IAC-24-E6.LBA.7.91714

Unveiling NASA's Agile Projects, Successes, Challenges, and Transformative Insights

Dr. Jackelynne Silva-Martinez[a]*, Alex Desharnais[b], Dr. Joseph Rios[c], Kelley Jones-McDowall[d], Tammy Ashraf[e], Amit Patel[f], Jon Holladay[g]

[a] *NASA Johnson Space Center, Agile Community of Practice Lead, 2101 E NASA Pkwy, Houston, TX 77058, jackelynne.p.silva-martinez@nasa.gov*
[b] *NASA Jet Propulsion Laboratory, Agile Community of Practice Deputy, 4800 Oak Grove Dr, Pasadena, CA 91011, alexander.h.desharnais@jpl.nasa.gov*
[c] *NASA Ames Research Center, Chief Technologist, Aviation Systems Division, Moffett Field, CA, 94035, joseph.l.rios@nasa.gov*
[d] *NASA Kennedy Space Center, Launch Service Program Resident Offices Branch Chief, Florida 32899, kelley.m.jones@nasa.gov*
[e] *MCSG Technologies, Inc., Space Systems Engineer, 8800 Greenbelt Rd. Greenbelt, MD 20771, t.ashraf@nasa.gov*
[f] *Leidos Innovation Corporation, Senior Systems Engineer, 555 Forge River Rd Suite 150, Webster, TX 77598, amit.j.patel@leidos.com*
[g] *NASA Engineering Safety Center, Systems Engineering Technical Fellow, 8800 Greenbelt Rd, Greenbelt, MD 20771, jon.holladay@nasa.gov*
* Corresponding Author

Abstract

The NASA Agile Community of Practice recently hosted the first NASA Agile Technical Interchange Meeting (TIM). The TIM provided an opportunity for Agile practitioners across the Agency to share their successes, challenges, and recommendations from Agile transformations. NASA has increasingly turned to private industry for collaborative efforts in space exploration, satellite deployment, and other missions. Embracing Agile principles, NASA is adapting its project management strategies to foster more flexible, efficient, and collaborative relationships with commercial partners. This paper provides highlights from the projects presented at the Agile TIM on how those teams have been able to iterate rapidly, respond to changing requirements, and deliver value more effectively.

Keywords: agile, organizational development, NASA, innovation, agility

1. Introduction

The NASA Agile Community of Practice (CoP) was formally opened in August 2023. Teams across NASA though have been applying Agile practices years prior. Among the many efforts the CoP has been doing, the Technical Interchange Meeting (TIM) allowed to share and learn from the various Agile teams across the Agency. This paper provides the methods used to prepare for the TIM and presentation summaries highlighted during the interchange.

Agility is the ability of an organization to respond quickly to changes and to successfully adapt to fast changing environments and achieve better outcomes. The operational performance to achieving agility can be done through Agile. Agile is a mindset of values and principles that teams use in their ways of working. The mission of the NASA Agile CoP is to effectively infuse Agile values and principles in NASA to better support projects and products [1]. Those principles include: embracing change, delivering value early and often, collaborating with stakeholders, empowering teams, and measuring and learning. The execution of this first NASA Agile TIM forms part of the activities the CoP has outlined in its roadmap to support the Agency's Agile transformation.

2. Methods

The NASA Agile TIM was held on May 6th, 2024. The interchange meeting covered stories from projects using Agile principles, tools, and methodologies, as well as successes, challenges, and recommendations from Agile transformations. Each presentation had about 20 minutes to share their content, followed by 10 minutes for questions and answers. The TIM was conducted both in person at the Glenn Research Center and virtually via Microsoft Teams. Abstracts, registration, and presentations were managed through the NASA Agile CoP website hosted under the NASA Engineering Network site [2]. Presentations and recordings were made available to the entire CoP and NASA in general via the same NEN site as well as NASA Agile CoP Teams Channel [3]. The agenda as executed was as shown in Table 1. The meeting concluded with a roadmap for future activities and a call for ongoing collaboration and knowledge sharing.

Time	Topic	Presenter	Format
8:30	Introductions and Welcome	Dr. Jackelynne Silva-Martinez	In person
9:00	Keynote: The Criticality of MBSE to Deploying Agile Systems Engineering	Dr. Bruce Douglas	In person
10:10	Group Photo & Break		
10:30	Creating a Culture of Agility	HQ/Denise Amling	Remote
11:00	Scaled Agile Framework and the effects on the Application Platform Services Cyber Team	MSFC/Kyle Driver	In person
11:30	Stennis Space Center's Agile Journey	SSC/Alex Elliot	Remote
12:00	Experience with a Hybrid Traditional/Agile Approach on Hardware-Centric Project	AFRC/Jeanette Le	In person
12:30	Lunch		
1:30	Keynote: Agile in NASA 2040	HQ/Carla Procaccino	In person
2:00	Tailoring Agile Approaches to Drive Earth Science Research and Development Projects	GSFC/Tammy Ashraf	Remote
2:30	Effect of Software Architecture on Team Agility: An Informal Case Study	ARC/Dr. Joseph Rios	Remote
3:00	Break		
3:15	NASA Launch Services Program (LSP) Systems Engineering Collaboration with SpaceX	KSC/Kelley Jones-McDowall	In person
3:45	Agile Principles from the ISS CMC Buy and Fly Hardware Certification Process	JSC/Amit Patel	Remote
4:15	How OpenMDAO Maximizes our Impact with Agile Practices	GRC/Robert Falck	In person
4:45	Wrap-up & Retrospective	JPL/Alex Desharnais	In person
5:00	End of Agile TIM		

Table 1. NASA Agile Technical Interchange Meeting Agenda

3. Presentation Summaries

This section provides a brief overview of each presentation from the TIM.

3.1 The Criticality of MBSE to Deploying Agile Systems Engineering

Bruce Douglas' keynote presentation delved into several critical aspects of developing high-reliability, safety-critical systems using Agile methodologies and Model-Based Engineering (MBE) and Model-Driven Development (MDD) [4].

A significant portion of the discussion revolved around the application of Agile in systems engineering, especially within NASA's environment where software, hardware, and other components must integrate seamlessly. Bruce stressed the difference between creating system specifications (outcomes of systems engineering) and computation (outcomes of software engineering), underlining that the work products of these two disciplines are fundamentally different.

This presentation also explored the use of models not just as diagrams but as data-driven representations that must be continuously verified and validated to ensure correctness. The conversation included the necessity of involving stakeholders throughout the development process to ensure that the systems being built truly meet their needs. Metrics and feedback loops were emphasized as essential tools for tracking progress and making necessary adjustments.

Furthermore, the session addressed the concept of DevSecOps, which integrates development, security, and operations into a single cohesive process. This is particularly crucial for NASA, where the reliability and security of systems are non-negotiable. The presentation highlighted practices like test coverage analysis, continuous integration, and the importance of verifiable models, all aimed at ensuring that the final product is not just functional but also robust and secure [5].

Lastly, the discussion touched on the importance of high-reliability systems and the unique challenges they present, including specialized hardware, stringent resource constraints, and the need for conformance to rigorous standards.

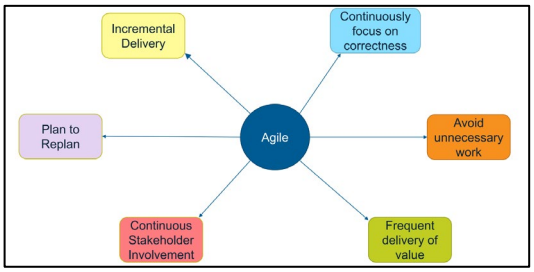


Fig. 1 What do you mean by Agile? [5]

3.2 Creating a Culture of Agility

Denise Amling's presentation focused on the theme of creating a culture of agility within organizations, particularly within the context of NASA. Denise discussed strategies for scaling a culture of agility within an organization and highlighted that while individual Agile teams can achieve great results, the real challenge lies in creating an Agile organization that can drive systemic change and innovation.

Organizational culture is the collection of values, expectations, and practices that guide team members' actions. It defines how members should behave, communicate, and collaborate. For Agile to succeed on a large scale, it must fit into the existing culture of the organization. Culture is influenced by everyone in the organization, from the lowest level employees to the CEO. Isolated Agile teams might succeed with strong executive support, but this does not lead to widespread change. To work with innovative companies such as SpaceX or Blue Origin, NASA must adopt Agile principles organization-wide, similar to how it worked during the Apollo program.

Denise introduced the concept of the Agile Onion, which layers tools and processes at the bottom, followed by practices, principles, values, and at the top, the Agile mindset [6]. While tools like JIRA or standups are visible, they are less impactful without underlying principles like trust and openness. The Agile mindset—being truly Agile—is the hardest to define but is the most powerful aspect of Agile. Agile principles can be more easily adopted at the team level but face significant challenges at the organizational level due to the need for leadership buy-in. Leaders must understand, know, and believe in Agile for it to take root across the organization. It was stressed that leadership must demonstrate agility in action, set clear priorities, trust teams, and avoid hoarding resources.

Several challenges at NASA could hinder Agile adoption, including outdated processes, resource hoarding, and the slow pace of decision-making. It was suggested that leaders need to accelerate learning loops, emphasize progress over perfection, and dismantle outdated processes. Communication is crucial and leaders must over-communicate their Agile intentions to ensure understanding [7].

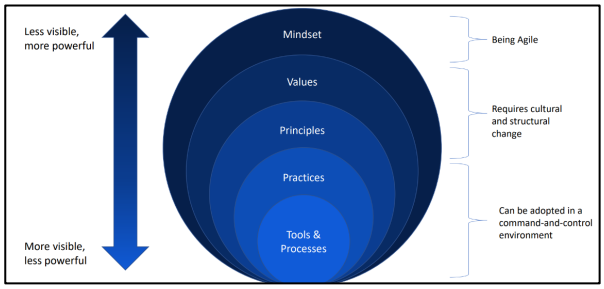


Fig. 2 Agile onion [6, 7]

3.3 Scaled Agile Framework and the Effects on the Application Platform Services Cyber Team

Kyle Driver shared the Agile journey of the Marshall Flight Center's cyber security services team. It used to be a team that was divided into five separate silos and they were supporting 55 security plans at the same time. Multiple environments, public, private, thousands of servers, and hundreds of applications, all expecting to be the number one priority. All this with a process and decision tree that took many meetings to figure out what the various tracking sheets held. This caused the accreditation process to take about 90-120 days. It was decided to try an agile release train technique within a Scaled Agile Framework (SAFe) with clearly defined roles and responsibilities [8].

The first step was to hold a Program Increment Planning event that allowed a shift in how the work was done, provided clear direction and highlighted how unrealistic the expectations were with the current resources and made transparent why there was such a high turnover and low morale on the team. This transparency allowed the Business Owners visibility to start prioritizing the work and decide what work could wait. The results of switching to SAFe showed how the team was able to increase resources, changed the Security mantra from a "no" to a "yes, if", enabled the team to continuously improve on quality and quantity delivery. Furthermore, team morale is better than ever: happier, healthier, and more united [9].

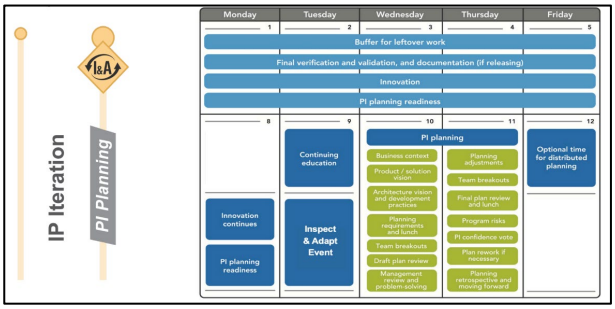


Fig. 3 Incremental Planning iteration [9]

3.4 Stennis Space Center's Agile Journey

Alex Elliot shared how Agile was introduced to Stennis via a couple of highlighted projects, Integrated System Health Management (ISHM), and Autonomous Systems Laboratory (ASL) to better communicate between the contractor team, NASA Project Manager, the Principal Engineer, and the NASA Data Acquisition System (NDAS). The goal was to decompose a very large task for a development team, and a means to demonstrate progress.

Stennis has been the testing facility for all NASA launch vehicles. Post Shuttle, Stennis has been working more with commercial providers to offer their testing facilities outside the government programs which drove the need for something more flexible in the Stennis software programs. Historically, Stennis did a lot of configuring of commercial off the shelf software. They would get a data system from a major vendor and they would bring the software, set it up, and give Stennis an instruction manual. But over the years they started writing more glue ware, more interface between systems, and customizing how their systems work [10].

Having multiple customers and a wide variety of systems, something that was Stennis-owned was needed. Using an Agile approach with the current workforce, the above projects showed the benefits of shifting from the traditional way of approaching projects by demonstrating progress during the coding phase versus being in a silo during the phase. It improved communication between the development team and stakeholders, enabled ASL to manage multiple projects using the same process and tools, and supported quick moving small satellite payload development and Stennis' first software in space. Even with the improvements, the challenges are still there between the agile camp and the traditional camp still coexisting at Stennis but continuing to press forward and push the Center to be even more Agile.

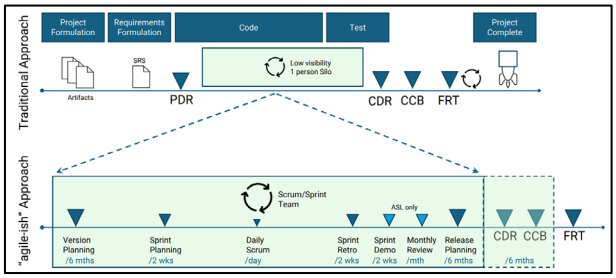


Fig. 4. Agile ceremonies [10]

3.5 Experience with a Hybrid Traditional/Agile Approach on Hardware-Centric Project

Jeanette Le presented this hardware-centric project focused on developing a cryogenic magnetic coupler designed to function in the lunar environment. This coupler is intended to facilitate the transfer of cryogenic fluids on the lunar surface while being resistant to lunar dust. The key innovation involves using magnets to manage the coupling process, making it both dust-tolerant and operable in extreme lunar conditions. The project encountered significant challenges and opportunities due to its hardware-centric nature and the need to adapt Agile methodologies typically used in software development. Notably, the team had to integrate traditional systems engineering processes with Agile practices, leading to a hybrid approach. This involved monthly sprints, integrated reviews, and mapping traditional and Agile workflows to meet project milestones and documentation requirements. The team faced difficulties due to the lack of Agile experience and the constraints imposed by the fixed two-year budget, requiring creative management of resources and timelines [11].

The hybrid approach led to both successes and shortcomings. On the positive side, it enabled the team to develop working hardware that met the project's operational goals and increased awareness of Agile methodologies within the team. However, the implementation was far from perfect, with issues such as overloading sprints, inadequate task definitions, and poor Scrum practices due to inexperience. The team often struggled with balancing Agile processes with traditional requirements, which added an extra burden and led to inefficiencies. While the project faced numerous challenges, the hybrid Agile-traditional approach allowed the team to achieve significant milestones, including the development of functional hardware. The experience highlighted the potential benefits of Agile in hardware projects but also underscored the need for better preparation and training to fully leverage Agile methodologies. Despite the hurdles, the project provided valuable lessons in integrating Agile practices into a traditionally structured environment.

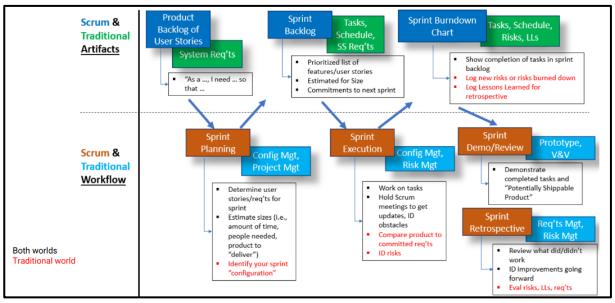


Fig. 5. Mapping Scrum and traditional artifacts and workflow [11]

3.6 Agile in NASA 2040

This keynote presentation by Carla Procaccino provided an overview of the NASA 2040 initiative, which aims to maintain NASA's leadership in research, technology, engineering, and space exploration by adopting agile methodologies. The importance of leadership engagement in driving Agile initiatives was highlighted. Leaders and sponsors are actively involved in supporting and promoting these initiatives across the Agency [12].

The discussion covered how the NASA 2040 team is adopting an Agile mindset to ensure long-term sustainability and continuous improvement. The team aims to use iterative cycles to adapt and learn from experiences. They are addressing challenges and perceptions related to standards in Agile environments, and efforts are being made to create new standards and processes that support Agile practices and improve Agency operations. A transition is happening from monolithic applications to microservices architecture, enhancing extensibility, deployability, and agility. Collaboration with the Food and Drug Administration (FDA) showcased how NASA's systems can be extended for use by external entities, demonstrating flexibility and responsiveness.

Scrum and other Agile practices have been used to gather feedback from various stakeholders, and small group and one-on-one engagements were recommended

for detailed feedback. Discussions on potential complexities in managing microservices, especially for real-time embedded systems, as well as the suitability of microservices for different environments were considered.

Participants asked questions about the practical aspects of Agile implementation in NASA 2040, the balance between innovation and commercial practices, and how to sustain these changes over the long term. They were encouraged to use available resources such as the NASA 2040 SharePoint site, and to have continuous engagement and feedback as those efforts mature.

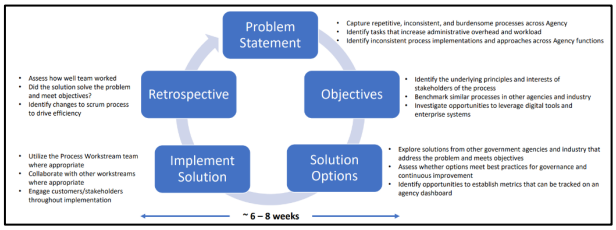


Fig. 6. Process Workstream execution plan [12]

3.7 Tailoring Agile Approaches to Drive Earth Science Research and Development Projects

Tammy Ashraf's presentation examined the integration of Agile in large transdisciplinary teams to address the complex challenges inherent in Earth system science research, particularly in the context of the global climate crisis. It posited that Agile, when combined with a transdisciplinary approach, could substantially enhance the efficiency, flexibility, and overall impact of scientific research endeavors. It critiqued traditional scientific research methodologies, highlighting their limitations in addressing the dynamic and urgent needs posed by climate change. Traditional methods, characterized by linear progression, siloed team structures, and significant costs, were identified as increasingly inadequate in responding to the rapid evolution of climate-related events. These conventional approaches often fail to deliver timely and actionable outcomes, necessitating a re-evaluation of methodological frameworks.

To mitigate these challenges, the presentation proposed the adoption of Agile methodologies within scientific workflows. Agile's key strengths including its capacity for adaptability, emphasis on delivering early returns on investment, and facilitation of cross-disciplinary collaboration were underscored as particularly beneficial in environments marked by high levels of uncertainty and complexity. The shift from linear, sequential workflows to iterative cycles of output, as exemplified in Earth system research projects, was presented as a means to enable more responsive and flexible research processes. In this case, Agile practices facilitated effective collaboration among climate scientists, engineers, and other stakeholders, fostering an environment conducive to transdisciplinary research.

A significant component of the presentation was dedicated to elucidating the concept of transdisciplinary research, which transcends traditional disciplinary boundaries to integrate knowledge from multiple fields and sectors. The presentation detailed the various levels of knowledge integration, including disciplinary, multidisciplinary, participatory, interdisciplinary, and transdisciplinary approaches. Transdisciplinary research was characterized as an approach that involves co-producing knowledge with stakeholders from diverse sectors, thereby allowing them to actively shape research processes and outcomes. This collaborative approach ensures that scientific research remains not only rigorous but also directly applicable to real-world challenges, thereby enhancing its relevance and impact. Agile was identified as particularly well-suited to support transdisciplinary research due to their inherent focus on collaboration, flexibility, and iterative processes. Agile's iterative feedback loops, which facilitate continuous input from stakeholders and team members across various disciplines, were presented as a mechanism for integrating diverse perspectives. This approach allows for the continual refinement of research goals and methods in response to new insights and changing conditions, thus aligning research outputs more closely with the needs of the broader scientific and stakeholder communities [13].

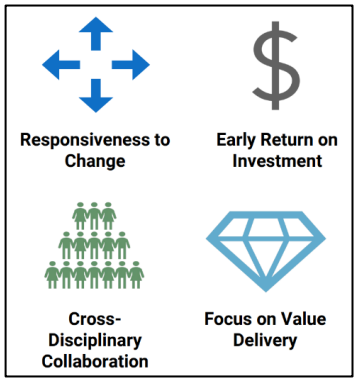


Fig. 7. Benefits of Agile science research [13]

The presentation also addressed the challenges associated with implementing Agile within transdisciplinary teams, particularly the cultural shift required among researchers traditionally trained in linear methodologies. The resistance to Agile methodologies was acknowledged, with an emphasis on the necessity of fostering a growth mindset that values flexibility, collaboration, and adaptability. The difficulty of aligning diverse values, mindsets, and expectations of team members highlighted the importance of Agile's focus on people and collaborative processes in overcoming these challenges. Furthermore, the presentation articulated the value-driven nature of Agile: consistent visibility with stakeholders, continuous adaptability in response to

change, accelerated delivery of value, and early risk mitigation. These components were exemplified through case studies illustrating how Agile can enhance the alignment of scientific research projects with stakeholder needs, ensuring that research outcomes are both scientifically rigorous and practically relevant. The importance of aligning team members' trust, values, and mindsets, effectively managing stakeholder engagement, and balancing researcher-driven initiatives with stakeholder needs was emphasized.

This exploration of Agile within a transdisciplinary context suggests that such an approach can significantly enhance the capacity of Earth science research to address complex, systemic challenges. The necessity of evolving methods in response to shifting strategic priorities was highlighted, advocating for a flexible and adaptive approach to Earth science research that can respond to the urgent demands of climate change. By fostering the integration of diverse knowledge and perspectives, Agile contribute to the production of research that is both scientifically robust and socially relevant, ultimately advancing the broader goals of global climate resilience and sustainability [13].

3.8 Effect of Software Architecture on Team Agility: An Informal Case Study

Many NASA research activities are software intensive. The ability to maintain the appropriate level of agility on such effort can be helped or hindered due to software architectural choices. These choices should be intentional and deliberate, but often the ability of the development team to respond in an agile fashion is not a key consideration in these architectural choices. Dr. Joseph Rios provided insights to this phenomenon by examining the choices made in the development of NASA's 2019 Software of the Year related to drone traffic management.

When a concept is in development and researchers require the ability to test new ideas and software requirements in rapid fashion, a modular, decomposed approach to software can be helpful. When building services for drone traffic management, a microservices approach allowed for isolation of features and eased the ability to make incremental changes to specific services without impairing the overall software system or introducing significant regressions. In addition, as the concept took shape and was applicable to new research questions, microservices offered the ability to reuse code and add new features without painful refactoring. In addition, microservices allow for a language agnostic approach, wherein each service may be written in the most reasonable language. For example, if a Python library offers significant features for a service, the whole service could be written in Python while the majority of other services are written in Java. Extending the system is easier as well, with external teams having the opportunity to write their own microservices to extend functionality. Finally, the microservice approach provided a ready platform for incorporation of best practices around DevOps, cloud deployments, system monitoring, and others [14].

While microservices may not be appropriate for every software system, the idea that the architecture of the system has an impact on the agility of the team should be a key consideration for project managers, product owners, architects, systems engineers, and others.

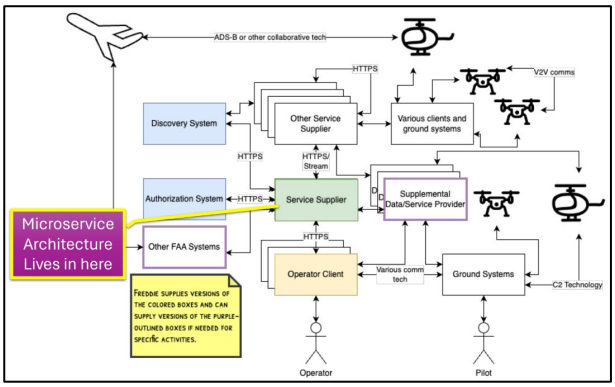


Fig. 8. Microservice architecture [14]

3.9 NASA Launch Services Program (LSP) Systems Engineering Collaboration with SpaceX

In 2010, the Launch Service Program awarded the budding launch vehicle company SpaceX a contract to fly one of its important science missions (Jason-3). Before flying Jason-3, the SpaceX Falcon 9 had to be certified. One element of certification was to perform a systems engineering audit of the launch vehicle provider. SpaceX struggled to explain how they were doing systems engineering and was unwilling to admit they were doing systems engineering at all. By embedding one of its lead systems engineers (Dr. Denton Gibson, PhD) at SpaceX, the LSP systems engineer identified that SpaceX was doing agile systems engineering even though they were not ready to acknowledge it. This revelation enabled LSP to be more agile and adapt its own systems engineering processes to SpaceX's non-traditional systems engineering approach. LSP adapted its systems engineering approach to focus on areas where they saw vulnerabilities in SpaceX's systems and developed tools to enable this agile systems engineering approach.

Kelley Jones-McDowall discussed the findings from the systems engineer audit and how LSP used that knowledge to adapt its processes and develop tools (e.g. Smartsheet) to enable LSP to be agile without sacrificing technical rigor. As a result, the LSP technical and programmatic team can continue to be more proactive versus reactive on systems engineering items and focus the technical team on areas where they are most value added. The Smartsheet tool is used to help the Systems Engineers manage tasks and schedule, distribute

assignments, allow cross discipline communication, and triage the technical content that needs full independent assessment and chief engineer attention. This has aided LSP to maintain a constructive working relationship with the SpaceX team. This effort is continuous and LSP is currently looking at the next evolution of their systems and processes at a full programmatic level in preparation for a diverse launch vehicle provider and customer-based future [15].

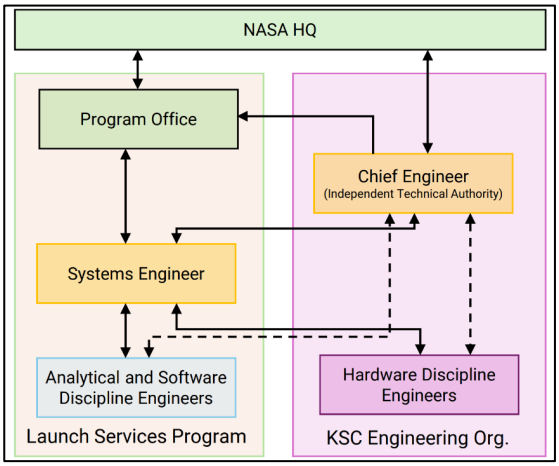


Fig. 9. Launch services systems engineering [15]

3.10 Agile Principles from the ISS Cargo Mission Contract Buy and Fly Hardware Certification Process

The Leidos Cargo Mission Contract (CMC) partnered with the NASA International Space Station (ISS) program to develop an agile streamlined Buy and Fly (BNF) flight hardware certification process, which builds on the ISS Joint Program Directive (JPD) for non-critical Class 1E, Experimental Flight Hardware, certification process. This program-partnered process also outlines the roles of the supporting organizations and stakeholders. Since 2016 the BNF process has reduced cost and schedule for numerous ISS hardware projects while maintaining technical thoroughness and documentation, for both Commercial Off The Shelf (COTS) and custom-built hardware [16, 17, 18].

Amit Patel explained how the BNF process includes a Pre-Coordination meeting utilizing project charts in a templated format early in the project schedule, which is key for efficiencies as it captures the overview, requirements, interfaces, integration, con-ops, preliminary safety assessment, anticipated verifications list from Systems Engineering and Safety, and lays out a path for project completion and verifications closures. A proposed requirements matrix is captured in the charts for COTS and low complexity hardware, and a standalone Project Requirements and Verifications Matrix (PRVM) is used for higher complexity projects. The Pre-Coordination meeting ensures key Subject Matter Experts (SMEs), requirements owners, and stakeholders are involved early in the schedule to provide their review, inputs, and actions to support a clear path to complete certification. The BNF process allows for the following flexibility, reduction in clerical tasks, and less formal documents: The Pre-Coordination Minutes are used as project documentation, capturing SME/stakeholder inputs and actions. Lower complexity drawings can be annotated directly within the charts. Project charts evolve into a certification package, which provides a complete record of project plan, requirements, safety records, verifications, and Project Manager (PM)/NASA project sponsor signatures [18, 19].

The success of the BNF process is also attributed to getting teammates, supporting organizations, and stakeholders used to the agile process with initial lower complexity projects, then growing to higher complexity projects. The agile teammates grew in maturity and experience due to taking ownership of the project success, being part of the shared technical leadership, and being involved in the Ground Rules and Assumptions (GR&A) documentation for the projects [8]. Project leadership encourages a culture of continuous improvement, empowerment, communication, sharing knowledge, focus on technical excellence, and simple yet thorough documentation. Team rapport building and shared technical leadership are the mechanisms that allows open and unguarded communication, so that work keeps progressing on schedule and risks are identified/minimized [20].

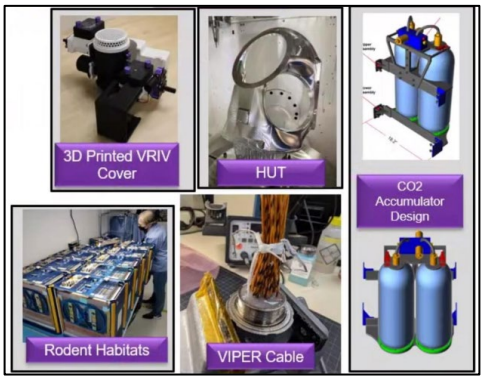


Fig. 10. Design, development, and certification projects [20]

3.11 How OpenMDAO Maximizes our Impact with Agile Practices

This presentation by Rob Falck from NASA's Glenn Research Center discussed how the OpenMDAO team had integrated Agile practices into their software development process. OpenMDAO, a tool designed for optimizing large, complex systems, had gained significant adoption across government, industry, and academia. Unlike other NASA projects such as OTIS or Orion, OpenMDAO was research-focused, allowing for rapid iteration and accepting failure as a part of the

learning process. The development team had tailored Agile practices to fit their needs, focusing on keeping both users and developers satisfied by being responsive to feedback and automating repetitive tasks.

The presentation highlighted how the OpenMDAO team had adapted Agile methodologies to their smaller team size and specific project requirements. Traditional Scrum was found to be too rigid, so the team adopted a more flexible approach that emphasized communication, continuous integration, and test-driven development. The team actively sought feedback from users, which helped in quickly addressing small issues and bringing larger problems back to the team for discussion. This proactive engagement with users and iterative development had been key to their success [21].

One of the critical components of the team's Agile practices was the use of open-source tools and platforms like GitHub and GitLab for version control and continuous integration. This setup allowed for rapid iteration and easier interaction with users. The team also used JupyterBook for executable documentation, which ensured that documentation stayed in sync with the software and allowed users to experiment with code directly. This approach not only reduced the developer's workload but also enhanced the overall user experience.

The presentation concluded by discussing the challenges related to licensing, particularly the limitations of the NASA Open Source Agreement (NOSA). The team suggested that NASA should consider amending or retiring NOSA to better support collaboration with external partners. The presentation underscored the importance of staying current with best practices, periodic refactoring, and experimenting with new tools to manage technical debt effectively. Overall, the OpenMDAO team's experience demonstrated the value of customizing Agile practices to fit the unique needs of a research-focused, open-source software project [21].

Continuous Integration	Nightly	Weekly
• Unit tests	• Tests against stressing use-cases.	• Tests against pre-releases of dependencies.
• Some integration Tests	• Too intensive to be unit tests.	
	• Executed inside our firewall on software that may not be approved for release.	
• **Tests if developer addressed an issue succesfully**	• **Tests if "development" branch has broken some "real-world" use cases.**	• **Tests if someone else's code has broken ours before release.**

Table 2. Agile Open-source testing setup [21]

4. Conclusion

The Agile CoP TIM highlighted Agile projects across the different NASA Centers. Presentations covered the importance of continuous delivery, quality improvement, and stakeholder involvement. Presenters provided insights into their teams' experiences with technical and business epics, user stories, use cases, scenarios. Discussions focused on the importance of maintaining quality through continuous integration and delivery, and the role of stakeholder feedback in Agile practices.

The TIM also covered model-based engineering and real-time embedded systems, with an emphasis on incremental development and hypothesis-driven development to avoid defects and ensure system correctness. In addition, by addressing challenges in Agile implementation, such as managing technical debt and ensuring stakeholder engagement, NASA teams have been able to use Agile frameworks to enhance system reliability and performance.

Overall, the TIM underscored the adaptability of Agile principles to NASA's complex environment, focusing on delivering high-quality, reliable systems that meet the stringent requirements of various NASA projects. The Agile CoP has provided community support and made available resources including the execution of this TIM, which are helping to further share and enhance Agile practices within NASA [22].

Acknowledgements

Special thanks to Agile TIM presenters: Jeanette Le, Robert Falck, Denise Amling, Kyle Driver, Alex Elliot and Carla Procaccino. Thank you to the support of all organizing committee, including: Daniel Hoffpauir, Prenthis Aguilar, Curtis Flack, Eric Hendricks, Carolyn Storer, Marian Cronin, Derrick Cheston, Shenandoah Speers, Paul Liu, Caren Ensey, David Swartwout, Scott Tashakkor, and John Baca.

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