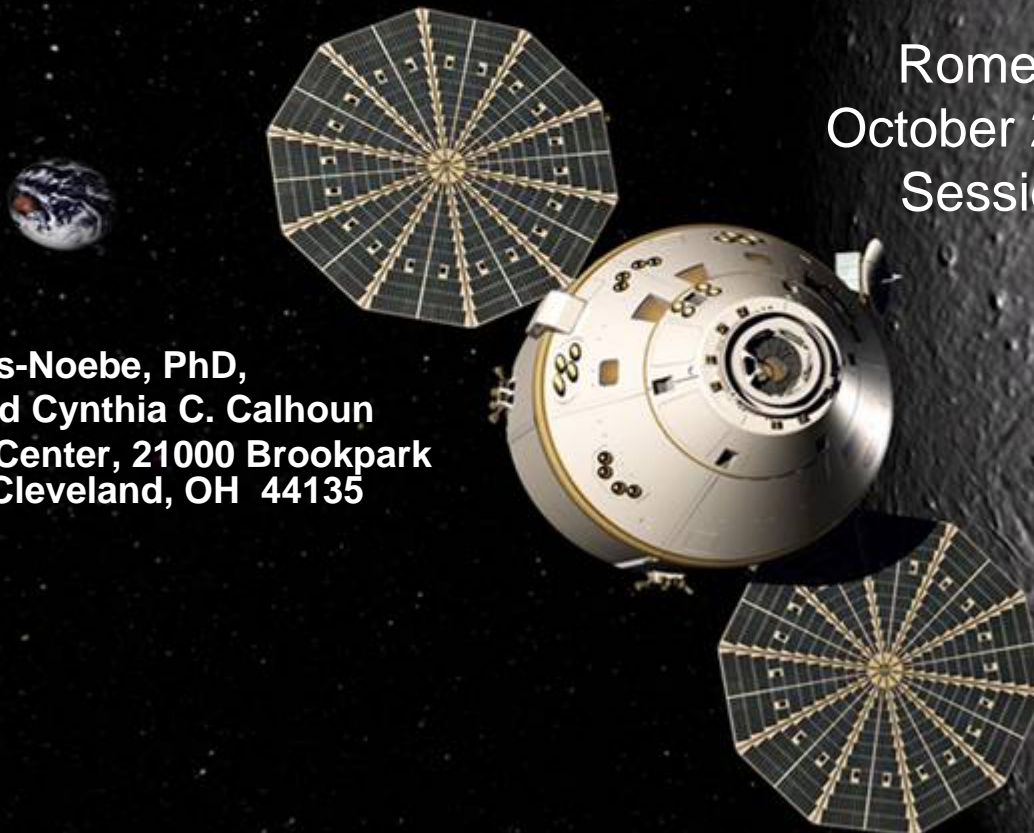


Integrated Risk Management Process for NASA Orion Crew Exploration Vehicle

3rd IAASS Conference:
'Building a Safer Space
Together'

Rome, Italy
October 22, 2008
Session 28

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My Objective Today



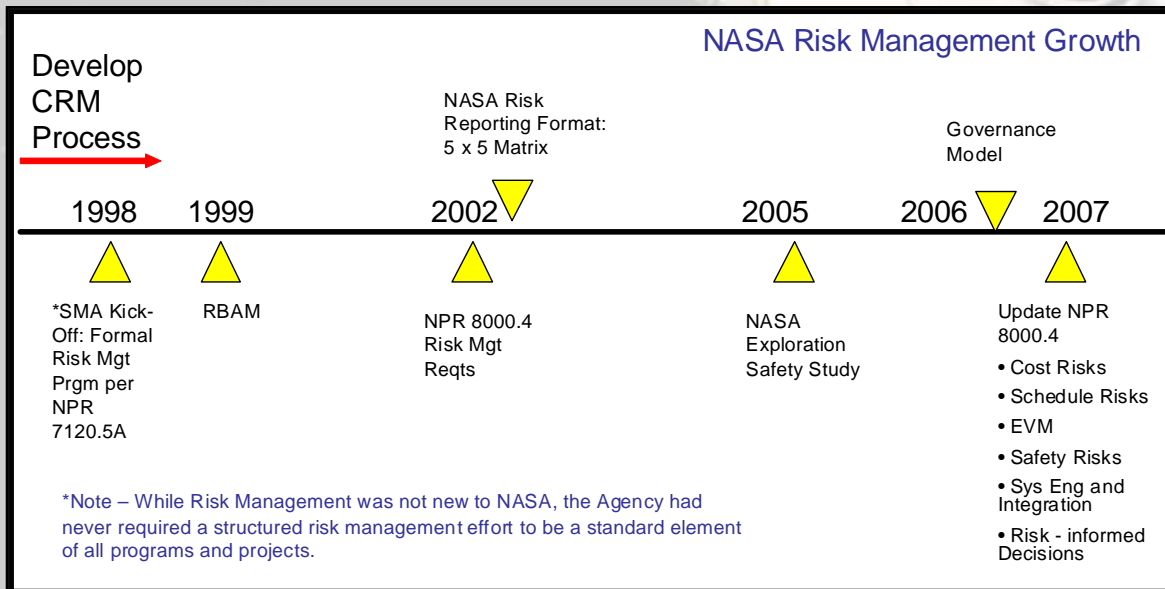
To present the concept of an Integrated Risk Management process and environment between Customer (NASA) and Contractor



History of Risk Management



- A logical, consistent approach to manage future uncertainties - been around since the beginning of time.
- Everything in life involves a degree of risk – from birth to death. Human Space Exploration is a risky endeavor.
- Managing uncertainties or risks have been influenced by technological advances as well as by the hazards that need to be addressed.
 - Invention of the steam-powered engines changed how society / government viewed and controlled technological risks.
- First Continuous Risk Management Course was taught in January, 1998 by the Software Assurance Technology Center at NASA GSFC in conjunction with Software Engineering Institute of Carnegie Mellon University



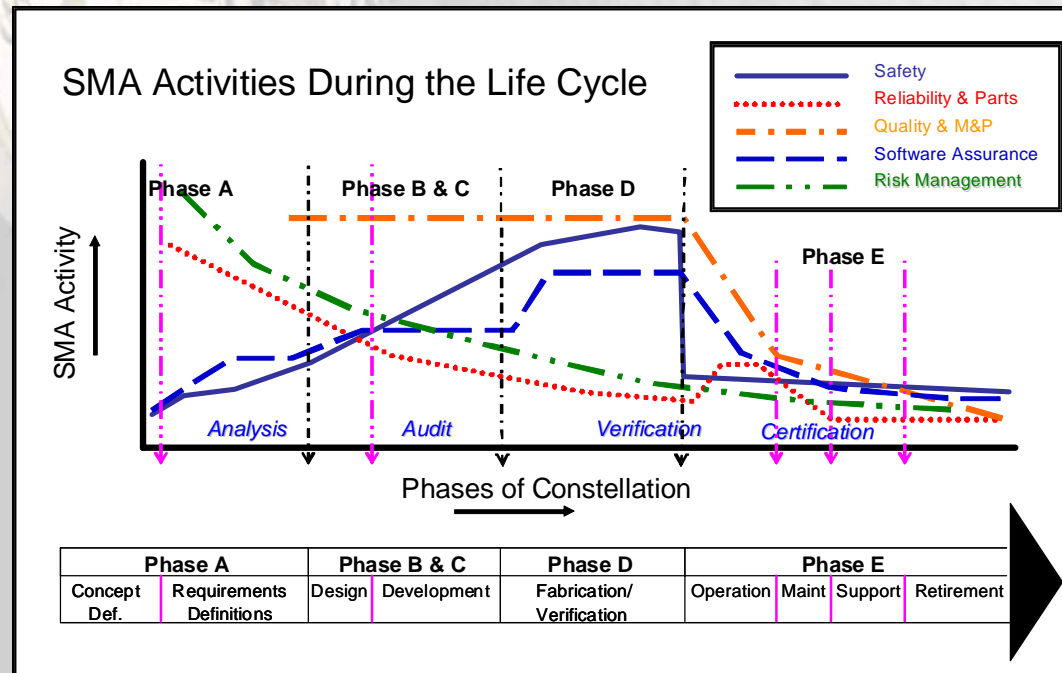
“We know the advancement of knowledge and the rate of progress is proportional to the risk encountered.”
 Neil Armstrong, March 2004, Houston TX.



Risk Management Process in Review



- An organized, systematic decision-making process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risk to increase the likelihood of achieving program/project goals. NPR 7120.5 NASA Program and Project Management Requirements
- Increasingly important, based on the limitations of budgets, schedules, expanding technologies, and exploration dreams of reaching the Moon and beyond.
- Should start early in the formulation phase with initial risk identification and development of a risk management plan and continue throughout the project life cycle.



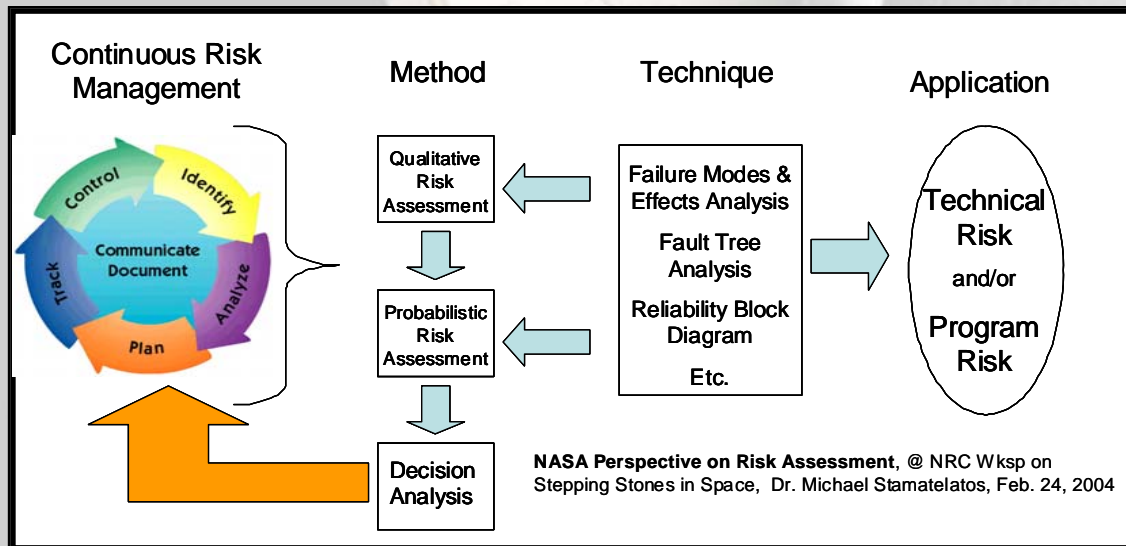


Project Leadership Responsibility



- Project Leadership must integrate RM into everyday life. This practice provides a disciplined environment that assesses continually what could go wrong, strategies to mitigate those risks, and helps prioritize precious resources based on risk.
- Need to anticipate and address uncertainties that threaten mission objectives, budget, and schedule of a project.
 - Uncertainties may include questions of material and parts quality; delays in delivery of sufficient materials to meet project needs; budgetary and personnel changes; and, incomplete knowledge.
 - These types of risks lead to schedule delays and budget overruns that can severely undermine confidence in the project
- Several factors play a key role in ensuring the process is successful during the implementation of CRM.
 - These factors include: open risk communication both horizontally and vertically, simple and efficient processes, an easy-to-understand risk tool, active engagement from program/project leadership, and vocal management champions.
 - Results in a trustworthy risk management process that has a positive effect on the programmatic decisions

- NASA has been broadening its repertoire of RA tools and has begun to systematically use a more comprehensive set of tools collectively called *Probabilistic Risk Assessment (PRA)*.
 - PRA is a systematic, logical, comprehensive discipline that uses tools like FMEA, FTA, Event Tree Analysis (ETA), Event Sequence Diagrams (ESD), Master Logic Diagrams (MLD), Reliability Block Diagrams (RBD), etc. to quantify risk
- Classical analyses have supported risk management process, implementing results of various methods with a basis of cost/ performance/ decision analysis to provide the information project managers need for successfully bringing in today's space missions within cost and schedule.
- However, there is a tendency to use risk assessment in a confirmatory way, when a design is already on the table, rather than as analysis-in-the-loop. As a result, system safety activities have significant limitations in influencing early design decisions.





Risk Integrated Concept



- **Utilization of Risk Data for Key Program/Project Decisions**
 - Risk informed decisions improve the probability of success for any project.
 - A more formal decision package format works better to get the right information in front of the management when those key decisions are being made. This ensures management is managing decision options in a consistent fashion.
 - Other important factors which play a role when making decisions include cost, schedule, performance and even safety.
 - There is a delicate balance between cost, schedule, and technical risks which requires trades to be made in the decision making process.
 - All options should be discussed to ensure the best solution can be met under the schedule and budget constraints.
 - Sometimes decisions trade one risk for another, or call for the balancing of a critical design or operations commodity to optimally balance risk.
 - **One exception to the rule: Never compromise on Safety!**



Risk & Knowledge Management



- A concerted effort in ESMD to integrate risk management and knowledge management into learn lessons from past programs, such as Apollo, Space Shuttle, and the International Space Station
 - *Many of NASA's documented mishaps did not occur due to a lack of knowledge but often because of a lack of questions that could have led to an effective application of existing knowledge*
- Identification, resolution, and avoidance of technical and programmatic issues are important for reducing risk in spaceflight programs. Documented lessons learned, experiences, and best practices enable program personnel to mitigate recurring technical and programmatic issues that negatively impact cost, schedule, system performance, mission success, and safety. Such documentation plays a key role in preserving NASA's corporate knowledge for new and continuing programs.
- To accomplish this, ESMD risk and knowledge management practitioners use a set of interrelated risk and KM processes, including:
 1. Pause and Learn (PaL).
 2. Knowledge-Based Risks (KBRs).
 3. Web-enabled high-performance teams.
 4. Knowledge-sharing forums.
 5. Experienced-based training.
- Knowledge management should enable a learning culture of continuous sharing and learning to appropriately manage risks, apply the best collection wisdom to challenges and to avoid repeating already experienced lessons when possible. An effective integration of knowledge management with risk management has the best chance of helping the Agency achieve the goal of becoming a true learning organization

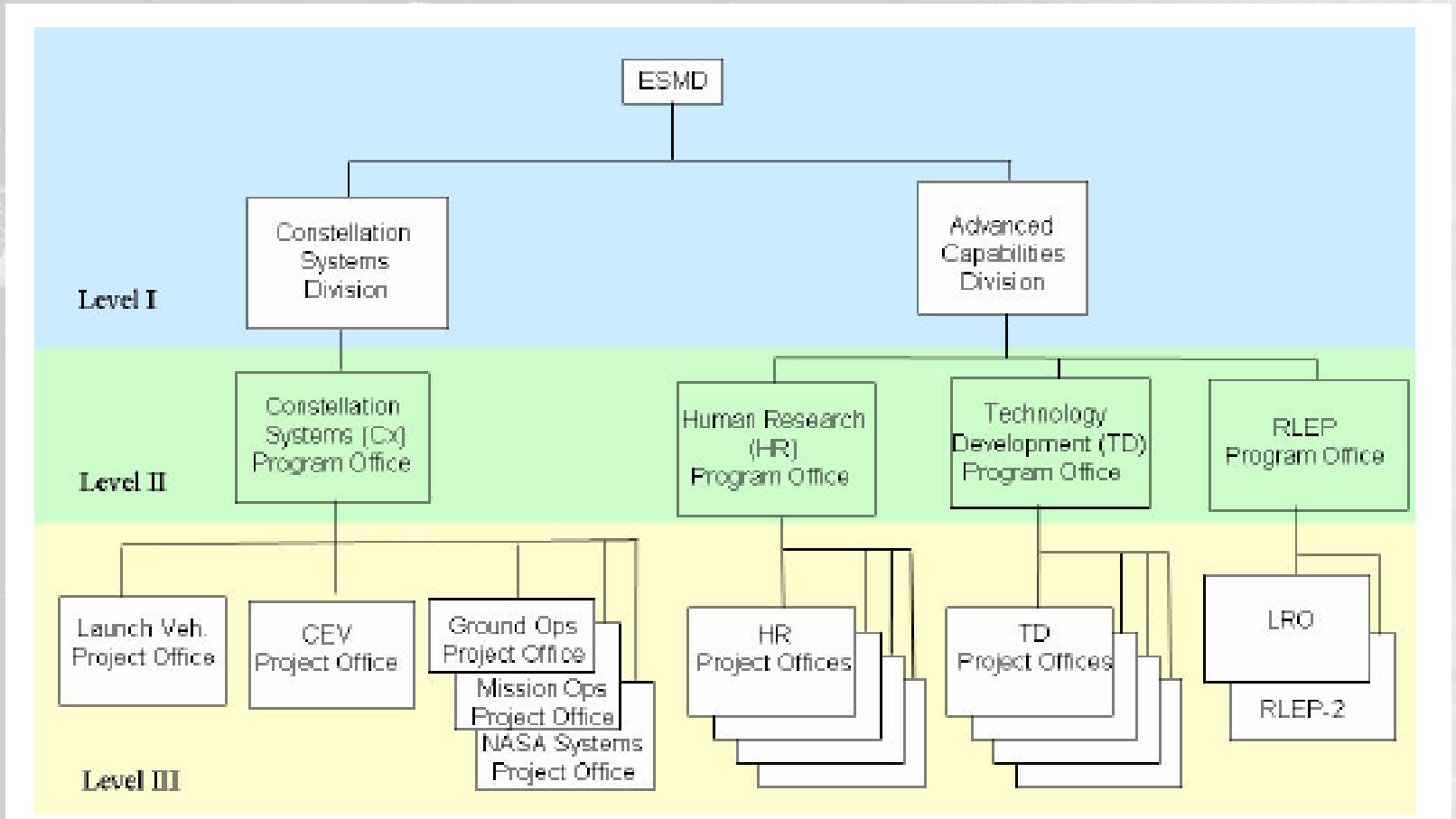
“Those who cannot learn from history are doomed to repeat it.” George Santayana



Integrated Risk Management Process for NASA Orion Crew Exploration Vehicle

**“Do not fear risk. All exploration, all growth is calculated.
Without challenge people cannot reach their higher
selves. Only if we are willing to walk over the edge can we
become winners.”**







Integrated Risk Management for Orion



- An integrated risk management team working at all levels of the Orion Project
 - “**Badgeless**” team
 - NASA (customer)
 - Multiple contractor teammates (Prime and Subs)
- Integrated working groups (IWG) formed to provide analytical or functional integration and other services (specialized skills, analytical products, design criteria/standards management, etc) to Integrated Product Teams (IPTs), Subsystem product Teams (SPTs) and other IWGs.
- One IWG is the Integrated Risk Management team whose approach is an integrated process throughout all levels of the project.
 - Each company performs risk management independently and separately.
 - As one team, (NASA and all Orion contracting companies), risks are identified and discussed at a working group level lead by Risk Integrators (RI) and escalated to the appropriate Risk Board (RB) or Panel for approval.
 - Each risk is managed at the level/entity where budget and resources are available.
 - One Risk Management Plan for all parties The Integrated Risk Management Plan was written in conjunction with representatives from the NASA Orion team and Prime Contractor and their subcontractors. It defines and describes a common risk management process to be used across the entire Orion CEV Project.
- “Dedicated to a common goal: **Success of the Orion Project**”

Orion/Constellation Work Locations

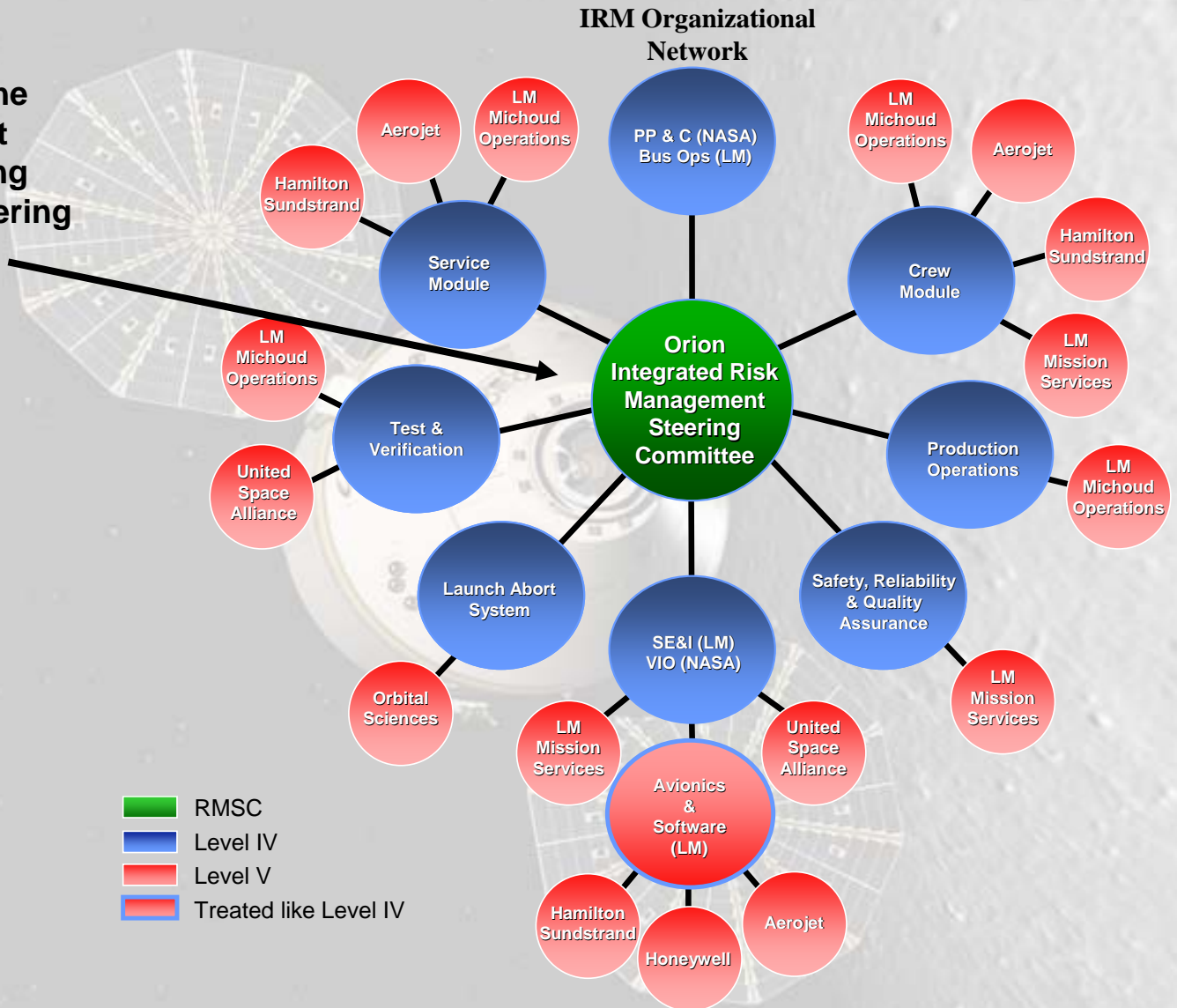




IRMWG Organizational Network



At the center of the Risk Management Integrated Working Group is the 'Steering Committee'





Risk Management Structure



Project Orion Organizational Structure

- **Level I** – Exploration Systems Mission Directorate (ESMD)
- **Level II** – Constellation (Cx) Systems Program Office
- **Level III** – NASA Orion Project/Program Office
 - NASA Project Manager
 - Contractor Program Manager
 - NASA Risk Management Officer
 - Has two Risk Management leads
 - Contractor Integrated Risk Management (IRM) Director
 - Has two Risk Management leads
- **Level IV** – Spacecraft Major Elements
 - 7 Panels, each jointly chaired by a NASA and the Contractor manager
 - Each panel also has a NASA, and the Contractor Risk Integrator
- **Level V** – Major Element Subsystem
 - Level IV Subsystems and Major Subcontractors
 - Each Subcontractor has a Risk Integrator
 - Some, but not all Level V and below subsystems, have a Risk Integrator

Orion



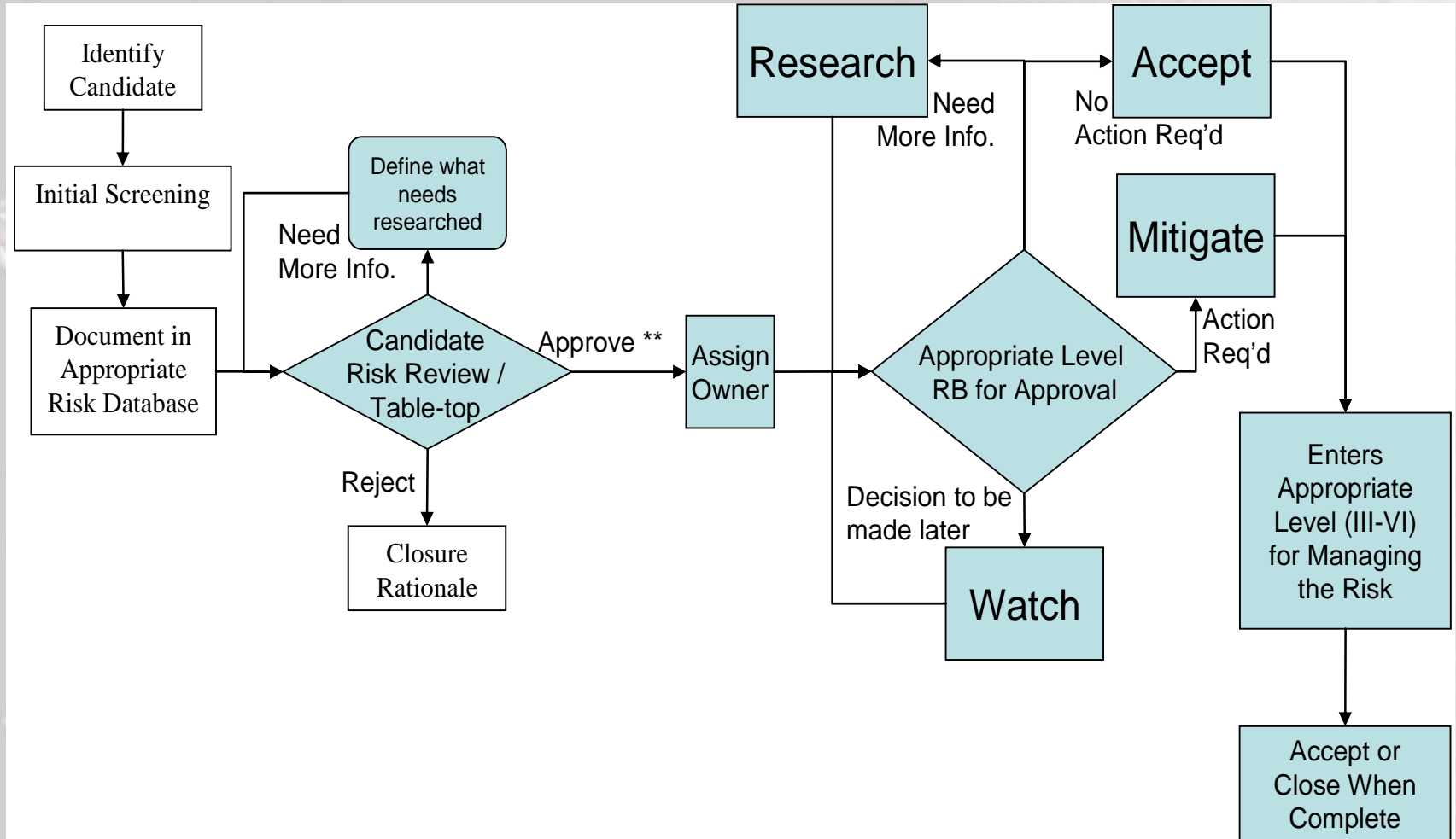
Common 'Understanding'



- Common Structure/Process
- Common Risk Statement Format
- Common Definitions/Terminology
- Common Scoring Criteria
- Common Handling Strategies
- Common Closure and Acceptance Criteria
- Common Database



Simplified Risk Process Flow



** Candidate is approved by an appropriate authority at the level the candidate is discussed



Candidate Risk



- Any concern (or uncertainty) is classified as a Candidate Risk
- A Candidate Risk is described with a Risk Statement, Title, and Context
- Candidate Risk visibility is limited to the owning organization that created it (protected in the database)
- Candidate Risks become Risks after discussion/agreement among the appropriate team members, along with applicable Risk Board concurrence

Writing Risk Statements

Components of a Risk Statement

Given the **Condition**, there is a possibility that the **Consequence** will occur.

Condition is defined as a single phrase that describes current key circumstances, and situations that are causing concern, doubt, anxiety, or uneasiness

Key points in identifying a condition are:

- Must be a FACT or perceived to be FACT
- Must be REALITY BASED
- Must be ACTIONABLE

Consequence is defined as a single phrase or sentence that describes the key adverse event or negative outcome(s) of the current conditions.

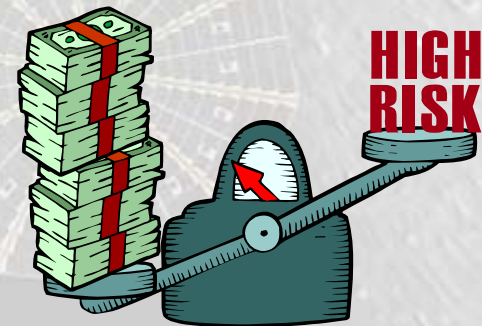
The Risk Score

- Orion uses the 5x5 diagram to numerically display the risks
 - Risk Score is the block where Likelihood and Consequence intersect
- Each attribute is assigned a value
 - Likelihood: 1-5
 - Consequence (Safety, Performance, Cost, Schedule): 1-5
 - Timeframe: near-term <3 mos., mid-term 3-9 mos., far-term >9 mos.
- Risk Level
 - High - Red
 - Moderate – Yellow
 - Low - Green

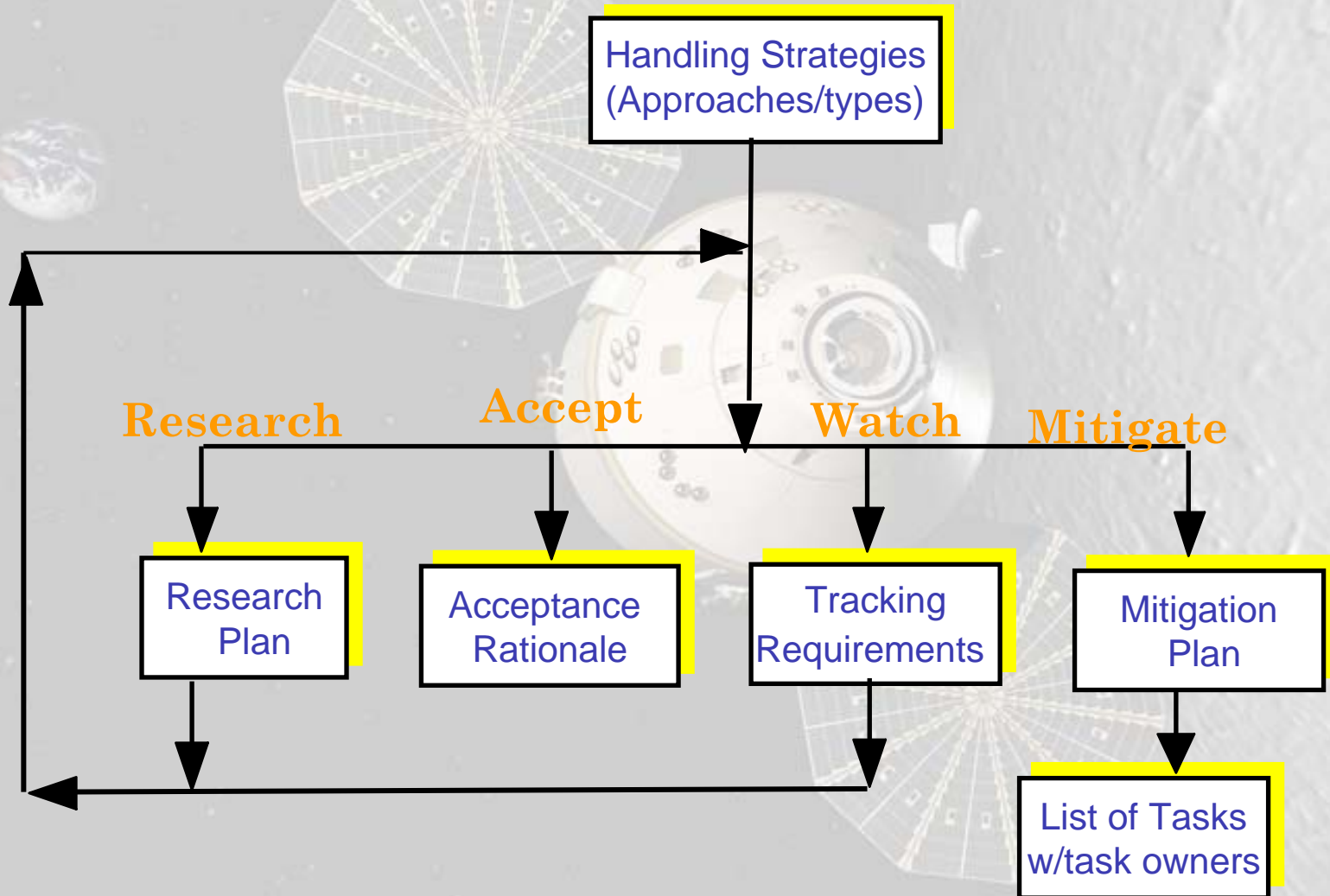
Likelihood of Occurrence	Very High (5)	10	16	20	23	25
	High (4)	7	13	18	22	24
	Moderate (3)	4	9	15	19	21
	Low (2)	2	6	11	14	17
	Very Low (1)	1	3	5	8	12
		Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
		Consequence of Occurrence				

Prioritizing Risks

- Purpose:
 - Sort through a large amount of risks and determine which are most important
 - Separate out which risks should be dealt with first (the vital few risks) when allocating resources
- Each organization jointly develops a Top Risk List at their Risk Board
- Each Top Risk List gets discussed at the Risk Board at the next higher level in the organization



How to Handle the Risk





Orion Metrics - Track



Program metrics for reporting

Name	Description
Number of approved risks by organization	Red, Yellow, Green Count for each org
Cost Liens	Impact value to project determined by likelihood factor
Cost threats – unfunded mitigation	Number and cost of unfunded steps
Mitigation plan stability	Trend of number of step changes
Number of New/Open/Closed items	Trend the activity reporting period
Mitigation latency/tardiness	Number of late tasks

Process metrics used for RM process improvement

Name	Description
Number of escapements	Problems occurring not identified as risks
Duplicate risks/candidate risks	Coordination across all entities
Types of risks	Assessment of maturity of project (project phase)
Number of Candidate risks/month	Assessment of risk identification activity
Candidate risk staleness	Indicates if process is getting right attention
Risk staleness	Indicates if process is getting right attention
RB action items	Assessment of IRM pre-coordination
RB delays	Assessment of management RM focus
Training and risk identification correlation	Assessment of training effects
Distribution of RB results	Indicates workload of IRM team

Maintain Control on the Risk Handling

- The four decisions that can be made are:
 - Continue as planned
 - Replan – Modify the current mitigation plan
 - Invoke a fallback plan
 - Close or Accept the risk
- Ensure that project risks continue to be managed effectively
- Use tracking data to determine how to proceed with risks

Closure vs Acceptance

- Some risks have enough residual risk after mitigation and therefore can only be “Accepted”
- Any risk with a Risk Score of 3 or less can be “Closed”
- Any risk with a Risk Score of 4 or higher can only be “Accepted”
 - Must get concurrence from RB of the highest escalation level (e.g. Top Program Risk needs Program Manager concurrence)

Likelihood	Very High 5	10	16	20	23	25
	High 4	7	13	18	22	24
	Moderate 3	4	9	15	19	21
	Low 2	2	6	11	14	17
	Very Low 1	1	3	5	8	12
		1 Very Low	2 Low	3 Moderate	4 High	5 Very High
		Consequence				



Communicate and Document



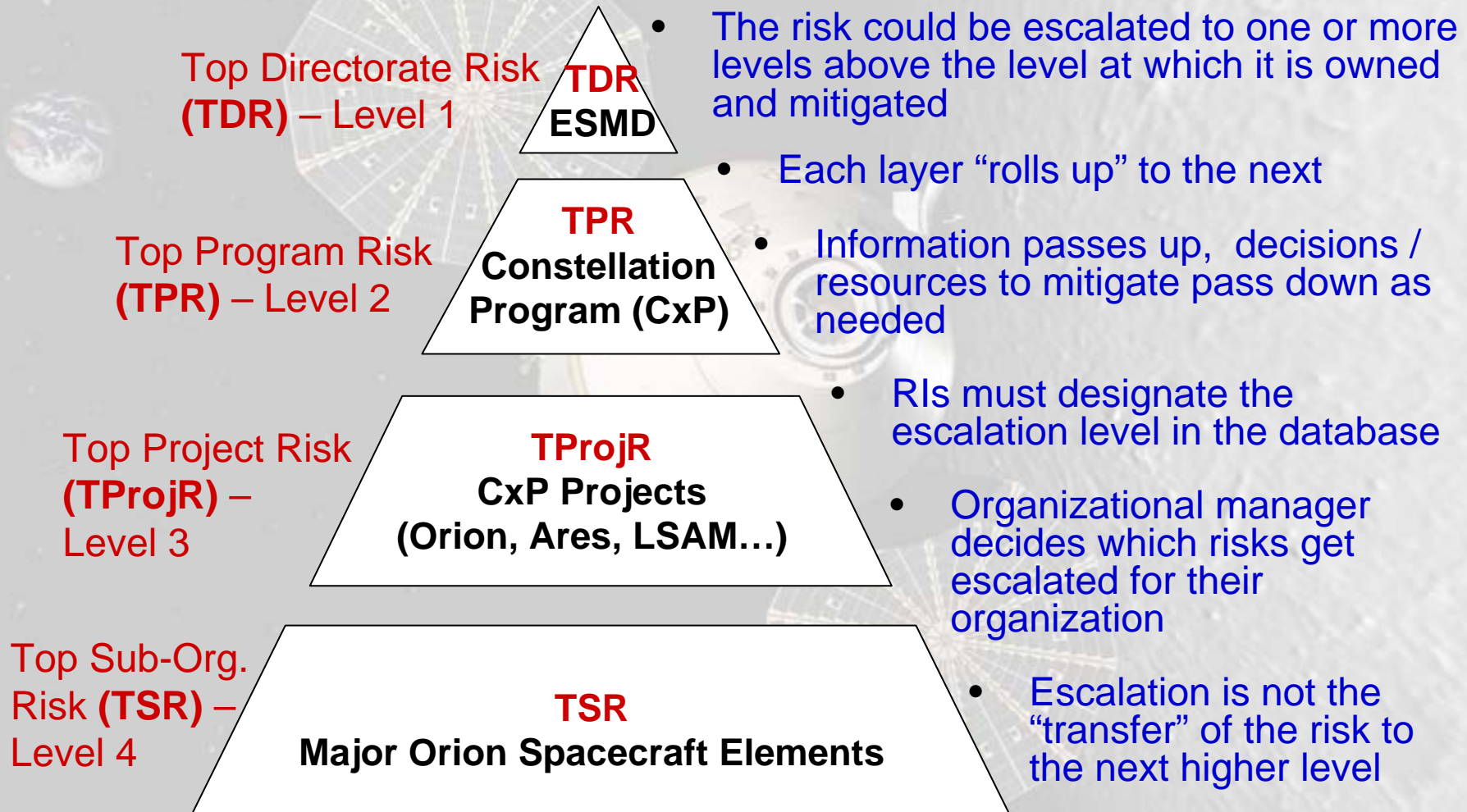
- Risk Communication – risk boards
- Risk Communication in Major Reviews
- Risk Database Communication
- Collaborative Environment Communication



Risk Escalation

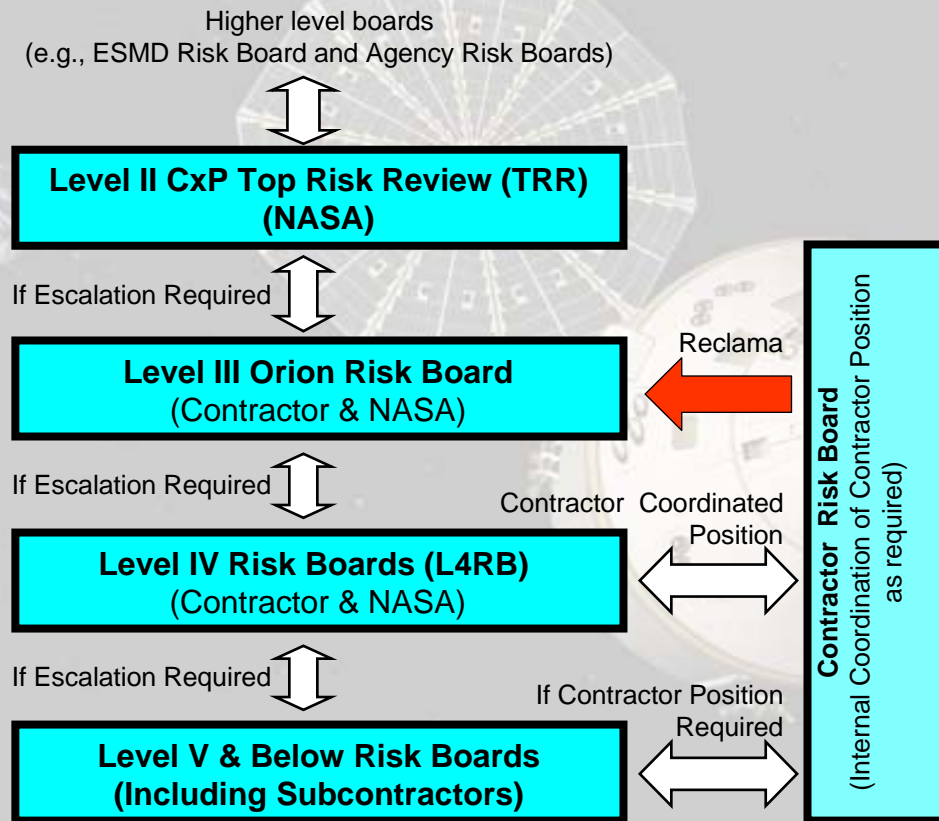


Definition: The process of raising risk attention to a higher organizational level at risk boards or other appropriate forums





Risk Board Relationships



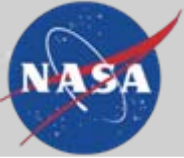
- Risks may be identified, captured and managed at any level
- Risks are managed at the lowest appropriate level (w/authority and resources to work mitigation tasks)
- Risks are communicated to all appropriate levels (exceptions include company-sensitive data)
- Risks may be escalated to a higher level (or pulled up by the higher level) due to:
 - Significant Impact within the Project/Program
 - Coordination of Mitigation
 - New Resources Req'd
 - Visibility Req'd
 - Disagreement on a Risk/Mitigation
- Risks may also be pushed to a lower level when it can be better managed at that level
- If agreement with the L4RB is not achieved, Contractor can present position to the Orion RB for resolution



Cost Threat Definition



- **Definition: A Cost Threat is anything that may cause additional moneys to be spent above and beyond the current Orion Project Baseline**
- Cost Threats Arise from several reasons:
 - Baselined work has unforeseen complexities/variances which may cost more than originally estimated
 - Schedule slips have occurred which may use additional resources
 - Requirements growth/changes require new funding
 - Labor rates or material costs have increased
 - Mitigation activities requiring additional funding to reduce project risks
- Each Orion organization evaluates their work elements to determine potential cost threats, and document in the RM database.
- Cost threats for Orion are tracked in the CxIRMA database; Cost Threats are an agenda item at the various risk boards
- A Cost Threat is the money required to mitigate risk that is not currently in the Orion Project Baseline. Used to allocate management reserve to address potential cost overruns associated with unfunded mitigation of Orion risks.
- A cost threat remains in place until the budget is approved through a CR, risk is accepted or cost threat is rejected.
- The Orion Program Planning & Control Office (PP&C) ensures that all cost threats are recognized and integrated into a total project cost risk assessment.
- **Bottom line: No risk – no money**



Keys to Success (So Far!)



- ✓ Need Executive Buy In – Top Down Approach
- ✓ Establish a Risk Management Steering Committee
- ✓ Establish Risk POCs for Each Organization (Risk Integrators)
- ✓ Establish an IRM Working Group (IRMWG) to Facilitate Communication
- ✓ Document the RM Process in a Risk Management Plan (RMP)
 - ✓ Develop the RMP as a Team (IRMWG)
- ✓ Provide IRMWG Periodic Face-to-Face Opportunities to Iron Out Issues
- ✓ Develop Effective Training
 - ✓ Train everyone on the project
- ✓ Horizontal and vertical integration:
 - ✓ Products
 - ✓ Ideas
 - ✓ **Communication**