

Adaptive Mission Assurance (AMA) for NASA High Risk Tolerant, Constraints-driven Missions

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Adaptive Mission Assurance (AMA) for NASA High Risk Tolerant, Constraints-driven Missions

Outline

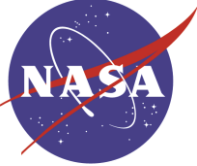
- ➔ • Introduction
- AMA Mindset
- The Sprint
- Unpacking the Approach
- Summary



Introduction

Background

- Adaptive Mission Assurance (AMA) has been adopted to support DoD, Intelligence Community Science and Technology Demonstration missions for two decades
 - *High risk tolerant while cost and schedule are heavily constrained*
 - *Challenged to optimize probability of mission success by trading technical performance and risk for cost and schedule*
 - *Incorporates “Agile” mindset, principles, and frameworks*
 - *Approach evolved and matured over the past 20 years*
 - *>95% success rate for meeting mission objectives*
- Task with Aerospace Corporation to develop an AMA implementation concept for NASA high risk tolerant, constraints-driven missions
- Whitepaper for public release being produced



Introduction

The Challenge

- Space community is acquainted with and skilled in Class A Mission Assurance
 - Accustomed to ultra-low risk tolerance for requirements-driven missions
 - 1st priority is to eliminate risk as much as possible to achieve highest probability of success
 - 2nd priority is good enough cost and schedule
 - Consequently, they trade cost and schedule to ensure lowest risk of near 100% performance
- Class D / Sub-Class D are Risk Tolerant, Constraints-driven missions
 - Typified by uncertainty, change, evolving outcomes, limited resources, and directed schedules
 - Requires 1st priority be cost and schedule with a willingness to accept risk
 - 2nd priority is good enough performance that still achieves mission goals and objectives
 - Consequently, they must trade on performance and risk for meeting cost and schedule constraints

Constraints-driven missions are challenged to “gracefully” accept risk within cost & schedule constraints while still achieving an agreeable expectation of mission success

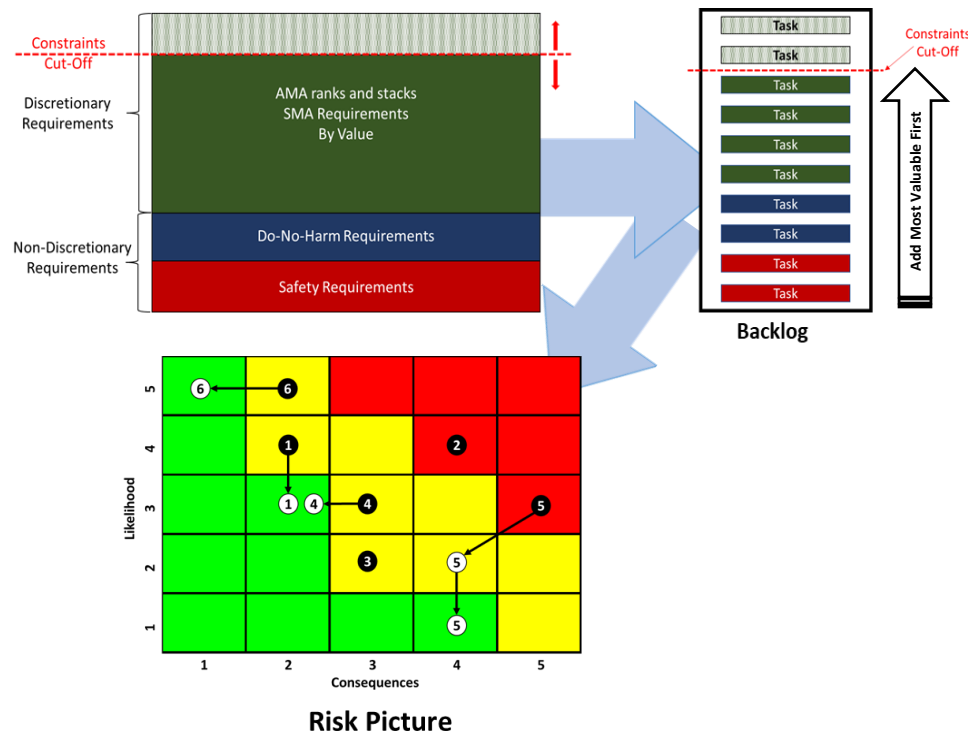


Meeting the Challenge

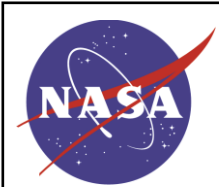
Adaptive Mission Assurance (AMA) for Risk Tolerant, Constraints-driven Missions

A **Value-driven** approach that **Tailors up**

- Incorporates an “Agile” mindset, principles, and frameworks
- Begins with the minimum “prescriptive” requirements for **Safety & Do-No-Harm**
- **Tailors up** discretionary mission assurance tasks based on best **Value** for the unique mission context;
- **Value** = Relative Impact to Mission Objectives / Relative Impact to Project Resources and Schedule
- Then, it dynamically “adapts” for delivering **Highest value first** as the mission “evolves” and “stuff happens”
- Prefers tasks with the most bang-for-the-buck; i.e., **Not always the highest risk**



Optimizes by favoring the best value activities while burning down risk to a targeted residual that is agreeable and understood by stakeholders for a more realistic expectation of mission success



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AMA Mindset

The “Agile” Manifesto

The Agile Manifesto for Software Development

We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

Individuals and interactions over processes and tools

Working software over comprehensive documentation

Customer collaboration over contract negotiation

Responding to change over following a plan

That is, while there is value in the items on the right, **we value the items on the left more.**

The Agile Manifesto for Mission Assurance

We are committed to understanding how to best improve chances of mission success for all types of missions. Through this work we have come to value:

Individuals and interactions over processes and tools

Mission Success over comprehensive documentation

Stakeholder collaboration over prescriptive requirements and checklists

Responding to change over following a plan

That is, while there is value in the items on the right, **we value the items on the left more.**

An Agile Mindset enables the ability to create and respond to change in an uncertain or turbulent environment



AMA Mindset

The 12 “Agile” Principles

The 12 Agile Principles for Software Development

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer’s competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Businesspeople and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

The 12 Agile Principles for Mission Assurance (MA)

1. Our highest priority is mission success through early and continuous delivery of the most valuable mission assurance activities.
2. Change is inevitable, even late in the development. An agile approach to MA embraces change for learning, discovery, and innovation
3. Monitor results, revisit planning, and update risk frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Program, institutional, and mission team representation must work together daily with a preference to face-to-face conversation
5. Build projects around seasoned individuals. Motivate them by giving them the environment and support they need and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a mission team is face-to-face conversation.
7. A continuous consensus understanding of what constitutes mission success and risk among stakeholders is the primary measure of progress.
8. Agile processes promote optimal mission assurance within constraints. Program, functional and mission team representatives should sustain a consensus on optimal, achievable MA given limited budgets, resources and time.
9. Continuous attention to technical excellence and good systems engineering enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best opportunity of success for constraints-driven, risk tolerant missions emerges from small experienced teams.
12. At regular intervals, the mission team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.



AMA Mindset

Essential Points of View

- **Failure AS an Option**

- “Failure” is not always the opposite of “Mission Success”
- Testing, Experimentation, and Technology Demonstration is “Learning”
- Learning, Innovation and Discovery always involve failure(s)
- Ultimate Success (big “S”) includes both successes (little “s”) and failures

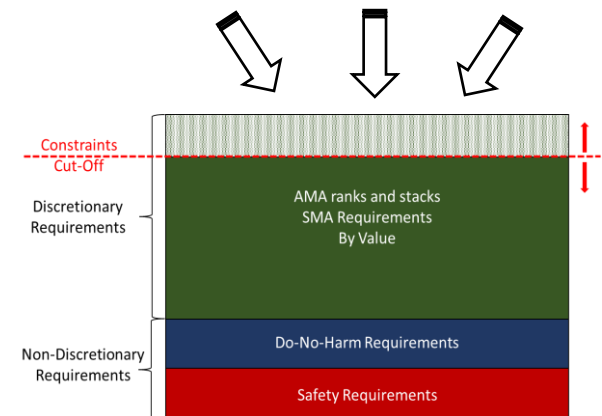
- **Value as a Primary Driver**

- Value determines which tasks will deliver the most “bang for the buck”
- Value of a task is measured as the projected impact to a successful mission outcome divided by its impact to constrained resources, cost or schedule
- The most valuable tasks may not always associate with the highest risks
- Constraints-driven missions are given a “pre-sized” box with limited capacity so that teams will want to place the most valuable tasks in the box first

SOMETIMES



Most Valuable First...





AMA Mindset

Essential Points of View

- **Embrace Simplicity and Change**

- *Mission assurance is anything that contributes to mission success*
- *Avoid duplication by leveraging PM, SE, and Developer tasks*
- *Favor documentation that leverages operative artifacts in the value chain*
- *Change is inevitable, even late in mission developments*
- *Uncertainty is implicit to learning and demonstration so plans must accommodate emergent changes in priorities, risk, and issues*
- *Maintain stakeholder understanding of risk and mission objectives*
- *Maintain consensus on what is optimal and achievable mission assurance*



- **Small Experienced Teams**

- *Constraints-driven missions succeed with small teams of seasoned experts*
- *Build projects around experienced people and trust them to get the job done*
- *Delegate authorities to mission team representatives freeing them to innovate*
- *Tightly integrate representatives with the decision making of mission teams while maintaining their unique program and technical accountabilities*





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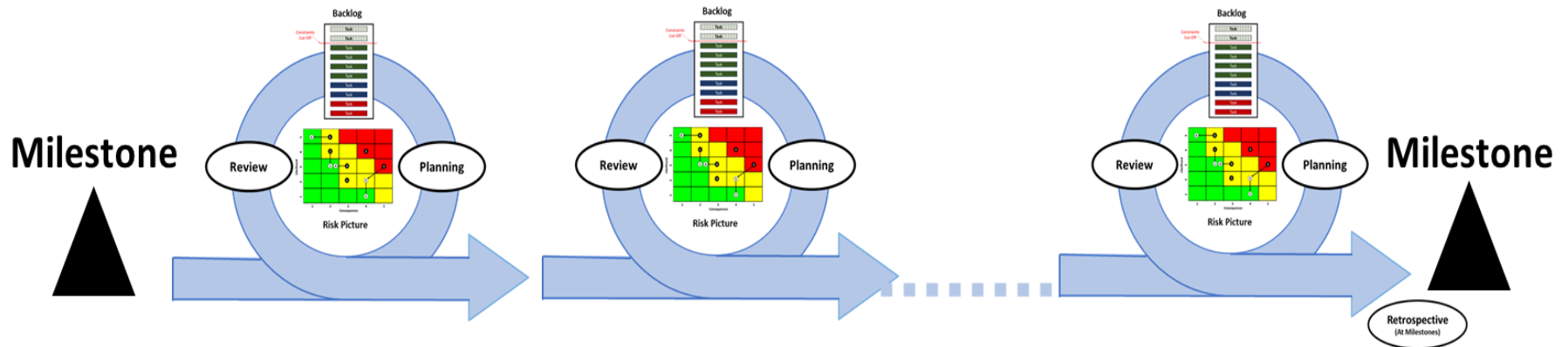
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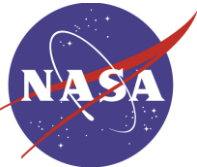
The Sprint

AMA Operates in Short Iterative Sprints

- Driven by team's communication tempo (~2-4 weeks)
- Each lifecycle phase will contain multiple sprints
- Sprints evolve a Backlog of tasks as the mission development progresses
- Maintains a dynamic Risk Picture as affected by the dynamic Backlog responding to change

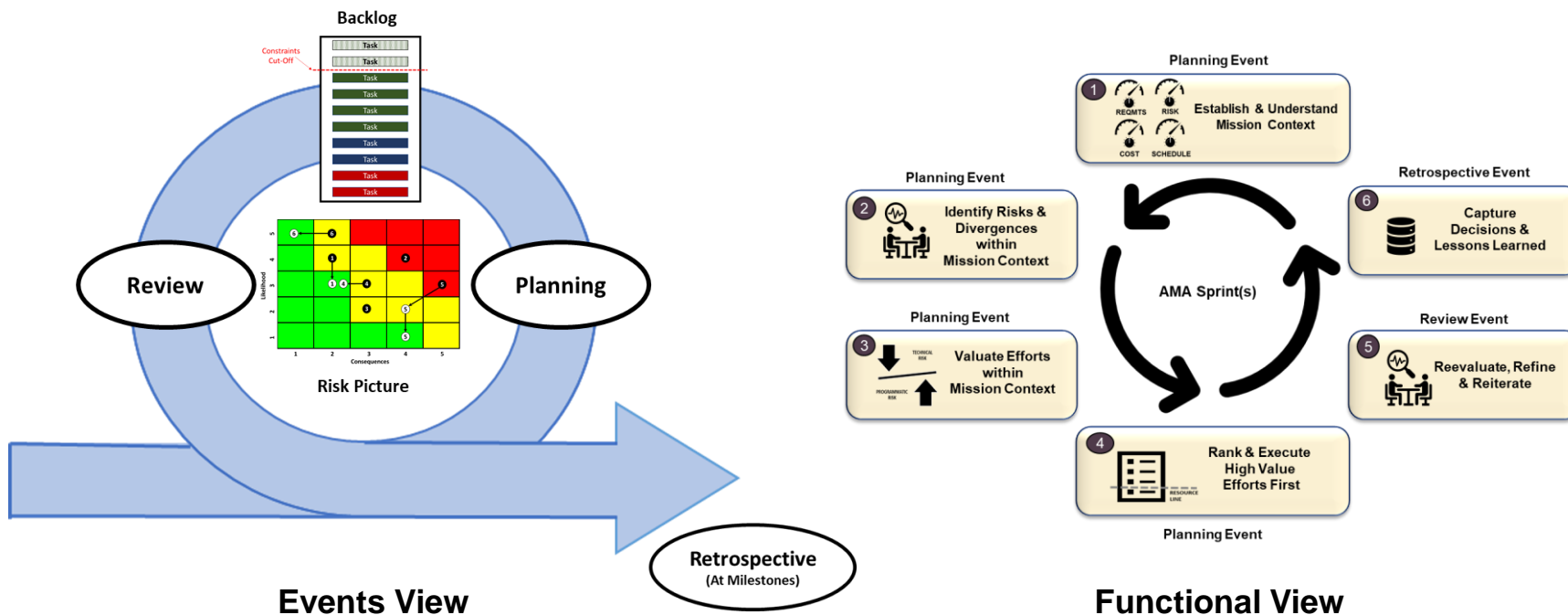


Sprints evolve the Backlog and Risk Picture for responding to change and managing expectation across lifecycle

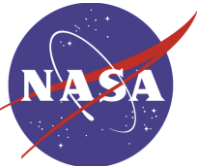


The Sprint

Anatomy of a Sprint



Three Events (Planning, Review, & Retrospective) function to evolve Two Artifacts (the Backlog & Risk Picture)



The Sprint

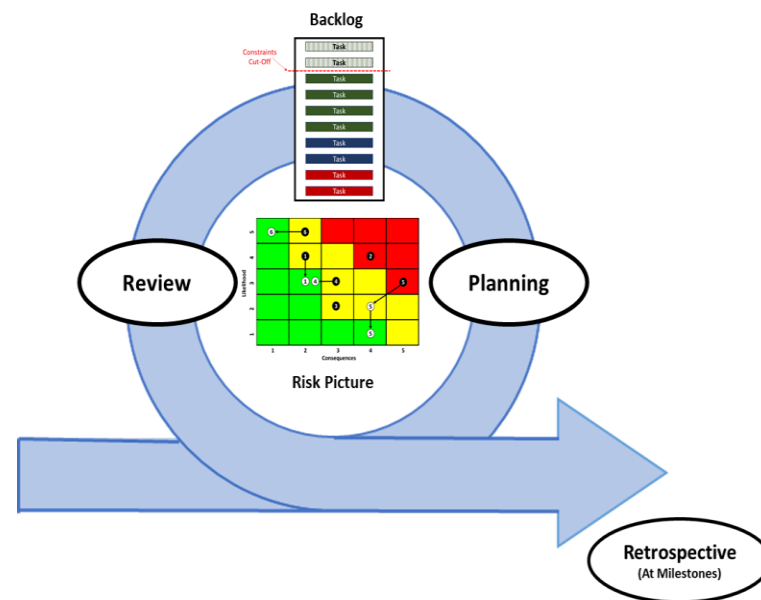
Artifacts

- **AMA Backlog**

- Dynamic “MAIP”* that evolves with each Sprint
- A register of Tasks implementing SMA Requirements
- Prioritized based on the value of the Task
- Authorizes tasks for execution
- Updates with emerging risks, issues, and outcomes

- **Risk Picture**

- Dynamic Risk Picture that evolves with each Sprint
- Continually maintains the “As Is” and “To Be” risk picture
- Updates with the backlog responding to emerging risks, issues, and outcomes



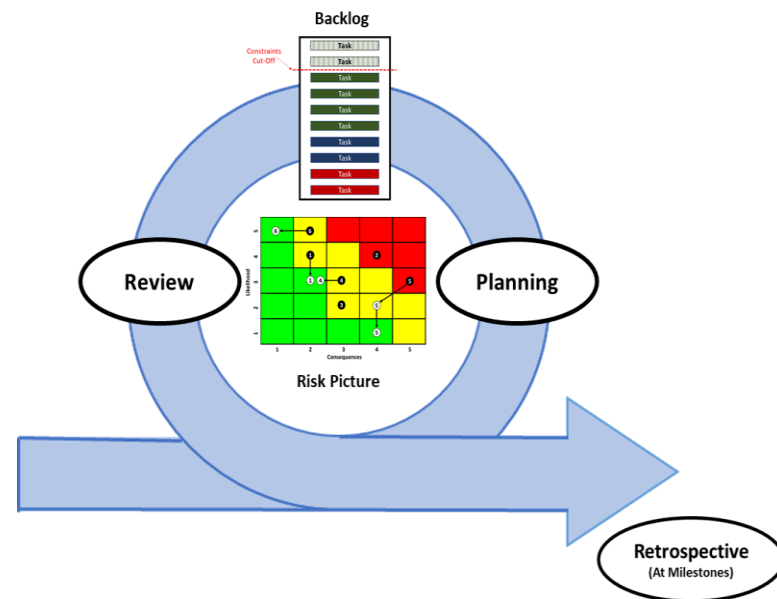
*MAIP – Mission Assurance Implementation Plan



The Sprint

Events

- **Planning Event(s)**
 - Builds and maintains Backlog and Risk Picture
 - Ranks Tasks by Value and authorizes highest value tasks first
- **Review Event(s)**
 - Monitors active task outcomes, divergences or changes in mission context during the mission development
 - Informs the Planning Event for the next Sprint
- **Retrospective Event(s)**
 - Focus is on method AMA and Mission Development methods
 - Collects Lessons Learned for Organizational Bodies of Knowledge

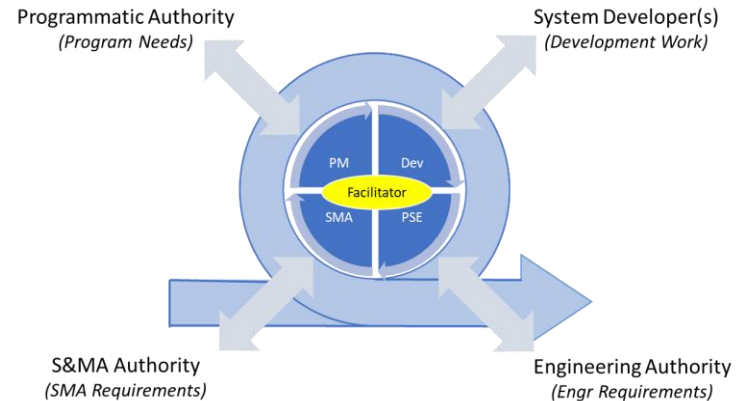




The Sprint

AMA Team and Roles

- **AMA Facilitator (Facilitator)**
 - Ensures effective execution of sprints
 - Role is facilitation; not participation in decisions or content
 - Assists team for defining clear and concise Backlog items
 - Assists PM for achieving consensus among stakeholders
- **Project Manager (PM)**
 - Leads mission team for decisions during Sprint Events
 - Approves priorities and authorizes tasks on the Backlog
 - Coordinates expectations of stakeholders
 - Represents Programmatic Authority
- **Project Safety & Mission Assurance Lead (SMA)**
 - Represents SMA tasks as they are valued and dispositioned
 - Monitors SMA task outcomes and emergent changes
 - Coordinates use of SMA subject matter expertise and support
 - Represents Institutional S&MA Authority



- **PSE – Project Systems Engineer**
 - Represents engineering activities and requirements
 - Represents Institutional Engineering Authority
- **Dev – Developer Lead(s)**
 - Represents work to develop systems, tools, data, information, and operational procedures
 - May consist of Center resources, development contractors, or both

Leverages NASA team structure(s) including representation from Programmatic and Institutional Authorities



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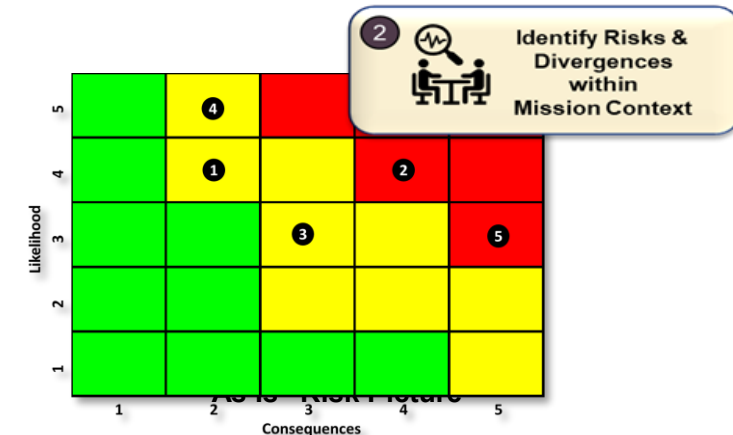

Planning Event(s)

Establishing Context

- **Establish Mission Objectives**
 - Consensus on story or list of statements about what the mission is supposed to do
 - Not a requirements list...but include minimum criteria
 - For Class D, Mission success is not always binary
 - Should be concise – ideally not more than one chart
- **Understand Constraints**
 - Consensus on understanding of constraints
 - Do objectives and complexity realistically match constraints?
- **Identify and Assess Initial Risks**
 - Determine risks -- keeping in what constitutes success
 - Perform comprehensive risk assessment for first Sprint; repeat for milestones
 - Consensus on the “As Is” Risk Picture

1 **Establish & Understand Mission Context**

- **Minimum mission success:**
 - Take at least four SHIMMER data collects and download the associated data with a data quality of 99.5%.
 - Perform at least 60 hours (not required to be consecutive) of CITRIS operations.
- **Nominal mission success:**
 - Perform four SHIMMER data collects per day, for at least 300 days over the mission year. Download all experiment data with a data quality of 99.5%.
 - Operate CITRIS continuously over the mission year. Experience no more than 60 days (not consecutive) of lost experiment time.
- **Maximum mission success:**
 - Perform eight SHIMMER data collects per day, for at least two years. Download all experiment data with a data quality > 99.9% (this was actually achieved).
 - Operate CITRIS continuously for two years with no more than five lost days (close, but no cigar).



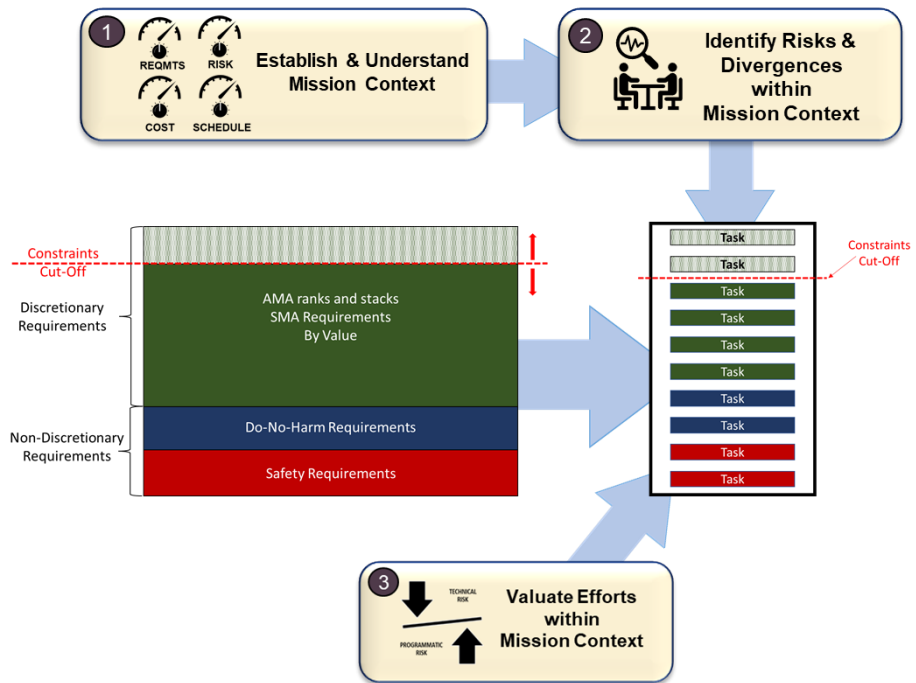
Facilitate Consensus for Establishing and Understanding Mission Context among Primary Stakeholders



Planning Event(s)

Building the Backlog

- **Build the foundation of “non-discretionary” tasks**
 - Human and Property Damage Safety tasks
 - Do-No-Harm tasks
- **Build up with “discretionary” tasks**
 - Add tasks that make sense keeping in mind the unique mission context and risk posture
 - Draw from existing Institutional SMA requirements for Class D / Sub-class D missions (if available)
 - Maintain traceability from task to requirements
 - Leverage systems engineering, project management, or developer tasks over independent SMA tasks



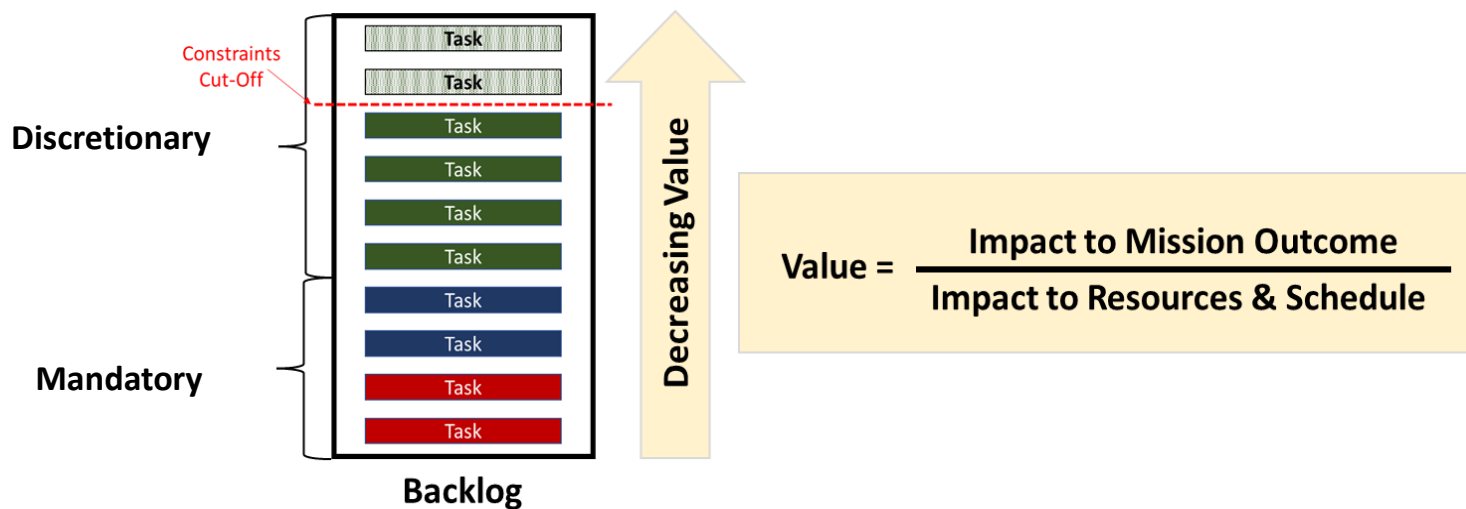
A register of SMA Tasks prioritized by “Mission Value” based on the value of the task



Planning Event(s)

Valuation of Discretionary Tasks

- Discretionary Tasks are prioritized by “Mission Value” based on the value of the task
- “Mission Value” is a ratio of a task’s impact on mission outcome to its impact on resources and schedule
- Note that priority is not risk driven since a task for reducing a high “red” risk may possess very low value if the impact to available resources and time is too high



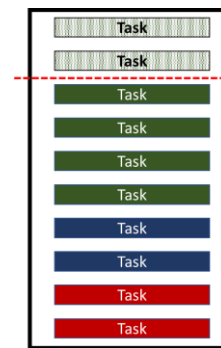
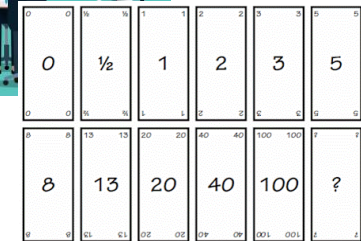
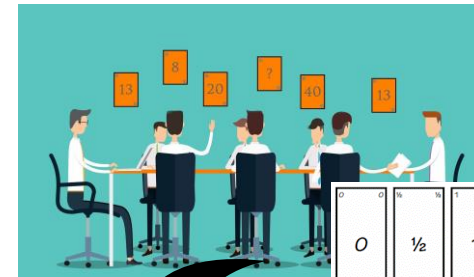
Impact is measured as “story points” using an Agile technique for relative estimation called Planning Poker™



Planning Event(s)

Valuation of Discretionary Tasks

- **Score each discretionary task for its impact**
 - Valuation favors *relative predictions* over “perfect estimations” by scoring competing activities using “story points”
- **Planning Poker™**
 - Registered trademark of Mountain Goat Software, LLC
 - Offers an informal less structured game-like format that avoids bogging down while leveraging full team knowledge
 - Uses “Playing Cards” representing “story points”
 - Team reviews and discusses each item before voting
 - Repeat discussion and voting until consensus is achieved
 - Great way to pool the team’s thoughts and insights
- **Value each discretionary task for prioritization**
 - Value is determined by the impact a task has on mission outcome divided by the impact that task has on resources or schedule



Constraints Cut-Off

	Mission Impact (Story Points)	Cost Impact (Story Points)	Value Score (Ratio)	Disposition	SMA Requirements	
					SMA Area	Reference
Plan	...	...	...	Mandatory	System Safety	3.3.5
	...	...	...	Mandatory	Contamination	9.1
	...	...	...	Mandatory	System Safety	3.3.8
3	10	2	5	Implement	Reliability	4.3
2	2	5	0.4	Discretionary	Workmanship	6.5
86	2	10	0.2	Discretionary	EEE Parts	7.6

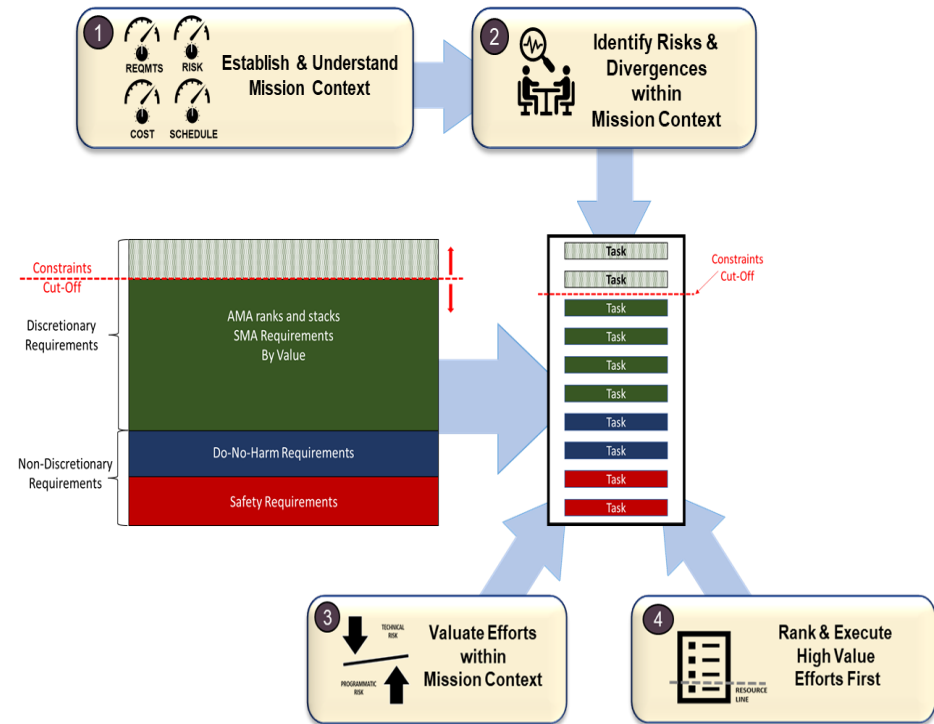
The real benefit of Valuation is the discussion and mutual understanding of value



Planning Event(s)

Rank and Execute High Value Tasks First

- **Rank tasks in order of value priority**
 - Most to least “bang for the buck” NOT “highest risk” to “lowest risk”
 - “Low hanging fruit” may fall higher on the list than more serious risks that are harder to mitigate
- **Determine the limit of task based on time and resources**
 - Starting with the most valued activities first -- Make rough order resource and time estimations
 - Items that fall below the line are not addressed
 - Establishes the task baseline across the lifecycle recognizing that values can change with subsequent Sprints (new risks or issues)

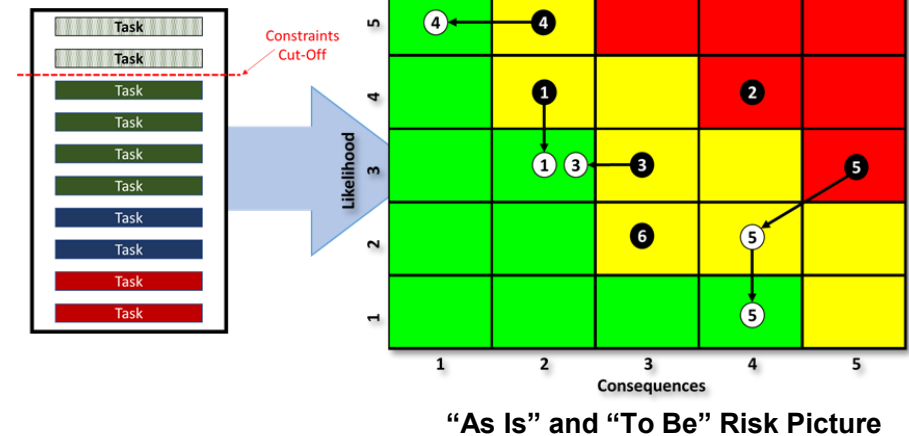


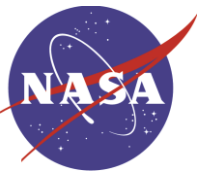


Planning Event(s)

Update the Risk Picture

- Capture the “To Be” risks based on activities authorized for execution (above the cut line)
- Score risk values keeping in mind that the goal is relative prediction, not perfect estimations
- Consider another round of Planning Poker™ for predicting “To Be” risk levels if appropriate
- May need to add risks for tasks that are not authorized due to constraints






Planning Event(s)

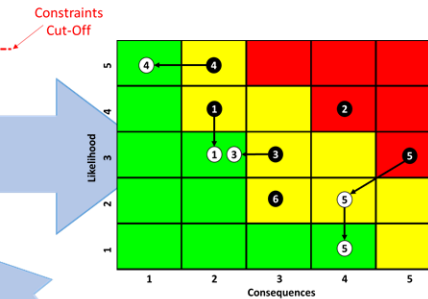
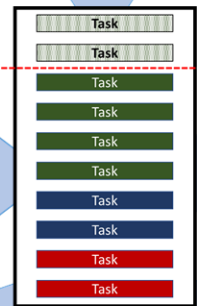
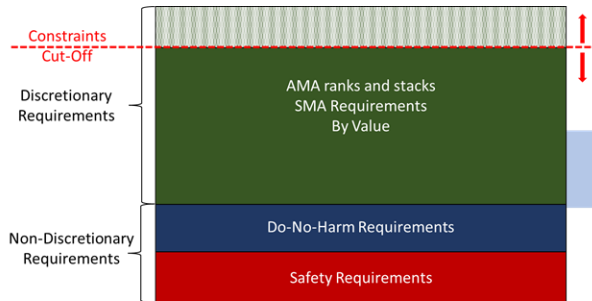

Repeat / Revisit during Subsequent Sprints

1 Establish & Understand Mission Context




REQMTS RISK
COST SCHEDULE

2 Identify Risks & Divergences within Mission Context



Subsequent Sprints

3 Valuate Efforts within Mission Context



TECHNICAL RISK
PROGRAMMATIC RISK

4 Rank & Execute High Value Efforts First

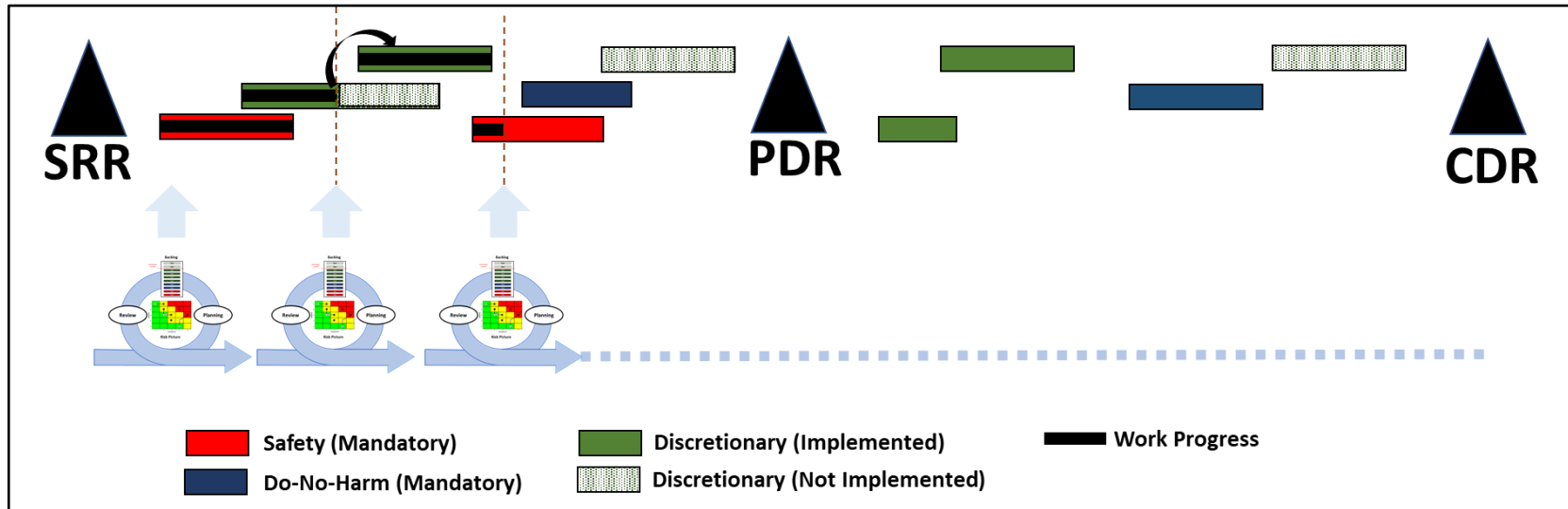


RESOURCE LINE



Backlog Execution

Backlog dynamically authorizes Tasks across the Life Cycle



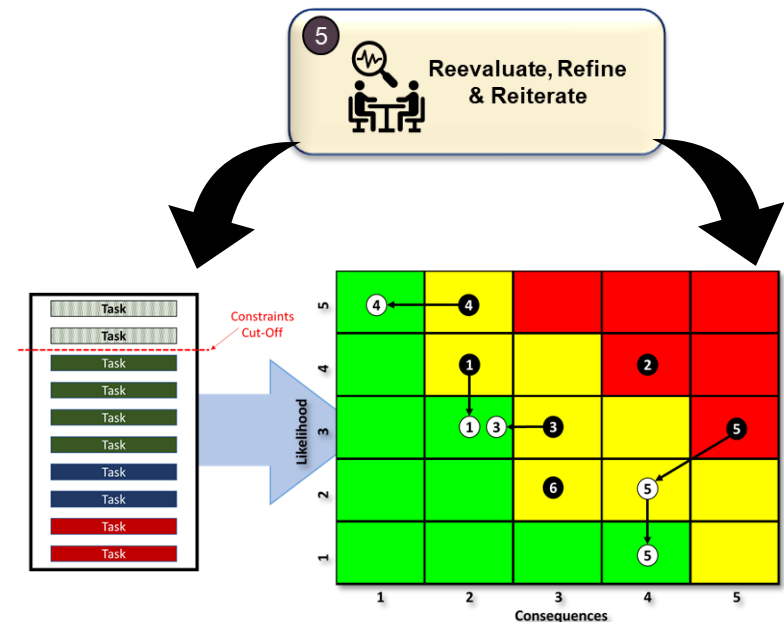
- Tasks may change from sprint to sprint as the Backlog evolves and is reordered based on changing valuations
- Could abandon already initiated tasks shifting to higher value tasks based on changing valuations
- Future phase plans can change as higher value tasks are selected based on the current sprint mission context
- Risk Picture changes as the Backlog evolves thus managing stakeholder expectation



Review Event(s)

Reevaluate, Refine & Reiterate

- Conduct a review at the end of the sprint to review active task outcomes, divergences that emerge during the mission development or changes in mission context
- Review Task Outcomes
 - *Are there any new risks related to the outcomes?*
 - *Effects to mitigations driving burndown for “To Be” risks?*
 - *Were some things more expensive (or cheaper) than expected?*
 - *New risks, divergences or emergent issues for mission development?*
- Capture any changes in Mission Context
 - *Changes in Mission objectives or constraints?*
 - *Changes in Stakeholder risk posture, concerns for risk picture?*
 - *Programmatic changes (budget, schedule)?*
- Informs the next Sprint; Can nominate new Backlog tasks for consideration at next Sprint Planning Event
- Update the Risk picture for the “as is” and “to be” as necessary
- Can Inform the Retrospective Event



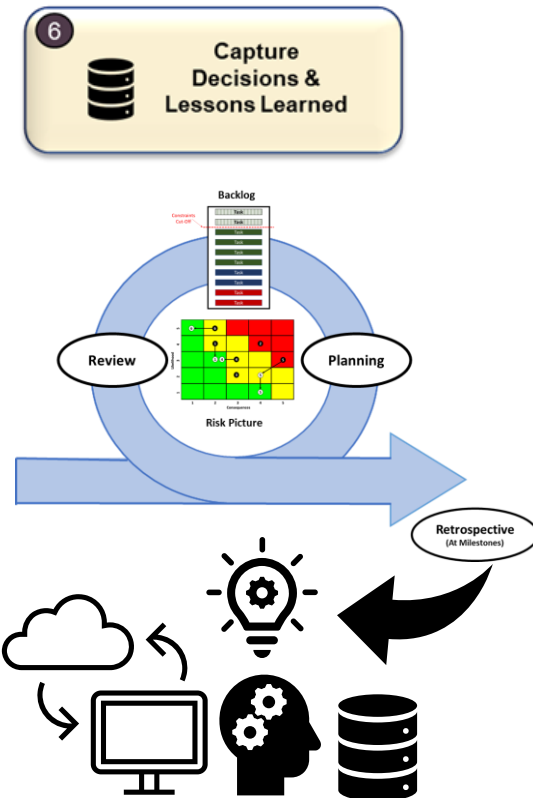
Updates to “As Is” and “To Be” Risk Picture?



Retrospective Event(s)

Capture Decisions & Lessons Learned

- Can occur at the conclusion of any Sprint but are most efficient and likely to be effective at mission development milestones
- Focus is on the method of AMA and mission development
 - *What is working or not working*
 - *Examine roles, interactions, communication, and techniques*
 - *Review encountered problems and how they were (or were not) solved*
 - *the AMA approach in subsequent phases and future mission developments*
- Capture decisions and lessons learned relative to mission development
 - *Benefits future mission developers*
 - *Consider project management, systems engineering, and mission assurance*
 - *Consider supporting functions such as acquisition, procurements, or legal*
 - *Incorporate with organizational bodies of knowledge or lessons learned*

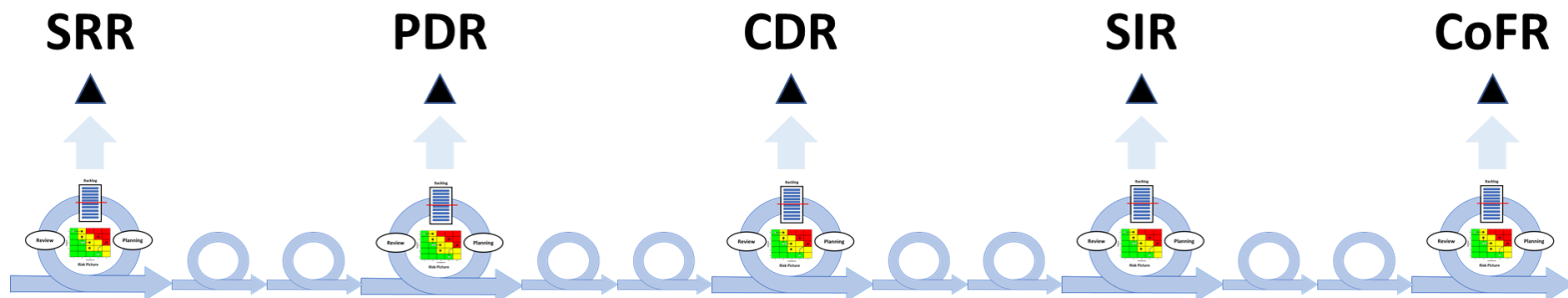




Supporting Readiness

Project Milestones, Key Decision Points, and Readiness Reviews

- Supporting Development Milestones and KDPs
 - *AMA evolves the Backlog and Risk Picture based on changes in mission context, divergences, and constraints*
 - *Team reports out current situation at each of the Milestones*
 - Reports the current “As Is” and “To Be” Risk Picture
 - Provides the activities to date, changes, decisions, and going forward plans in the Backlog
 - Demonstrates optimization of tasks delivering best value within constraints
 - *Frequent collaboration keeps the evolving risk picture in front of stakeholders and authorities, so they are not surprised at the milestone events*
 - *Guards against simple human nature of a willingness to accept risk early in the development giving way to an unwillingness to consider some probability of mission failure at CoFR*





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Summary

Answering The Challenge

- Incorporates the “Agile” mindset and discipline into what NASA already does with little to no additional work
- A value driven approach for delivering the highest value mission assurance first within constraints, meeting mission objectives while burning down risk to a well understood and agreeable residual for informing flight readiness decisions
- Frequent collaboration keeps the evolving Backlog and Risk Picture in front of Authorities and stakeholders so that no one is caught off guard at milestones and CoFR

Adaptive Mission Assurance (AMA) answers the challenge for “gracefully” accepting risk necessary for meeting strict cost and schedule constraints while achieving an agreeable expectation of mission success