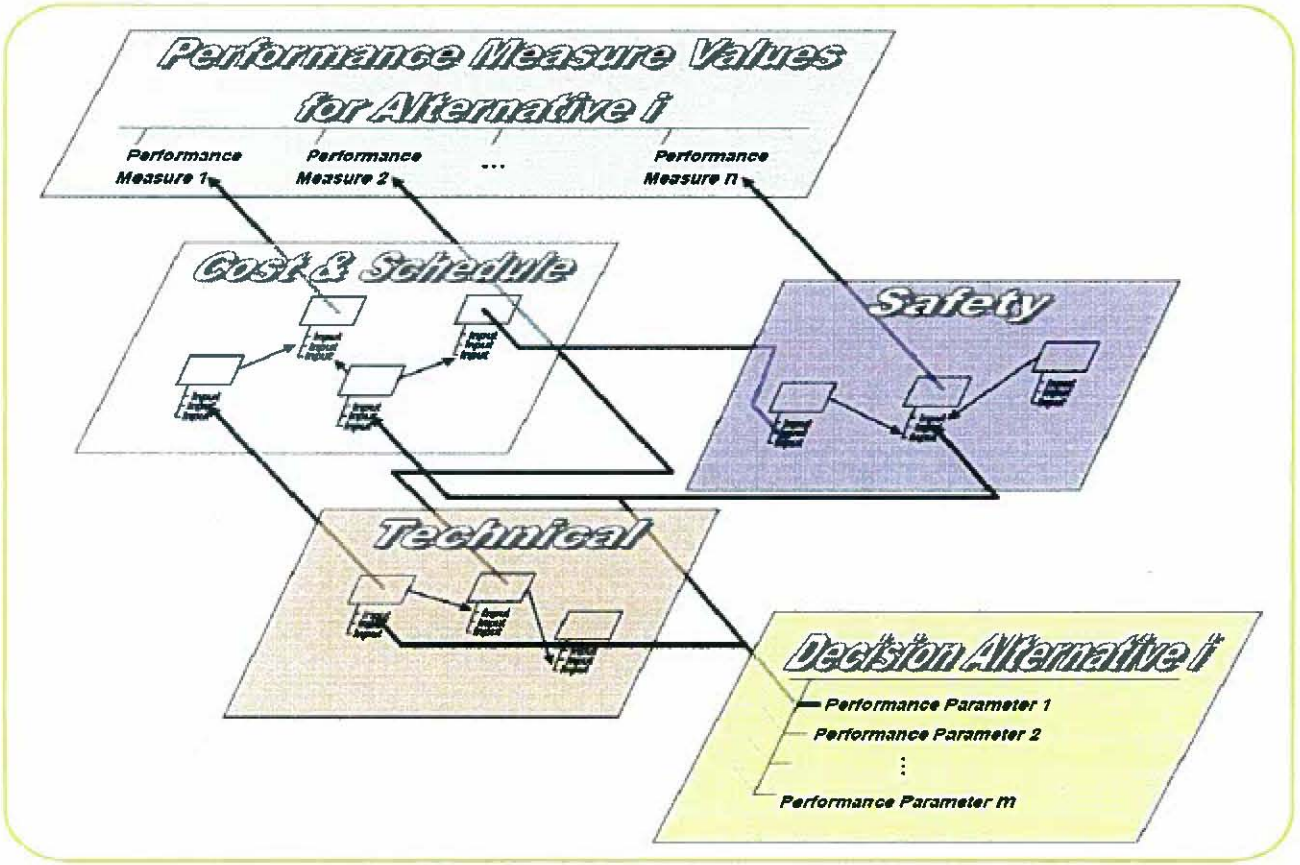
- **The goal is to develop a risk analysis framework that integrates domain-specific performance assessments and quantifies the performance measures**
  - **Risk Analysis** - probabilistic modeling of performance



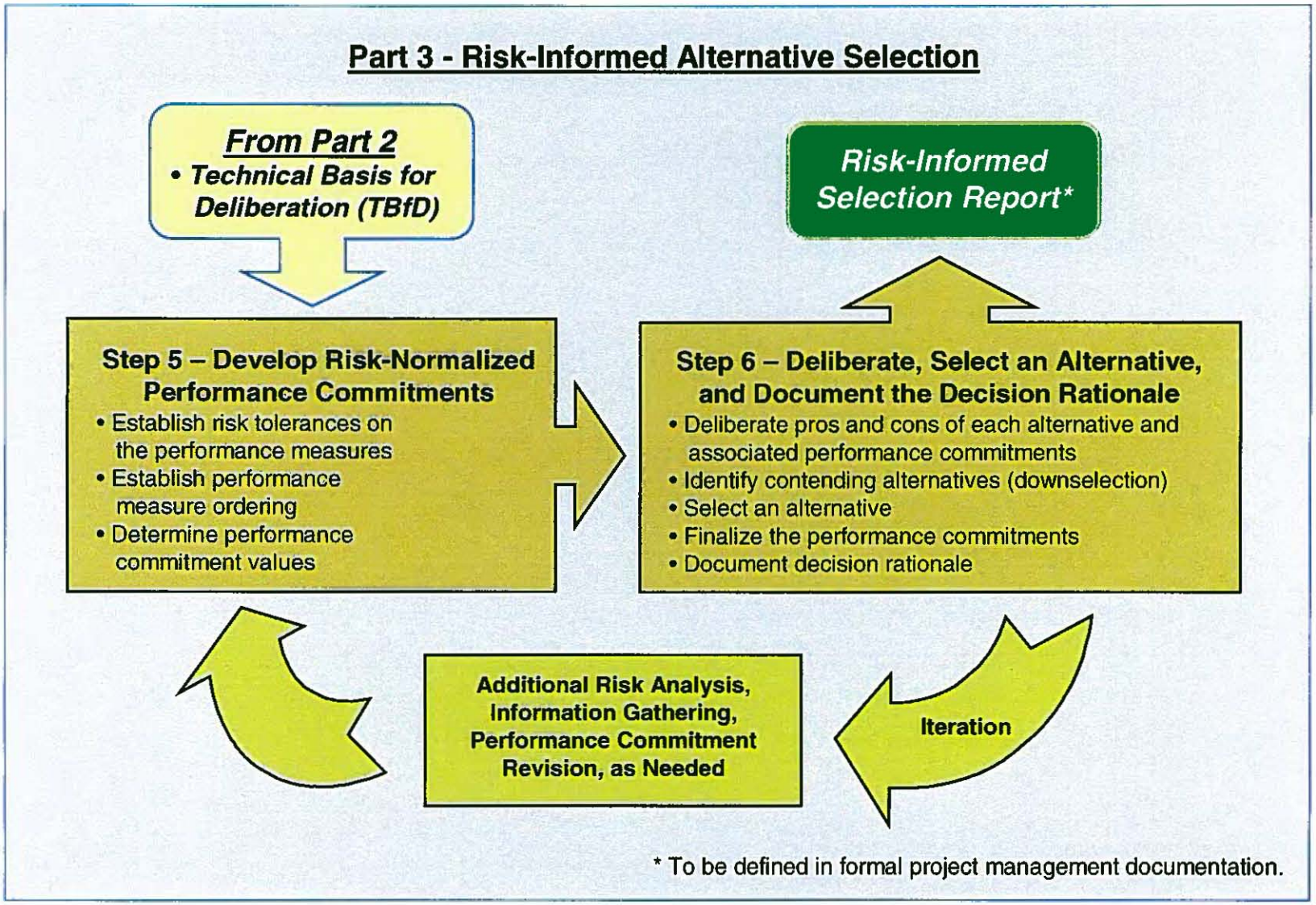
- **Establishing a transparent framework that:**
  - Operates on a common set of **performance parameters** for each alternative
  - Consistently addresses uncertainties across mission execution domains and across alternatives
  - Preserves correlations between performance measures

Setting Risk Analysis Framework

- **Detailed domain-specific analysis guidance is available in domain-specific guidance documents like the *NASA Cost Estimating Handbook*, the *NASA Systems Engineering Handbook*, and the *NASA Probabilistic Risk Assessment Procedures Guide***

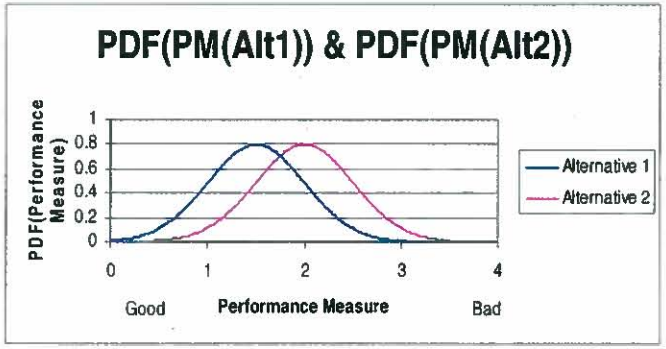


RIDM Process Part 3



RIDM Process – Part 3
Risk-informed Alternative Selection

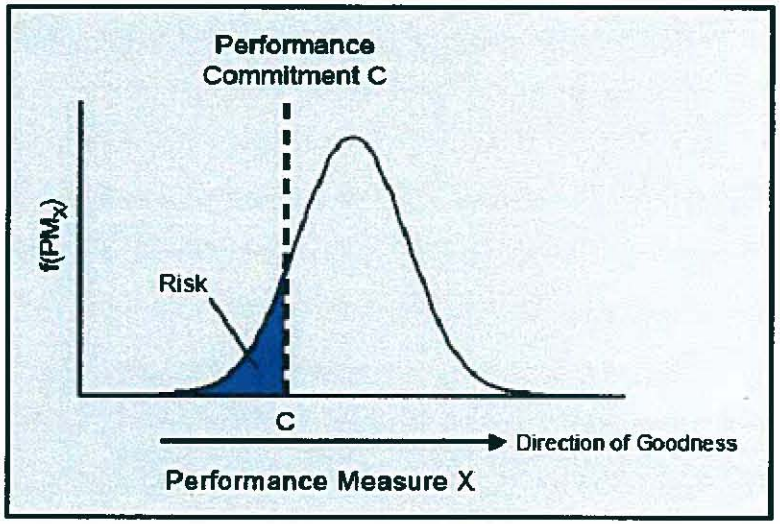
- **Performance measure probability density functions (pdfs) constitute the fundamental risk analysis results.**
- **However, there are complicating factors for performance measures that are expressed as pdfs:**
  - The pdfs for different alternatives may overlap, preventing a definitive assessment of which alternative has superior performance



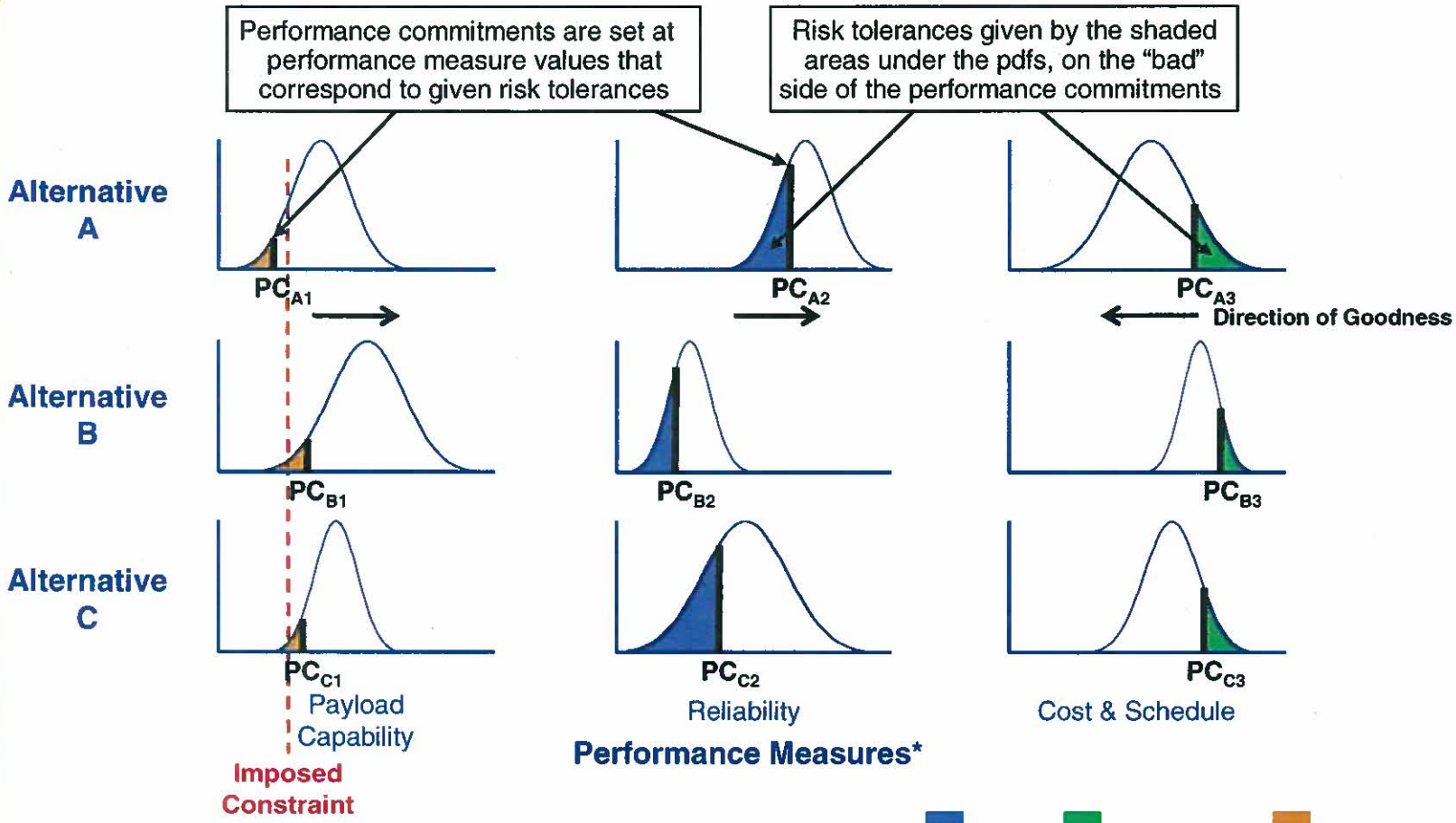
  - Different pdfs may exceed imposed constraints at different percentiles, thereby comingling issues of performance with issues of success

Performance Commitment

- **Mean values are used in many different contexts to compare alternatives, but this approach can:**
  - **Produce values that are strongly influenced by the tail ends of the pdfs**
  - **Introduce significant probabilities of falling short of imposed constraints, even when the mean values meet imposed constraints**
- **A *Performance Commitment* is the level of performance whose probability of not being achieved matches the decision maker's risk tolerance**
  - **Anchors the commitment the decision maker (DM) is willing to make for that performance measure**
- **Performance commitments support a risk-normalized comparison of decision alternatives, at a level of risk tolerance determined by the decision maker.**

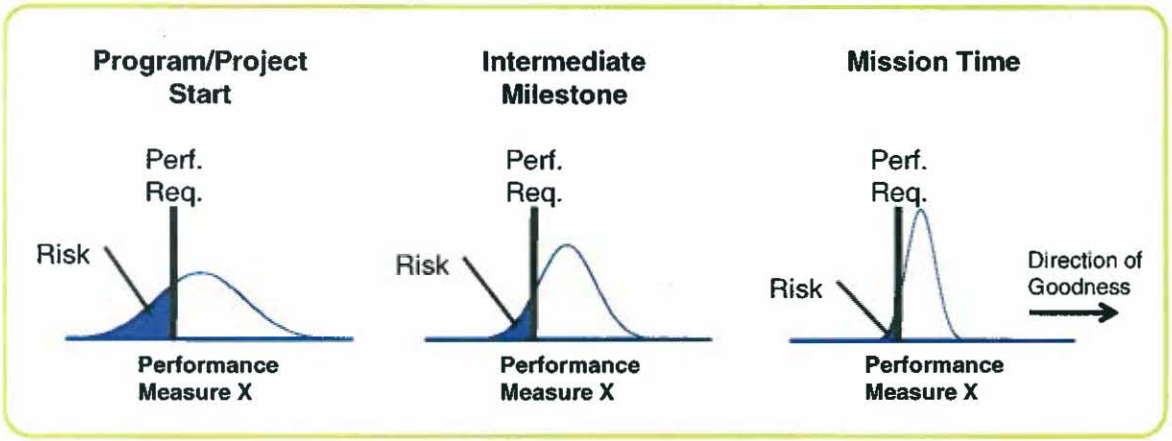


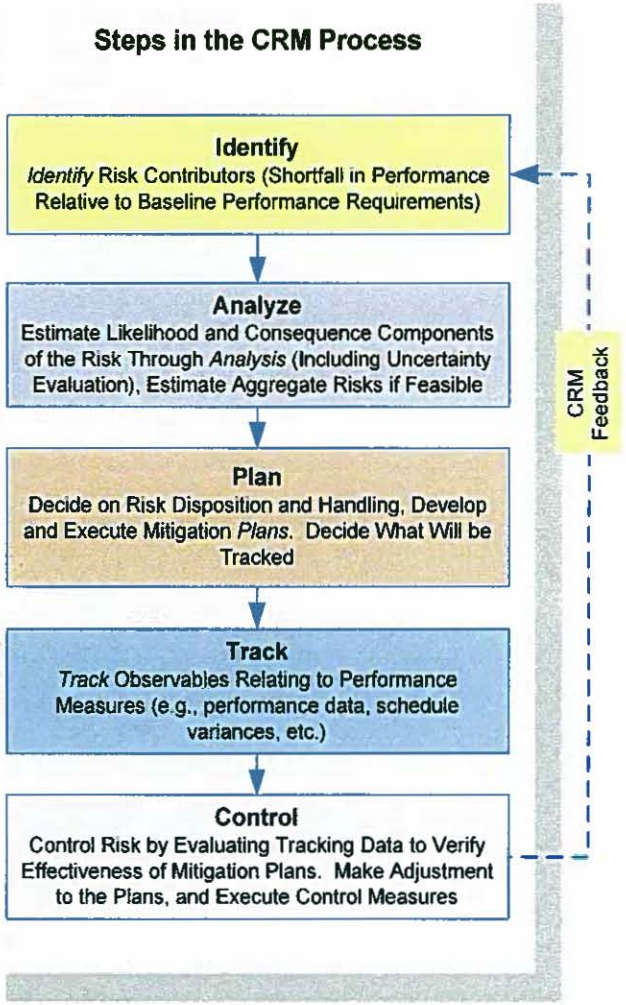
Deliberation of the Merits of Each Alternative in the Context of Performance Commitments (notional)



The Continuous Risk Management Process

- Is initiated by the results of the RIDM process:
  - The risk analysis for the selected alternative
  - An initial risk list
- Focuses on meeting performance requirements
  - By managing performance margins over time so that associated performance requirements are not violated
  - By "burning down" (over time) the risk of violating performance requirements
  - By means of mitigation actions





Summary

- Our ultimate goal is to manage risk in a holistic and coherent fashion across the Agency
  - The RIDM process is intended to risk-inform direction-setting decisions
  - The CRM process is intended to manage risk associated with the implementation of baseline performance requirements
- Currently we are working on
  - Enhancements to the CRM process
  - Better integration of the RIDM and CRM processes
  - Better integration of institutional risk considerations into RM framework