Risk Management from GSFC Perspective

Supply Chain Conference 2011

**Panel Session – NASA's Approach to Integrated Risk Management
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**Dr. Nat Jambulingam
GSFC Integrated Risk Manager**

What's Risk Management?

- An organized, systematic decision making process that efficiently identifies, analyzes, plans, tracks, controls, communicates and documents risk.

- Risk management is performed continuously.

- Helps to prevent "unacceptable risk" due to…
    - Lack of planning for what could go wrong
    - Departure from established systems engineering and management processes
    - Not following design and verification rules
    - Lack of engineering curiosity when a result is unexpected
    - Not asking independent experts for confirmation and advice
    - Lack of communication up and down the chain

Why Risk Management?

- **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 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**

$$RM \equiv RIDM + CRM$$
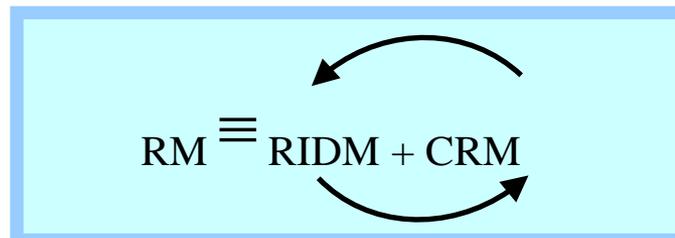
Motivating Factors for doing RM

- **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**
  - **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**
- **To better establish close ties between the selected alternatives and the requirements derived from it.**

Risk-related NASA Documents

- **2002 – Issuance of PRA Procedures Guide**
- **2004 – Issuance of NPR 8705 "Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects"**
- **2006 – Issuance of NPR 7123.1 "Systems Engineering Processes…"**
- **2006 – Revision of NPR 8715.3A "NASA General Safety Program Requirements," Rewrite of System Safety Requirements (Chapter 2)**
- **2007 – Revision of NPR 7120.5D "Space Flight Project Management Processes…"**
- **2007 – Reissue of NASA/SP-2007-6105 "NASA Systems Engineering Handbook"**
- **2008 – Reissue of NPR 8705.2B "Human-Rating Requirements for Space Systems"**
- **2009 – Issuance of NPD-1000.5 "Policy for NASA Acquisition"**
- **2009 – Revision of NPR 8000.4A "Agency Risk Management Requirements"**
- **2009 – Issuance of NASA/SP-2009-569, "Bayesian Inference for NASA Probabilistic Risk and Reliability Analysis"**
- **2010 – Issuance of NASA/SP-2010-576 "NASA Risk-informed Decision Making Handbook"**

<u>**Emerging themes:**</u>
**Integrated perspective of risk analysis**
Scenario-based modeling of risk
Better treatment of uncertainties

Risk Management Drivers at GSFC

- **Agency Level Requirements per NPR 8000.4A**

- **Center Level Requirements per GPR 7120.4**

- **Directorate Level Requirements such as**
  - **Flight Program/Project level Risk Management Plan**
  - **Institutional Project Risk Management Plan**
  - **Procedures and Guidelines by Office of the Management Operations Directorate (200-PG-8000.0.1)**
  - **Threat, Lien and Encumbrance Policy to determine the potential cost impact associated with risks (Programs and Projects)**

Risk Escalation Process at GSFC
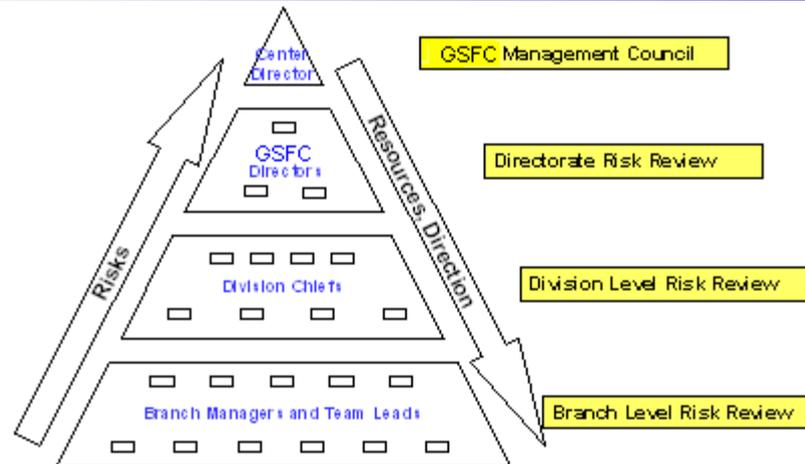
Risk owners shall perform due diligence to understand the risk and escalation process. Reasons for escalation may include:

- Additional resources are needed to mitigate the risk.
- Direction is needed from the next level of management.
- External integration is required (e.g. suppliers, other programs/projects/centers).
- The risk has cross-cutting significance.

The following levels are defined to support the Center's escalation process:

<u>Top Center Risk (TCR)</u> – Requires Center management resources or direction

<u>Top Directorate Risk (TDR)</u> – Requires Directorate Management direction.

<u>Top Organizational Risk (TOR)</u> – Requires Division Management direction and/or resources.

Lessons Learned

The Challenger Launch Decision

COLUMBIA
Accident Investigation Board

BROWN CLARK CHAWLA ANDERSON RAMON HUSBAND MCCOOL

STS 107

JANUARY 30, 2004

Columbia Accident Investigation Report (over 300 references to risks)

"There is great risk in placing human beings atop a machine that stores and then burns millions of pounds of dangerous propellants. Equally risky is having humans then ride the machine back to Earth while it dissipates the orbital speed by converting the energy into heat, much like a meteor entering Earth's atmosphere. No alternatives to this pathway to space are available or even on the horizon, so we must set our sights on managing risky process using the most advanced and versatile techniques at our disposal." It starts with the decisions we make and the uncertainty in those decisions.

Common Themes of Mishap Reports

- **Risk Management/Assessment**
- Testing, Simulation, Verification & Validation
- Independent Review
- Communications
- Health Monitoring During Critical Operation
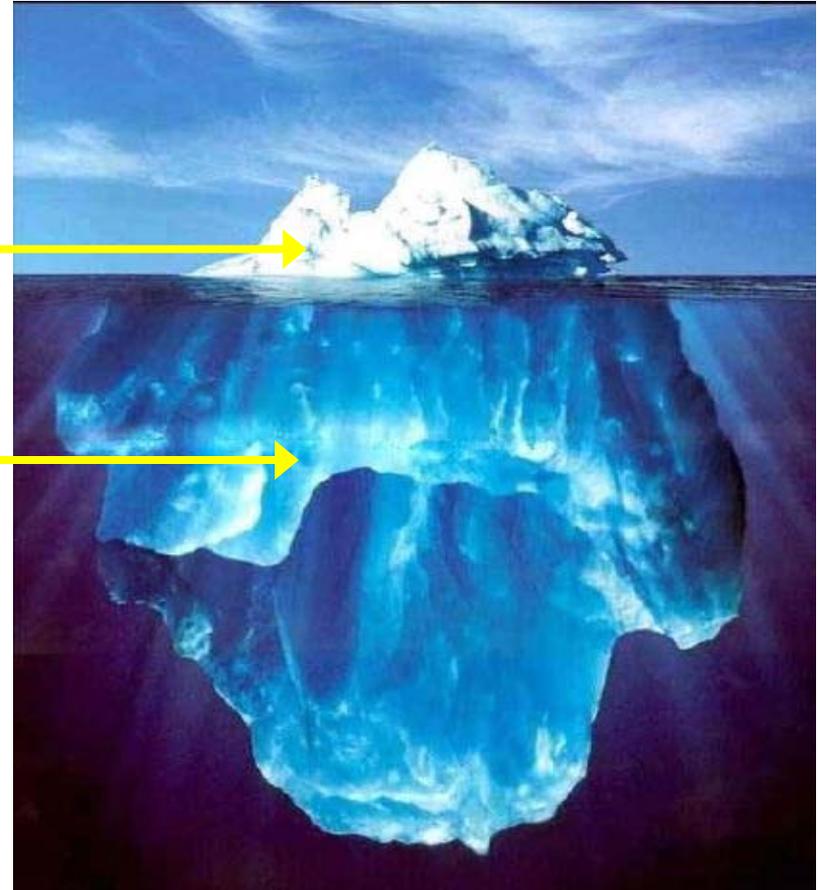- Safety/Quality Culture
- Resources/Staffing

Where Are The Risks?

Most risks are below the surface.

Knowns

We understand our risks & options.

Unknowns

✓ Someone understands our risks

✓ Beyond our current knowledge but knowable if we work at it

✓ Not knowable with today's knowledge, therefore we make blind decisions
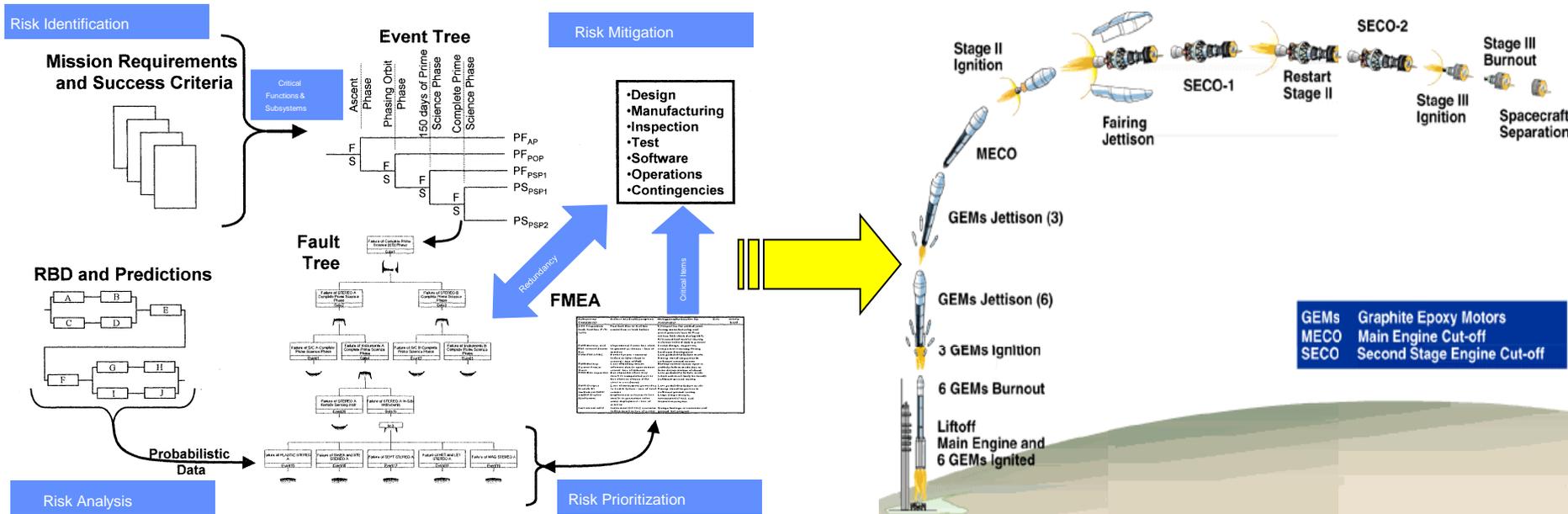
Once Risks have been identified, much is still below the surface. You need to know your degree of exposure!

Reasons for Success (4R Model)

Risk management & Mission Success

Risk Management helps us better identify the risks, manage the uncertainty and understand our decisions

Implementing a Risk Management Process increases the likelihood of Mission Success

What is Risk (per NPR 8000.4)

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

Ref: NPR 8000.4A "Agency Rosk Management Procedural Requirements"

Acceptable Risk

Acceptable risk is a result of a knowledge-based review and decision process

Management and stakeholders must participate in the risk acceptance process

Effective communication is essential to the mutual understanding of risk

Assessment and communication of acceptable risk must be a continuing process

"Risk that is <u>understood</u> and <u>agreed</u> to by project team, partners, Center management, suppliers, HQ mission directorates, stakeholders"

Unacceptable Risk

- Lack of planning for what could go wrong
- Departure from established systems engineering and management processes
- Not following design and verification rules
- Lack of engineering curiosity when a result is unexpected
- Not asking independent experts for confirmation and advice
- Lack of communication

Writing A Good Risk Statement

Condition + Consequence = Risk Statement

✓ Condition - a single, factual, phrase briefly describing the current key circumstances, situations, etc., is based in reality and have no uncertainty attached.

✓ Consequence - a single phrase or sentence that describes the key, negative outcome of the current condition.

✓ Risk Statement – a descriptive statement of a clear condition, that is concise, followed by a single consequence and will be understood by a majority of program/project stakeholders.

Building Consistency into a Risk Statement

✓ **Consider these questions when writing a risk statement:**

    Is it clear and concise?

    Will most project members understand it?

    Is there a clear condition?

    Is the consequence clear?

    Is there only ONE condition followed by ONE
      consequence?

✓ *Consistency builds Credibility*

What Makes Up a Risk Statement?

□ Must be a Fact or perceived to be Fact

□ Must be Reality Based

GIVEN → **CONDITION** → there is a **POSSIBILITY** that, → **CONSEQUENCE** will occur.

□ Must have a Negative impact to the Condition

□ Must focus on the long term impact of the risk to the Program/Project
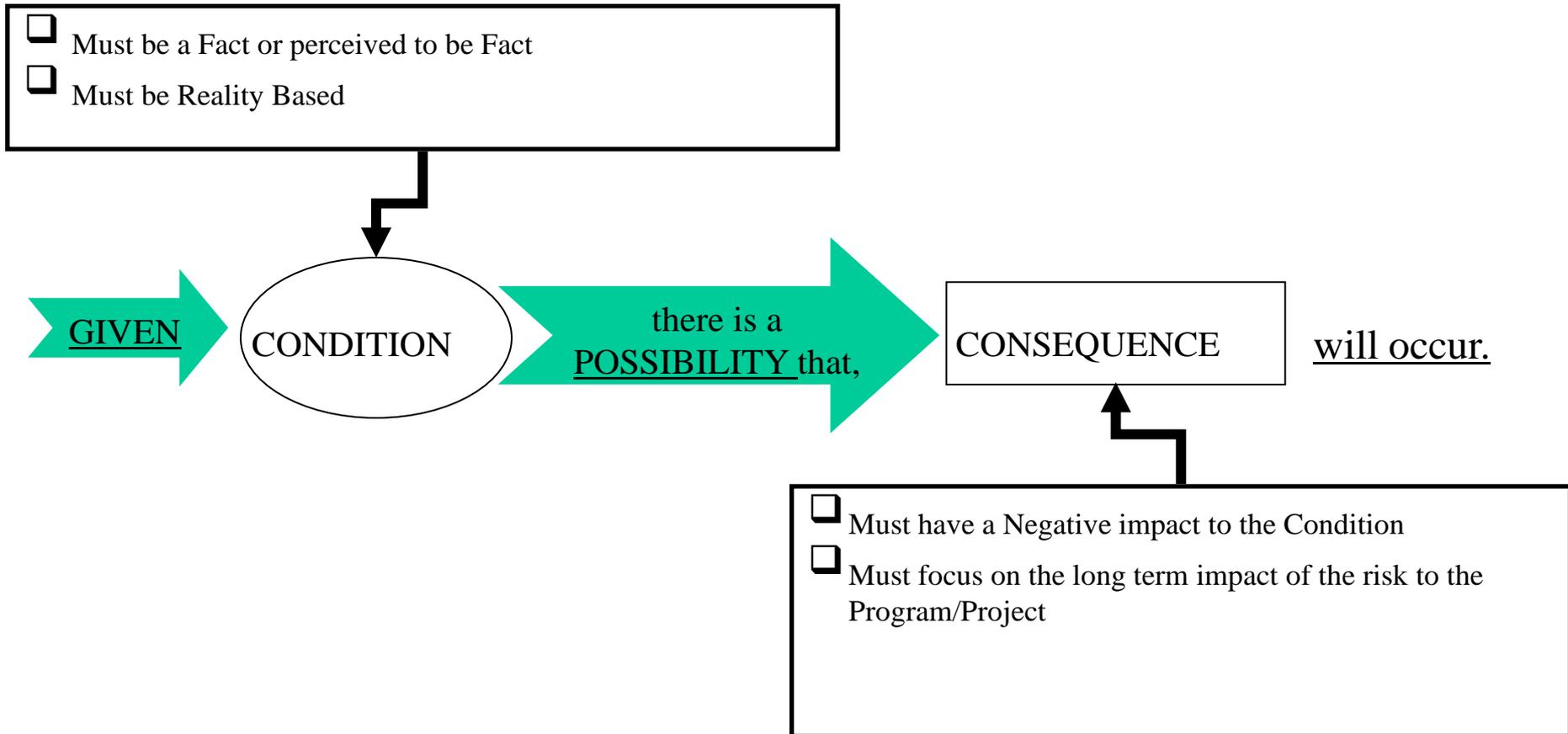
A good risk statement must be ACTIONABLE and have ONE condition and ONE consequence per statement

GSFC Risk Matrix Standard Scale

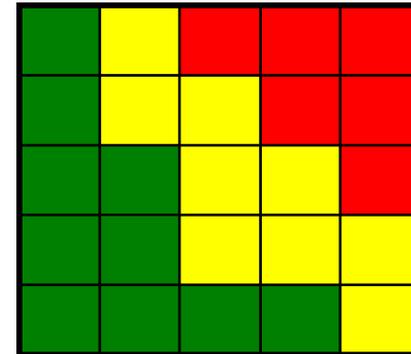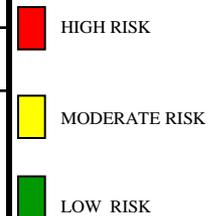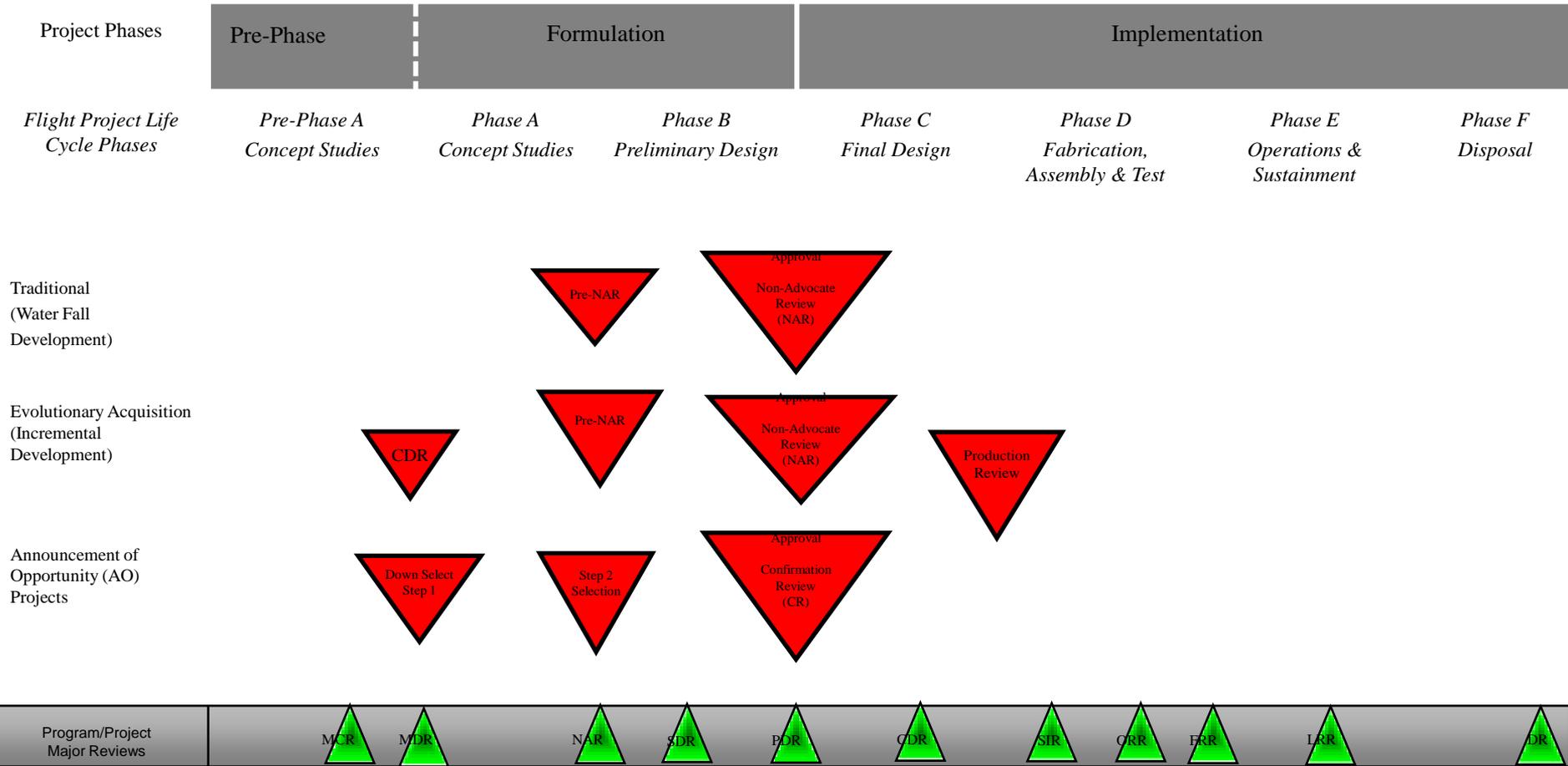| Likelihood	Safety (Estimated likelihood of safety event occurrence)	Technical (Estimated likelihood of not meeting performance requirements)	Cost/Schedule (Estimated likelihood of not meeting cost or schedule commitment)
5 Very High	$(P_{SE} > 10^{-1})$	$(P_T > 50\%)$	$(P_{CS} > 75\%)$
4 High	$(10^{-2} < P_{SE} \leq 10^{-1})$	$(25\% < P_T \leq 50\%)$	$(50\% < P_{CS} \leq 75\%)$
3 Moderate	$(10^{-3} < P_{SE} \leq 10^{-2})$	$(15\% < P_T \leq 25\%)$	$(25\% < P_{CS} \leq 50\%)$
2 Low	$(10^{-6} < P_{SE} \leq 10^{-3})$	$(2\% < P_T \leq 15\%)$	$(10\% < P_{CS} \leq 25\%)$
1 Very Low	$(P_{SE} \leq 10^{-6})$	$(0.1\% < P_T \leq 2\%)$	$(P_{CS} \leq 10\%)$

Likelihood (vertical axis: 5, 4, 3, 2, 1)
Consequence (horizontal axis: 1 2 3 4 5)

Consequence Categories					
Risk	1 Very Low	2 Low	3 Moderate	4 High	5 Very High
Safety	Negligible or No impact.	Could cause the need for only minor first aid treatment .	May cause minor injury or occupational illness or minor property damage.	May cause severe injury or occupational illness or major property damage.	May cause death or permanently disabling injury or destruction of property.
Technical	No impact to full mission success criteria	Minor impact to full mission success criteria	Moderate impact to full mission success criteria. Minimum mission success criteria is achievable with margin	Major impact to full mission success criteria. Minimum mission success criteria is achievable	Minimum mission success criteria is not achievable
Schedule	Negligible or no schedule impact	Minor impact to schedule milestones; accommodates within reserves; no impact to critical path	Impact to schedule milestones; accommodates within reserves; moderate impact to critical path	Major impact to schedule milestones; major impact to critical path	Cannot meet schedule and program milestones
Cost	<2% increase over allocated and negligible impact on reserve	Between 2% and 5% increase over allocated and can handle with reserve	Between 5% and 7% increase over allocated and can not handle with reserve	Between 7% and 10% increase over allocated, and/or exceeds proper reserves	>10% increase over allocated, and/or can't handle with reserves

■ HIGH RISK

■ MODERATE RISK

■ LOW RISK

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When Do You Start Risk Management?

Project Phases	Pre-Phase	Formulation		Implementation			
Flight Project Life Cycle Phases	*Pre-Phase A Concept Studies*	*Phase A Concept Studies*	*Phase B Preliminary Design*	*Phase C Final Design*	*Phase D Fabrication, Assembly & Test*	*Phase E Operations & Sustainment*	*Phase F Disposal*

Traditional (Water Fall Development)

Pre-NAR

Approval Non-Advocate Review (NAR)

Evolutionary Acquisition (Incremental Development)

CDR

Pre-NAR

Approval Non-Advocate Review (NAR)

Production Review

Announcement of Opportunity (AO) Projects

Down Select Step 1

Step 2 Selection

Approval Confirmation Review (CR)

Program/Project Major Reviews — MCR, MDR, NAR, SDR, PDR, CDR, SIR, ORR, FRR, LRR, DR
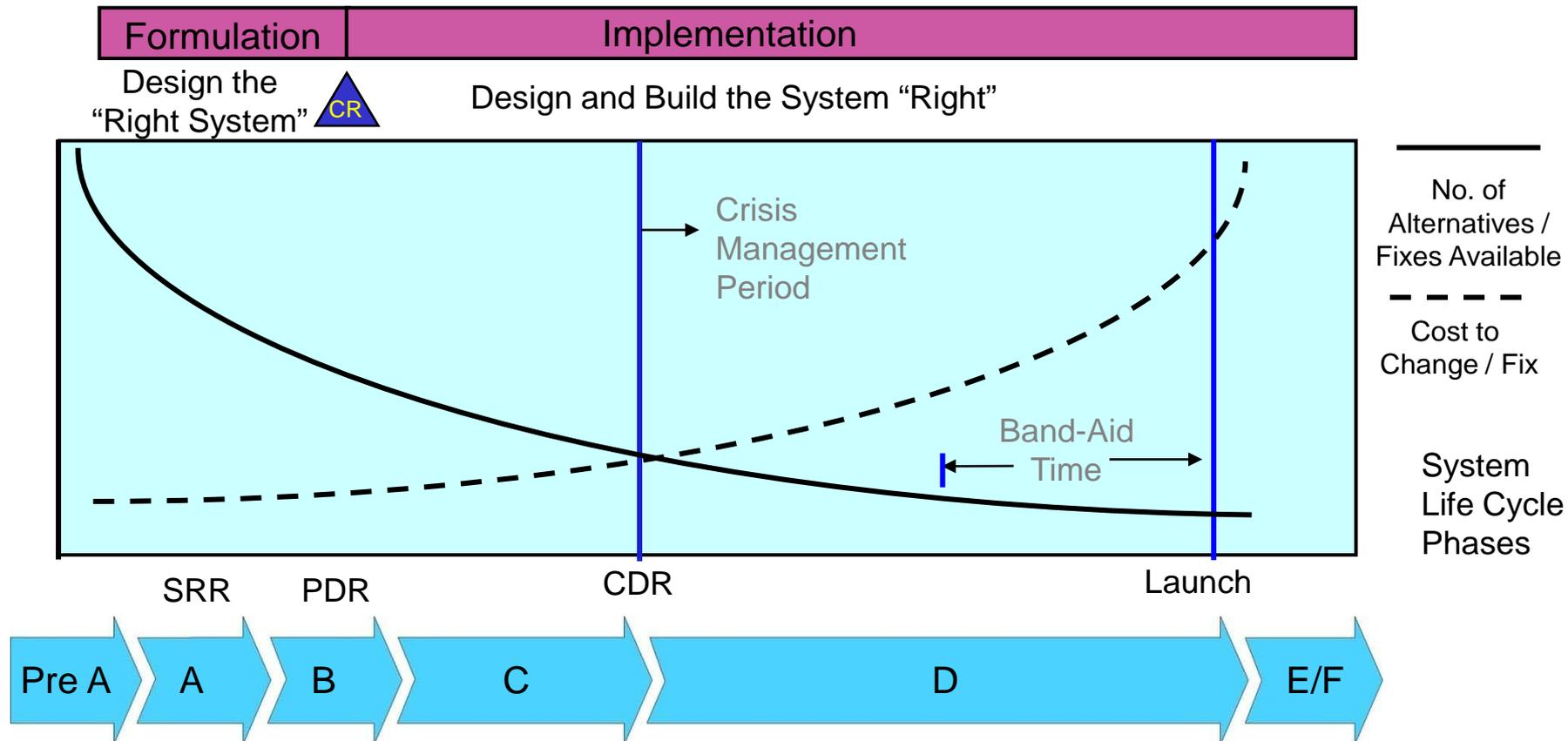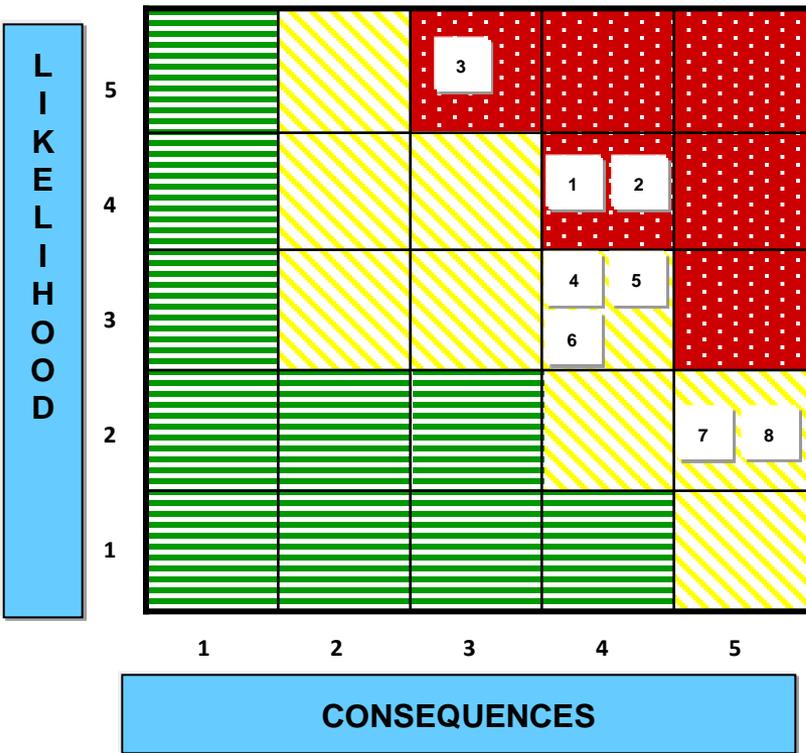
As Soon As Possible! - NPR 7120.5

Risk Management and the Life Cycle

Risk management is done throughout project life cycle

Performing risk management during the early phases has a high payoff

Formulation	Implementation

Design the "Right System" △CR

Design and Build the System "Right"

Crisis Management Period

Band-Aid Time

— No. of Alternatives / Fixes Available

- - - Cost to Change / Fix

System Life Cycle Phases

SRR PDR CDR Launch

Pre A A B C D E/F

Sample Risk Matrix

LxC Trend	Rank	Risk ID	Approach	Risk Title
⇨	1	11	M	
⇨	2	22	M	
⇨	3	33	M	
⇨	4	44	M	
⇨	5	55	M	
⇨	6	66	M	
⇨	7	77	M	
⇨	8	88	M	

LIKELIHOOD (5, 4, 3, 2, 1)

CONSEQUENCES (1, 2, 3, 4, 5)

Criticality
- High
- Med
- Low

L x C Trend
- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged
- ▢ New Since Last Period

Approach
- M - Mitigate
- W - Watch
- A - Accept
- R - Research

Example –Program Top Risk Report

Risks are identified and trended from the previous review to the current review

Risk Management & Your Role

- **Managing Risks is a part of your job**
  - ✓ **It is a management expectation.**

- **Identify and manage *Risks NOT Problems***
  - ✓ **However mitigating/eliminating risks may create new risks.**
  - ✓ **A single problem may have multiple risks.**

Summary

- **Everyone is involved in managing risks.**

- **Implement RM early in the program life cycle.**

- **Risks have been and always will be with us.**

- **Documentation and communication are essential parts of managing risk.**

- **NASA's Risk Management (CRM + RIDM) process starts with identifying risks, understanding risks, mitigation strategies, decisions and managing the uncertainties around those decisions.**

- **RM is a structured process that ensures consistency and increases credibility to include planning, tracking & controlling risks.**

- **Most risks are below the surface, yet there are always indicators.**

- **A good risk statement should be clear, concise and actionable.**

Familiar Conversations…

✓ **I've carefully thought out all the angles.**

✓ **I have done it a thousand times.**

✓ **It comes naturally to me.**

✓ **I know what I'm doing, its what I've been trained to do**

Nothing could possibly go wrong, right?

No beavers (castor canadensis) were injured while making these slides.

Think Again!