

# Implementation of Flexible Risk Philosophy and Tracking Methods on Class C/O Programs

Madison Telles, Senior Mission Assurance Engineer

Patrick Klansek, Principal Mission Assurance Engineer



2265 E El Segundo Blvd • El Segundo, CA 90245

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# PAIN POINTS OF RISK MANAGEMENT

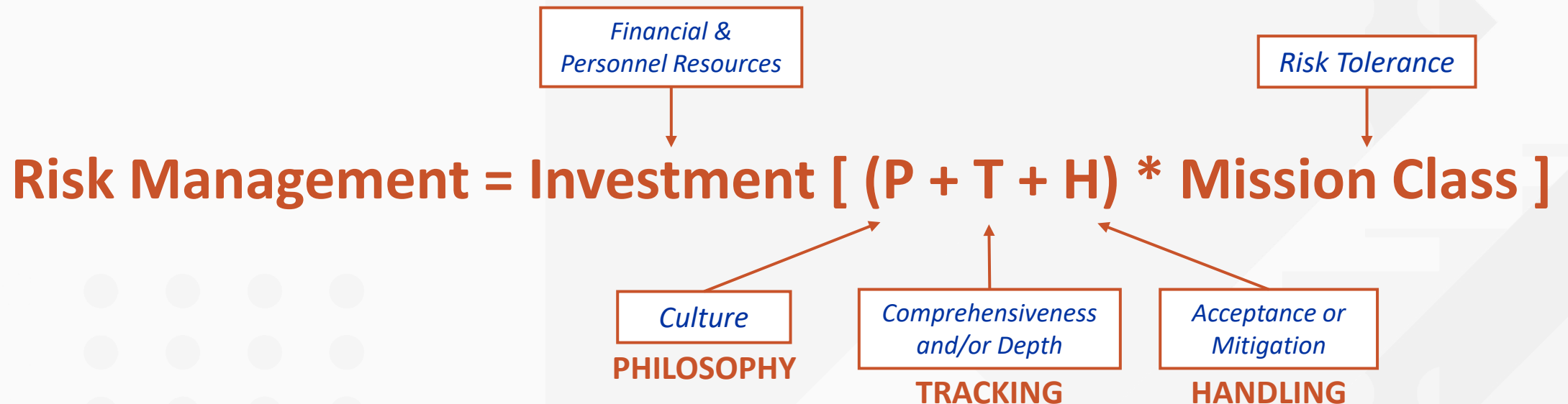
- Commonly seen as a later problem and/or external to the core execution needs of the program
  - If you know you must deal with something, but you know about it, is it ok to not explicitly track it?
    - If a tree falls in the forest but nobody is around to hear it, does it make a sound?
- Misunderstood as a paperwork activity
  - Documentation supports sound decisions
  - Traceable by others to limit the amount of reverse engineering to retroactively affirm decision
- Programs at Class C/D level believe they don't need robust risk processes and practices due to the nature of risk tolerance
  - C/D missions may care more about risk because it has less structure; it is adaptive to program needs

C/D missions **ARE NOT** risk agnostic, they **ARE** risk tolerant



# RISK MANAGEMENT EQUATION

- Contextualized as several functional levers that can be adjusted based on program needs
  - Strategy or consciousness will look different if one or several P/T/H elements are changed compared to a defined baseline



# PHILOSOPHY



# PILLARS OF AN EFFECTIVE RISK MANAGEMENT CULTURE



# EFFECTIVE RISK MANAGEMENT CULTURE



- Model courageous, resilient leadership
  - Make decisions, admit failures, move forward
- Build relationships
  - Constantly encourage, develop, and mentor those you support
  - Engrain MA thinking into teammates
- Trust is the lubricant of efficient execution; demonstrate care and concern as well as technical savvy
  - Healthy team dynamic based on a common vision is fundamental to success in all areas

# EFFECTIVE RISK MANAGEMENT CULTURE



- Identify affected or knowledgeable SMEs for best-effort inputs
  - Consensus is important, but does not have to be unanimous
- Capacity to handle uncertainty can reduce the impact of risk
- Everyone functions as one team with one goal in mind for the end customer

# EFFECTIVE RISK MANAGEMENT CULTURE



- Open sharing of information can help identify additional risk or take advantage of previous risk handling activities
- Good enough is best
  - Determining "good enough" is both art and science. Understand that excellence is possible even in constrained environments
- Keep things simple
  - When things are very complex and very complicated, reframe to simplify things into something that can be managed with discreet actions



# EFFECTIVE RISK MANAGEMENT CULTURE



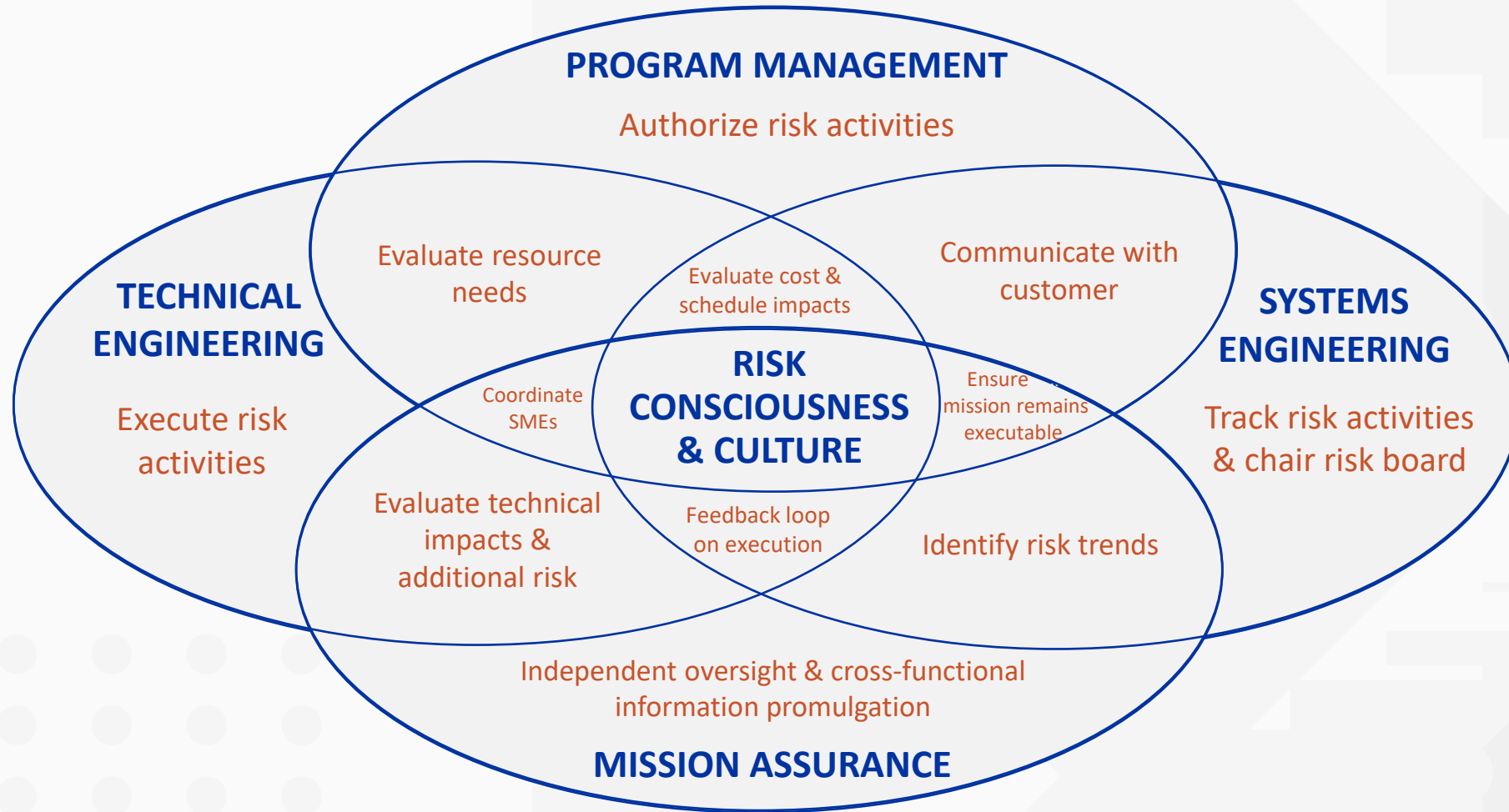
- Human and system safety *always* take precedence
- Take a step back and identify the most pressing issue. Tackle that first.
  - This includes high criticality or long-lead items
- Use feedback to steer next-steps
  - Can come from engineering, program leadership, or customer

# EFFECTIVE RISK MANAGEMENT CULTURE



- Drive action with imperfect information
- Deprioritize or accept risk where reasonable
- Understand priorities for mitigating risk
  - Design for minimum risk
  - Additional analysis
  - Condition detection & warning
  - Develop alternatives
- Course correct when needed based on new information or risk items

# SYMBIOSIS OF RISK



# TRACKING METHODS



# CRITICAL CRITERIA FOR PROGRAM TEAM

- Risk management scope creep is common, need to distill down to the important information which in turn allows for quick digestion and dynamic re-prioritization
- Risk originator & risk owner
  - Individual people; REA as risk owner maintains accountability to drive to closure
- Risk type
  - Technical, Cost, Schedule Safety
  - Every risk has all aspects; track the most severe case that will impact the end customer
- Risk statement
  - If [CONDITION] due to [CAUSE], then [CONSEQUENCE]
- Likelihood and consequence score
- Critical milestones for evaluation or closure
- Impacts to other products or programs



# CRITICAL CRITERIA FOR END CUSTOMER

- System safety status
- Handling of the risk
  - Mitigated or accepted? Why? How?
- Estimated and realized **technical** impact
- Estimated and realized **schedule** impact (Class C emphasis)
- Estimated and realized **cost** impact (Class D emphasis)

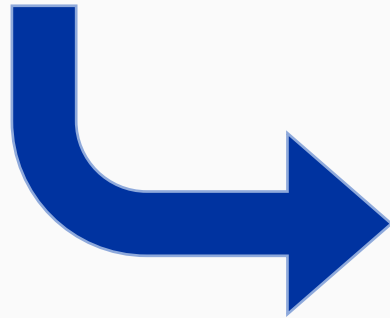
Refer to ATR-2023-01889 Table 2, Mission Class Risk Profiles




# USEFUL REPORTING TOOLS

## TRADITIONAL

Risk ID (#)	Risk Name (text)	Risk Description (text)	Date of Risk Identification	Risk Type (Internal, Supplier, External)	Risk Status (Open, Retired, Realized, Accepted)	Risk Rating (G,Y,R)	Risk Likelihood (1-5)	Risk Consequence Summary (1-5)	Risk Cost Impact (Best Case) (\$)	Risk Cost Impact (Most Probable) (\$)	Risk Cost Impact (Worst Case) (\$)	Risk Mitigation (text)	Risk Point Of Contact (Person Name)



## AGILE

 ZZ - TMP / ZZTMP-3974

### Test Risk Ticket 006 -- Unproven Landing ConOps for Mars Science Lab (MSL) and Curiosity Rover

[Edit](#) [Add comment](#) [Assign](#) [More](#) [Watch Item](#)

**Details**

Type: ? Risk/Opportunity Resolution: Done

Priority: 🔥 Critical Fix Version/s: None

Affects Version/s: None

Component/s: PRP, TCS

Labels: None

**General** Assessment Technical Staff/Peer Teams

Risk Category: Technical

Risk Statement: IF the rover descent mechanisms fail DUE TO the inability to practically test all major descent components on Earth, THEN there may be catastrophic loss of MSL and the Curiosity rover.

# BENEFITS OF AGILE FUNCTIONALITY IN JIRA\*

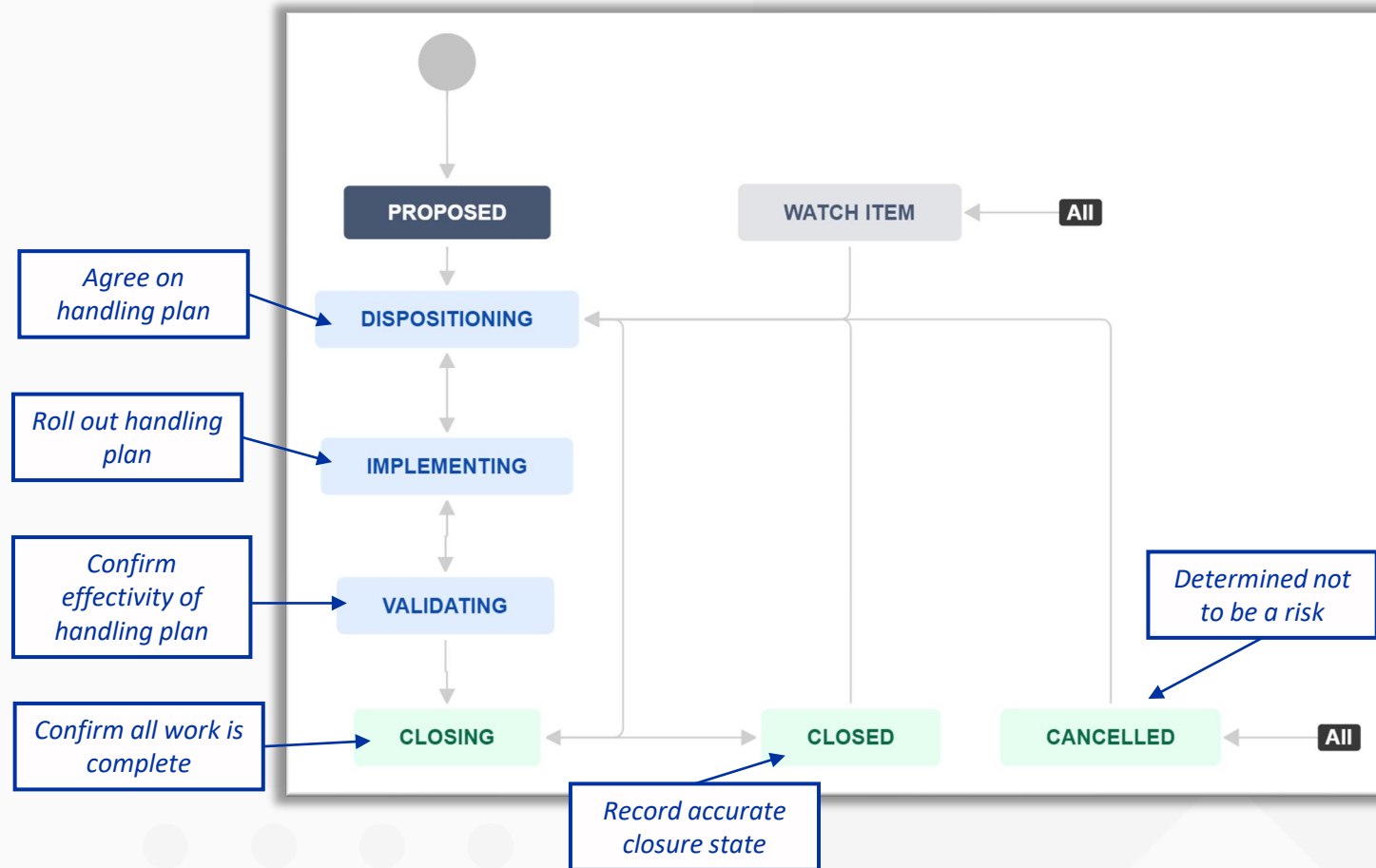
- Anyone with system access can open a risk
- Anyone with system access can view a risk
  - Tracker is very visible and file doesn't get lost in a folder somewhere nobody can find
- Documentation can be added directly to ticket, including dynamic links to other tickets
  - Risk artifacts, issues that inform a risk, etc
- Easy to reassign and reprioritize
- Approval tracking and automatic timestamped change log
- Easily configured exportable reports for those who don't have access
- Easy filtering, dashboards, and integration with other tools like PowerBI for data visualization

**\*Note:** The tool is less important than the functionality it provides





# PURPOSE OF THE RISK WORKFLOW



- Workflow models the thought process of evaluating, solving, and anticipating risk
- More representative of review, mitigation, and approval process for risk
- “Watch Item” holding state to document worry beads that may not warrant a full risk yet

Workflow customized to support the rapid-execution business model



# PHASES IN RISK WORKFLOW

Proposed



*“What are the details of what could happen?”*

Dispositioning



*“Based on what we know, how do we plan to address and tackle this? What else do we need to know?”*

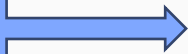
- Collect information that supports determining the **severity of the risk**
- Evaluate the scope to determine if it may affect other programs
- Identify who needs to be involved in the decisions moving forward

Implementing



*“How is the handling plan being executed?”*

Validating



*“Was the handling plan effective? What do we have to prove that?”*

- Evaluate the implementation for **completeness** and **effectiveness** for residual severity or return
- Determine if any additional risk is present that needs to be addressed

Closing



*“Have we completed all work to resolve the concern? Has it been cross-communicated?”*  
*“How do we carry lessons learned from this into the future?”*

- Document any lessons learned on the ticket and communicate up to appropriate product, program, or department leadership

Closed 😊



# USEFUL REPORTING TOOLS

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**Details**

Type:	<span>?</span> Risk/Opportunity	Resolution:	Unresolved
Priority:	<span>🔴</span> Critical	Fix Version/s:	None
Affects Version/s:	None		
Component/s:	PRP, TCS		
Labels:	None		

**General** Assessment Technical Staff/Peer Teams

Risk Category: Technical

Risk Statement: IF the rover descent mechanisms fail DUE TO the inability to practically test all major descent components on Earth, THEN there may be catastrophic loss of MSL and the Curiosity rover.

Likelihood: 3

Consequence: 5

Problem Source: Internal

Risk/Opportunity Rating: 15

Mitigated Risk/Opportunity Rating: 8

Mitigated Likelihood: 2

Mitigated Consequence: 4

End State: Closed

**Description**

EDL (entry, descent, landing) phase of Curiosity mission is comprised of 4 major phases/components:

- Heat shield – flight heritage
- Parachute – flight heritage
- Powered descent – development
- Sky crane – development

Some phases have repeated demonstrated flight heritage, whereas the powered descent and sky crane phases are in development specifically for MSL/Curiosity rover. The capability does not exist for all of these to be operationally tested sequentially prior to launch. There are several points of failure that should be addressed.



# USEFUL REPORTING TOOLS

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Edit Add comment Assign More Closing

**Details**

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Priority: Critical Fix Version/s: None  
Affects Version/s: None  
Component/s: PRP, TCS  
Labels: None

General **Assessment** Technical Staff/Peer Teams

Best Case Impact (\$k): 1,250  
Most Likely Impact (\$k): 10,750  
Worst Case Impact (\$k): 2,500,000

Cost Rationale: 

- Best Case: labor hours to run testing/analysis to demonstrate risk is within acceptable level and no mission-critical systems are subject to failure outside of nominal design
- Most Likely: some redesign and additional manufacturing efforts required based on findings from analysis to reduce risk to an acceptable level
- Worst Case: total loss of MSL and Curiosity rover

Closure Rationale: 

- Overall risk reduced based on extensive analysis of heat shield, parachute, propulsion descent mechanisms, and the sky crane. Where necessary, additional risk tickets were opened to address specific risks identified through the assessment of this risk. Ultimately, risk cannot be fully eliminated due to the requirements of the mission. There is residual risk in all phases of descent to the surface, but have been reduced to an acceptable level. Total loss of rover is possible, but significant impact to performance capability is considered the most pertinent to mission execution.

**HEAT SHIELD**  
Low severity residual risk.  
Heat shield materials have been tested and qualified to envelope uncertainty factors of heating while passing through Martian atmosphere. GNC and thermal analysis of worst-case entry heating is tracked on risk ticket [Document last modified: March 13] ticket RISK-1111

**PARACHUTE**  
Low severity residual risk.  
Extensive testing of new parachute deployment mechanisms were found, and flight heritage of parachute use across previous space-return missions (Space Shuttle, Soyuz, etc) .  
Re-contact of heat shield once parachute is deployed was reviewed and was deemed to be a minimal risk factor for failure. Reference risk ticket RISK-1111 for additional detail.

**POWERED DESCENT**  
Medium-low severity risk impact.  
2 fault tolerant to no-fire of solid thrusters for powered descent phase. Structures, thermal, and fault autonomy teams reviewed SOE and FMECA. Failure modes tracked on WRK-2000 and design changes were released following approvals on DSGN-2220 and DSGN-2221.  
Continual testing of powered descent performance indicates partial-power descent will result in significant damage to MSL/Curiosity, but is inherent to the mission design of descent. Residual failure mode remains the pyros firing, as any schedule slips may result in expiration of the canister. Analysis and final adjudication of this was documented on RISK-2222.

**SKY SCRANE**  
Medium severity residual risk impact.  
Drop testing of MSL/rover from sky crane mechanisms demonstrated susceptibility to Martian regolith kicked up by powered descent, tracked on RISK-3333. Additional shielding has been added to the crane housing and anchor points from cabling to rover to mitigate potential for degradation. Radar has potential to be affected by .02mm thick, .6cm<sup>2</sup> area coverage from regolith, so landing zone assessment has potential to be affected. Radar risk is tracked on RISK-4445.

Critical Path Impact: No  
Estimated Cost Impact (\$k): 12,500


Scope was acknowledged to be too wide for single risk, so other risk tickets were mentioned








Critical Path Impact: No  
Estimated Cost Impact (\$k): 12,500





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Affects Version/s:	None		
Component/s:	None		
Labels:	None		

**General** **Assessment** **Technical Staff/Peer Teams**

Technical Staff / Peer Teams: Assembly, Test, and Launch Operations Peer Team, Chief Engineer, Mission Operations / Ground Peer Team, Structures/Mechanisms Peer Team, Thermal Peer Team ...

Extensive list of teams that can be selected as affected OR for awareness



# CONCLUSIONS



# TAKEAWAYS

- Mission Assurance is not a function, it's a FABRIC
  - Inclusive of the vision, mindset, and execution – risk tracking is the loom that brings everything and everyone together
- Missions are best executed with risk and the culture around it in mind
  - When risk consciousness and culture is built into how the team functions and mission operates, stakeholders will be more informed about the residual risk posture

Risk Management = Investment [ (Philosophy + Tracking + Handling) \* Mission Class ]

