UMD Project Management Symposium

The Intersection of Risk Mitigation and Innovation:

The planning and development of the data management system for Nancy Grace Roman in a hybrid project management environment

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ABSTRACT

This paper focuses on the intersection of traditional project management and agile development methodologies to satisfy both NASA's risk mitigation and reporting needs for a "Class A" mission and the Space Telescope Science Institute development team's needs to explore and develop innovative solutions for ingest, processing, and distribution of data from the future Nancy Grace Roman Space Telescope. This paper will focus on how traditional project management rigor and the agile mindset coexist within the project. It will show how we have been successful in both involving and insulating our development teams from external project management requirements through the use of processes, tools, and automation, while still allowing for regular NASA and Institute tracking of Earned Value Management and Risk Management. The tools used are off-the-shelf and the methods used need not be unique to the Institute. Both can provide a similar framework for other projects facing similar situations.

INTRODUCTION

The Space Telescope Science Institute (STScI) has been tasked with leading the Science Operations Center (SOC) for the Nancy Grace Roman Space Telescope (Roman). By contract, STScI is required to work within the constraints of NASA's project management processes and systems engineering methodology. Because of the nature of the mission, NASA's processes and methodologies follow a strictly-sequenced process. The mission has significant cost and time goals, thus preventing the slow evolution of the ground system as occurred for two other space-based telescopes STScI supports, the Hubble Space Telescope (Hubble) and the James Webb Space Telescope (Webb).

In order to accommodate NASA's constraints and still allow for both significant innovation and rapid delivery of working products, STScI has adopted a hybrid methodology, with a more sequential process for overall/high level project management activities, while subsystems are able to adopt an agile mindset and follow the Scrum framework to develop necessary components. This paper is an exploration of how STScI implements a hybrid methodology while allowing freedom to development systems to follow a Scrum framework. The paper then focuses in on how two necessary components of traditional project management, risk management, and Earned Value Management are implemented, and how subsystems provide the data that upper management needs to satisfy NASA's reporting requirements without burdening the development teams.

ROMAN MISSION AND MANAGEMENT

Roman Mission

The Nancy Grace Roman Space Telescope, formerly known as the Wide Field Infrared Survey Telescope (WFIRST), was the top large space priority in the Astro2010 Decadal Survey.[1] Roman is a NASA flagship science mission scheduled to be ready to launch in 2026. Roman is considered a Class A mission according to the "Risk Classifications for NASA Payloads"[2]. NASA uses a variety of criteria to identify a Class A mission including priority (including national significance), primary mission lifetime, complexity and challenges, and lifecycle cost. Other examples of Class A science missions are the Hubble Space Telescope, Cassini, and the James Webb Space Telescope.

Roman Science

NASA is implementing the telescope on a donated 2.4 meter mirror, and will produce large-scale maps of the sky with Hubble-like resolution and sensitivity, but with 100 times the field of view. Roman is designed to be a complement to Webb. Roman has three key science themes: measuring dark energy, investigating exoplanets, and great observatory astrophysics and planetary science. Central to Roman's science mission is the availability of data. All Roman data will be generally available through the Mikulski Archive for Space Telescopes (MAST) as soon as it has been processed and archived. There will be no proprietary or embargo period for primary investigators.

Roman Management

The Roman mission is managed by NASA's Goddard Space Flight Center. NASA has partnered with the Jet Propulsion Laboratory (JPL), STScI, the Infrared Processing and Analysis Center (IPAC) at Caltech, as well as industrial and international partners. NASA is also working with science teams from research institutions across the United States. NASA will develop and operate the Mission Operations Center (MOC) for Roman, while STScI is responsible for developing and operating the SOC. The Science Support Center (SSC) at IPAC is responsible for proposal selection and grants management. Responsibility for observing program definition and science data processing is split between the SOC and SSC and the SOC is responsible for housing and distributing the data.

NASA

NASA follows the systems engineering (SE) project lifecycle and phases as outlined in the NASA Systems Engineering Handbook, originally published in 1995, revised in 2007, and most recently revised again in 2020.[3] Each of the phases has prescribed processes, defined purposes, and typical outcomes.

Science Operations Center (SOC) and the Data Management Subsystem (DMS)

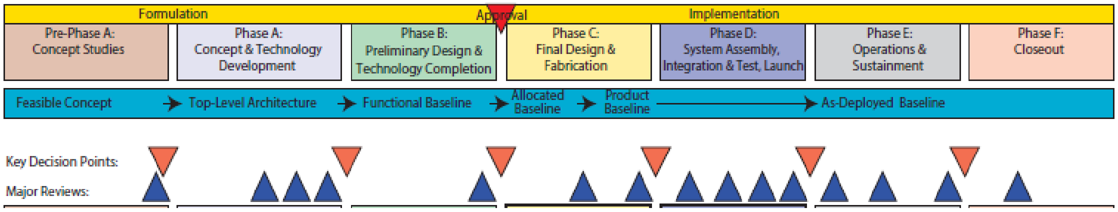
The SOC at STScI works with NASA and the Science Support Center (SSC) at IPAC. The SOC is responsible for the planning and scheduling for observations and shares data processing and production of data products with the SSC. Additional responsibilities include community engagement, user support and outreach, and hosting the petabyte-scale mission data archive, which holds all science data products and provides search capabilities to all mission stakeholders, and the public.

Within the SOC there are three primary subsystems. These include Data Management, Planning and Scheduling, and the Project Reference Database. These three subsystems comprise the technology components of the SOC.

- Data Management Subsystem: receives mission data from sources both internal and external, processes the data as necessary, stores data in the archive, and distributes data on request to partners and the community.
- Planning and Scheduling Subsystem: provides planning and scheduling functions to help manage the science program and generate the Roman science observing timeline, which is provided to the MOC for onboard execution.
- Project Reference Database Subsystem: contains tools to manage the repository of configured data used by the PSS and DMS.

MODELS AND METHODOLOGIES

At NASA, the concept of a sequential model is evidenced in the Systems Engineering Handbook, where the software lifecycle is divided into seven phases with key decision points (gates) to move between phases (See *Figure 1*). NASA's primary concerns in following a detailed lifecycle are obvious. The concern for the safety of the mission creates the need for quality controls and the management of risks.


Formulation
Approval
Implementation
Pre-Phase A: Concept Studies
Phase A: Concept & Technology Development
Phase B: Preliminary Design & Technology Completion
Phase C: Final Design & Fabrication
Phase D: System Assembly, Integration & Test, Launch
Phase E: Operations & Sustainment
Phase F: Closeout
Feasible Concept
Top-Level Architecture
Functional Baseline
Allocated Baseline
Product Baseline
As-Deployed Baseline
Key Decision Points:
Major Reviews:

Ignoring manned missions, where life is of paramount concern, most launched items cannot be repaired as Hubble was. This gives NASA an obvious desire to get it right, since there is often no ability to correct mistakes after the fact.

At STScI, there is a need to meet contractual obligations levied by NASA, as well as maintain the confidence of our partners. Since STScI is so tightly coupled with NASA, implementing the NASA Systems Engineering processes rather than developing home-grown ones makes logical sense. Roman is one of the projects that must fit within this larger framework, the NASA systems engineering framework, focused on managing risk while controlling budget, schedule, and quality. These project management, lifecycle management, and contract management obligations fall outside the standard implementation of agile development. However, the Institute recognizes that the systems they are asked to build for each successive mission are not cookie cutter repeats from one to the other. Each mission has unique challenges and requires innovative solutions. Thus, there is a desire to provide flexibility within the traditional sequencing.

At STScI, within the Data Management Division (DMD), the home for development of telescope pipelines and other operational elements, an agile mindset and framework allows the Institute to implement lessons learned during the development of the James Webb Space Telescope Science and Operations Center, allowing the ability to be flexible, innovate, and "fail early, fail fast." This latter concept allows the detection of errors or failures early in a process, as well as facilitates innovation by encouraging experimentation without significant investment of time. The DMD has adopted the Scrum framework as an agile implementation methodology.

ROMAN – CREATING A WORKABLE HYBRID ENVIRONMENT

STScI has created a hybrid environment that accommodates both STScI and NASA needs while allowing the development/Scrum teams to develop leading-edge systems that will support Roman data processing in the years to come.

STScI has a traditional management structure for overall control of the Roman SOC project. A Roman Mission Office provides centralized support for and overview of all aspects of the project, and has both project management and engineering leads. The Mission Office works closely with STScI's Systems Engineering and Testing teams. These teams provide requirements, interface control documentation, testing processes, verification and validation, and quality assurance. The project manager works closely with STScI's Project Management Office to manage the Integrated Master Schedule (IMS) and Earned Value Management (EVM) reporting. Note: this is by no means all of the tasks performed by any of these elements.

The overall schedule for Roman is set by NASA, with launch readiness currently scheduled for November 2026. The Roman ground system must also have a long-term, fairly stable release plan in order to ensure that all elements are available by launch readiness. There are five releases planned on the schedule, three primary development releases, a pre-launch update and modification release, and a post launch release that leverages on-orbit data to confirm functionality. All of the major dates are set by NASA and adhered to by NASA's partners.

DMD uses its agile software development framework for all missions, including Roman. The Roman DMS currently has two dedicated Scrum teams, and the ability to leverage the work of other teams who are responsible for common components that are shared across missions (e.g. MAST). Each of these teams has a product owner who is responsible for ensuring that there is a well-documented backlog of work. That backlog is built with the support of a DMS project engineer and a technical lead who provide a roadmap for the teams.

HYBRID IMPLEMENTATION

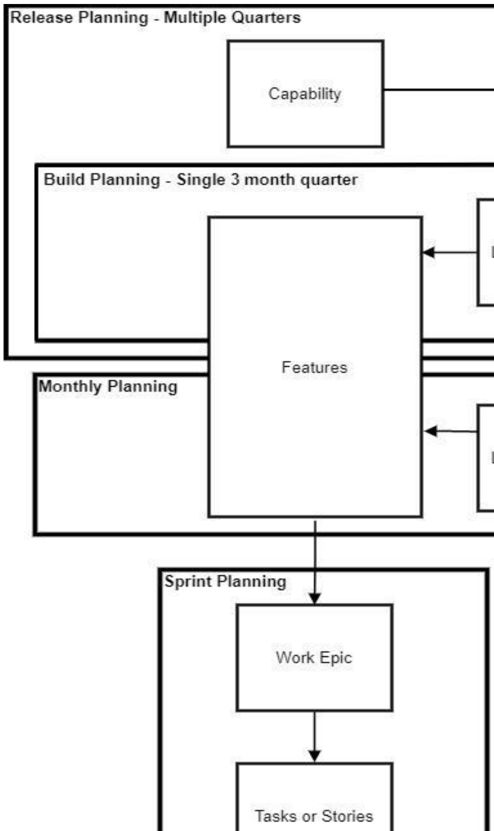
The hybrid nature of combining traditional and agile development approaches is implemented by involving agile team members in the planning processes as early as possible; giving them autonomy over development; and buffering them as much as possible from EVM and other reporting requirements.

Requirements and Planning

High-level requirements are inherited from NASA, and have previously been decomposed and baselined as SOC Level requirements. These serve as the roadmap for all planning within the SOC. At the release level, work to implement DMS has been divided into Capabilities. Capabilities are assigned to specific releases and L4 requirements are assigned to Capabilities. Builds are roughly aligned with fiscal year quarters, and there are at least four builds to a release. The build plan maps the L4 requirements that will be delivered in a build and the release plan maps the Capabilities that will be delivered in a release. See Figure 2 for a visual representation. DMS defines Features that will be implemented within (and occasionally across) builds. These Features are tracked on the IMS and used for reporting EVM. While Features encompass the SOC-Level requirements, there is often not a direct one-to-one mapping, since requirements may be developed over multiple builds. Assigning a Feature to a build means that all the work to satisfy the Feature must be completed in the build. For requirements delivered in a build, all work to satisfy the requirement must be finished so that STScI Integration and Test can verify the completeness of the SOC-Level requirement. Changing the implementation of a Capability from one release to another requires NASA concurrence. Changing the implementation of a requirement from one build to another requires STScI Mission Office approval. What is contained in the Features is at the discretion of the subsystem development teams.

Decomposition of SOC-Level requirement into Subsystem-Level requirements is built into the agile cadence. This is a collaborative effort between systems engineering, subsystem leads, and Scrum teams, and is performed “just in time”; that is, requirements decomposition occurs as close as possible to when the decomposed requirements are needed by the development team. SOC-Level requirements are maintained and baselined in IBM DOORS and require control board approval to change. Subsystem-Level requirements are baselined in DOORS once they have been approved by the subsystem teams and have a simpler change path, unless the change affects scope or cost.

Planning occurs within DMS on both quarterly and monthly schedules, with the involvement of management and Scrum teams. Scrum teams perform planning at both monthly and two-week sprint cadences. This gradual decomposition allows work to be broken down into sprint-consumable work packages and gives Scrum team ownership of the work as early as possible. During quarterly planning, product owners and Scrum masters work with DMS leads to set a roadmap for the quarter and develop the Features that will be tracked on the IMS. At the same time they ensure that all work is identified for the planned SOC-Level requirements, and that at a high level, all planned work covers all Subsystem-Level requirements. Each SOC-Level and Subsystem-Level requirement has a “definition of done” (how the requirement will be satisfied) that may be further decomposed during later stages. Within quarterly, monthly, and sprint



planning, teams are free to identify lower-level tasks needed to implement requirements and ensure full coverage of the same Subsystem-Level requirements.

Leveraging Tools

DMD and DMS have leveraged tools to facilitate the planning cycles and to track work completed during development. As noted above, requirements are maintained in DOORS. STScI uses Atlassian's Jira® for ticket management and leverages the capabilities of Jira Portfolio to provide the necessary hierarchy needed. Both SOC-Level and Subsystem-Level requirements baselined in DOORS are automatically copied into separate requirements projects in Jira using a specialized connection tool (ConnectALL) that works with both systems. Updates to requirements as a result of the change management process are also automatically copied into Jira by ConnectALL. Jira users with appropriate permissions can connect the requirement tickets to work tickets as needed for tracking and traceability. The use of a standardized tool for ticket management facilitates collaboration between different elements, assists with communication and reporting, and allows for streamling of the EVM reporting process.

Jira is used for more than tracking requirements and development tasks. Within reason, all tasks associated with the DMS project are tracked in Jira, including document development and reviews, working group activities, and the development of trade studies. Individual Scrum teams may also choose to track non-work activities, including mandatory and voluntary training and other events, for example conference attendance and participation.

STScI also uses an additional Atlassian product, Confluence, to facilitate collaboration, communication, and reporting for ticket and non-ticket related items. Since it is easy to link custom Jira queries to Confluence pages. Finally Box is used to store and collaborate on documents in other formats including MS Word, PowerPoint, and Excel.

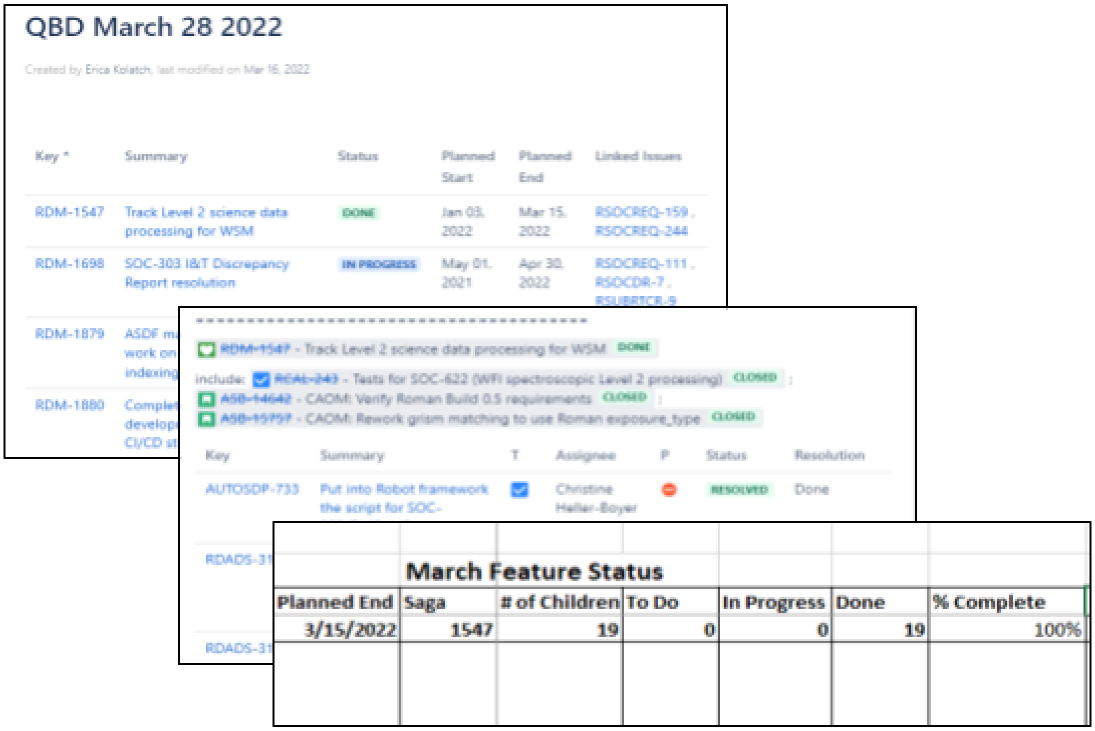
Development

Scrum teams own the monthly and sprint planning used to identify the work that will be accomplished during the two-week sprint cadence. Product owners develop and prioritize the backlog and work with Scrum masters and the team to groom the backlog. The sprint cadence begins with a planning meeting and ends two weeks later with a review meeting. Stakeholders are included in the review meetings, where all work accomplished during the sprint is discussed and in sprint planning, where goals are set for the upcoming sprint. Work items are "pulled" into the sprint and further decomposed as necessary. As part of the decomposition of work, "definitions of done" are documented at these lower levels, and testing runs in parallel with development. Teams have the ability to reorganize work within the full build cycle, and across months. This allows them to respond to changes and remain flexible while ensuring that work is accomplished to meet the build goals.

IMS AND EVM

STScI is committed to both maintaining an effective IMS and enabling an EVM system that supports an agile methodology for development. STScI is also not the first organization to face these challenges. There have been numerous studies and guides on how this integration can be successfully accomplished. Two sources were used to drive STScI's implementation. The National Defense Industry Association (NDIA) developed "An Industry Practice Guide for Agile on Earned Value Management Programs" in 2016 and revised it most recently in 2019.[4] Authors from three commercial firms working in the professional services and government contractor space published a white paper "On Your Toes: Measuring Earned Value in an Agile World."[5] These two sources helped to frame the recommended process for managing EVM on the Roman mission at STScI.

Capabilities and Features feed into the IMS and support EVM reporting. Capabilities and Features are automatically part of the IMS, as these are part of the planning roadmap. This means that the primary measure of work is a maximum three-month block called a Feature. In order to provide evidence that work is being accomplished and progress is being made, all work performed below that Feature is considered Quantifiable Backup Data (QBD) and is used to determine a percent complete for a Feature on a monthly basis. Tasks below the Feature level are omitted from the IMS, but still contribute to EVM reporting via the QBD. This practice, as recommended in the NDIA specification, provides objective performance reporting measurements in support of the EVM process while limiting the volatility of IMS activities and minimizing the overhead of IMS maintenance.



QBD March 28 2022

Created by Erica Kolatch, last modified on Mar 16, 2022

Key *	Summary	Status	Planned Start	Planned End	Linked Issues
RDM-1547	Track Level 2 science data processing for WSM	DONE	Jan 03, 2022	Mar 15, 2022	RSOCREQ-159 , RSOCREQ-244
RDM-1698	SOC-303 I&T Discrepancy Report resolution	IN PROGRESS	May 01, 2021	Apr 30, 2022	RSOCREQ-111 , RSOCDR-7 , RSUBRTCR-9
RDM-1879	ASDF m work on indexing				
RDM-1880	Complet develop CI/CD st				

☑ RDM-1547 - Track Level 2 science data processing for WSM DONE

include: ☑ RCAL-243 - Tests for SOC-622 (WFI spectroscopic Level 2 processing) CLOSED ;
☑ ASB-14642 - CAOM: Verify Roman Build 0.5 requirements CLOSED ;
☑ ASB-15757 - CAOM: Rework grism matching to use Roman exposure_type CLOSED

Key	Summary	T	Assignee	P	Status	Resolution
AUTOSDP-733	Put into Robot framework the script for SOC-	☑	Christine Heller-Boyer	●	RESOLVED	Done
RDADS-31						
RDADS-31						

March Feature Status

Planned End	Saga	# of Children	To Do	In Progress	Done	% Complete
3/15/2022	1547	19	0	0	19	100%

Figure 3: Quantifiable Backup Data for Feature RDM-1547

Scrum teams are responsible for recommending work buckets that should become Features, and developing the related tickets that will become QBD. Teams are also responsible for ensuring that appropriate linkages to Feature tickets are created within

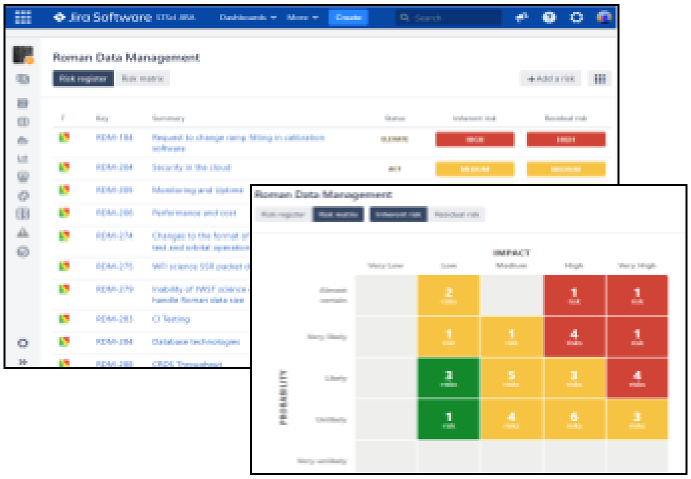
Jira so that the bottom level work tickets can be tracked to the Features on the IMS. For each month's EVM reporting, for each Feature, the number of work tickets completed is compared with the number of work tickets planned to generate a percent complete. (See *Figure 3*) This makes the calculation resilient to the identification of new work within a quarterly cadence, as long as the new work is associated with the completion of the Feature. Confluence is leveraged to track the connected tickets, and automated Jira reporting identifies the tickets that should be included. Tickets labeled as Roman, with a correct Build identified, and with appropriate start and/or end dates are included in the count. While some automated reporting is in use by other subsystems, because DMS work has been divided into multiple separate Jira projects, some of which are not exclusive to Roman, a slightly more manual process is used for the final calculation.

RISK MANAGEMENT

A comprehensive risk management plan was developed and delivered as part of the documentation provided in an early review. This risk management plan follows best practices for risk management including identification, analysis, mitigation, and monitoring on a monthly cadence.

Risks can be created at the subsystem level, by anyone working on the subsystem, and accepted and managed at that level. Should a risk rise to a level where subsystem management is not appropriate, a risk can be escalated to the Roman Mission Office at STScI where similar processes are followed. The STScI risk management process feeds the NASA risk management process. When the Mission Office requires NASA support to mitigate or resolve a risk, the risk can be escalated to NASA, and if accepted, will be managed by the NASA process.

The Roman Mission Office at STScI, and the subsystems below the Mission Office, also leverage Jira to perform risk management. A risk module and risk type within Jira allows for ease in creating, analyzing, reviewing, and managing risks on a monthly cadence. Jira also facilitates ease in risk reporting, providing easy heatmap views and risk registers.



Roman Data Management

Risk register | Risk matrix

T	Key	Summary	Status	Inherent risk	Residual risk
	RDM-184	Request to change ramp fitting in calibration software	[illegible]	HIGH	HIGH
	RDM-204	Security in the cloud	[illegible]	MEDIUM	MEDIUM
	RDM-205	Monitoring and Uptime			
	RDM-206	Performance and cost			
	RDM-274	Changes to the format of [illegible] test and orbital operations			
	RDM-275	WFI science SSR packet [illegible]			
	RDM-279	Inability of IWST science [illegible] handle Roman data size			
	RDM-283	CI Testing			
	RDM-284	Database technologies			
	RDM-288	CRDS Throughput			

Roman Data Management

Risk register | Risk matrix | Inherent risk | Residual risk

IMPACT

PROBABILITY	Very Low	Low	Medium	High	Very High
Almost certain		2 risks		1 risk	1 risk
Very likely		1 risk	1 risk	4 risks	1 risk
Likely		3 risks	5 risks	3 risks	4 risks
Unlikely		1 risk	4 risks	6 risks	3 risks
Very unlikely					

CONCLUSION

This paper starts with a brief discussion of the Nancy Grace Roman Space Telescope and its place within NASA's suite of current projects. As a Class A "flagship" mission, it is important that NASA manages the risks inherent in building something new and innovative, both for the telescope itself and the associated ground systems. For NASA, this means a controlled development process with clear gates before allowing the project to proceed. At the same time, a very short development period for the ground system prior to launch means that it is important that development teams have the ability to develop innovative solutions quickly and embrace change. This sets up the tension between the classic systems engineering model of NASA and the agile mindset of STScI developers.

The paper discusses how the Roman ground system project fits within a hybrid model, and how STScI is implementing its version of that hybrid model. The paper looks at the primary planning and requirements; development and internal testing; and SOC testing and delivery components and how they are combined by leveraging tools, including Jira and Confluence, to allow for successful agile development. We have also described how Earned Value Management and Risk Management are accomplished without forcing additional process on development teams by leveraging the structures already in place. Change management processes at various levels will help to keep these processes and the results they produce robust and responsive to evolving mission needs.

REFERENCES

[1] National Research Council, [New Worlds, New Horizons in Astronomy and Astrophysics], The National Academies Press, Washington DC (2010). https://www.nap.edu/catalog/12951/new-worlds-new-horizons-in-astronomy-and-astrophysics (27 March 2022).

[2] NASA, "Risk Classification for NASA Payloads," NPR 8705.4A, April 29, 2021, https://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_8705_004A_&page_name=main&search_term=risk%20classification%20for%20NASA%20payloads (27 March 2022).

[3] NASA, "Systems Engineering Handbook," NASA SP-2016-6105 Rev2, January 2020, https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook (25 November 2020).

[4] NDIA, "An Industry Practice Guide for Agile on Earned Value Management Programs, Version 1.3," 26 May 2019, https://www.ndia.org/-/media/sites/ndia/divisions/ipmd/division-guides-and-resources/ndia_ipmd_agileandevmguide_version_1-3_may302019.ashx?la=en (27 November 2020).

[5] Bier, L., Boatwright, K., Scott, D., "On Your Toes: Measuring Earned Value in an Agile World," CGI, (undated), https://www.cgi.com/sites/default/files/images/measuring-earned-value-in-an-agile-world-cgi-bdo-deltek-whitepaper.pdf (27 November 2020).