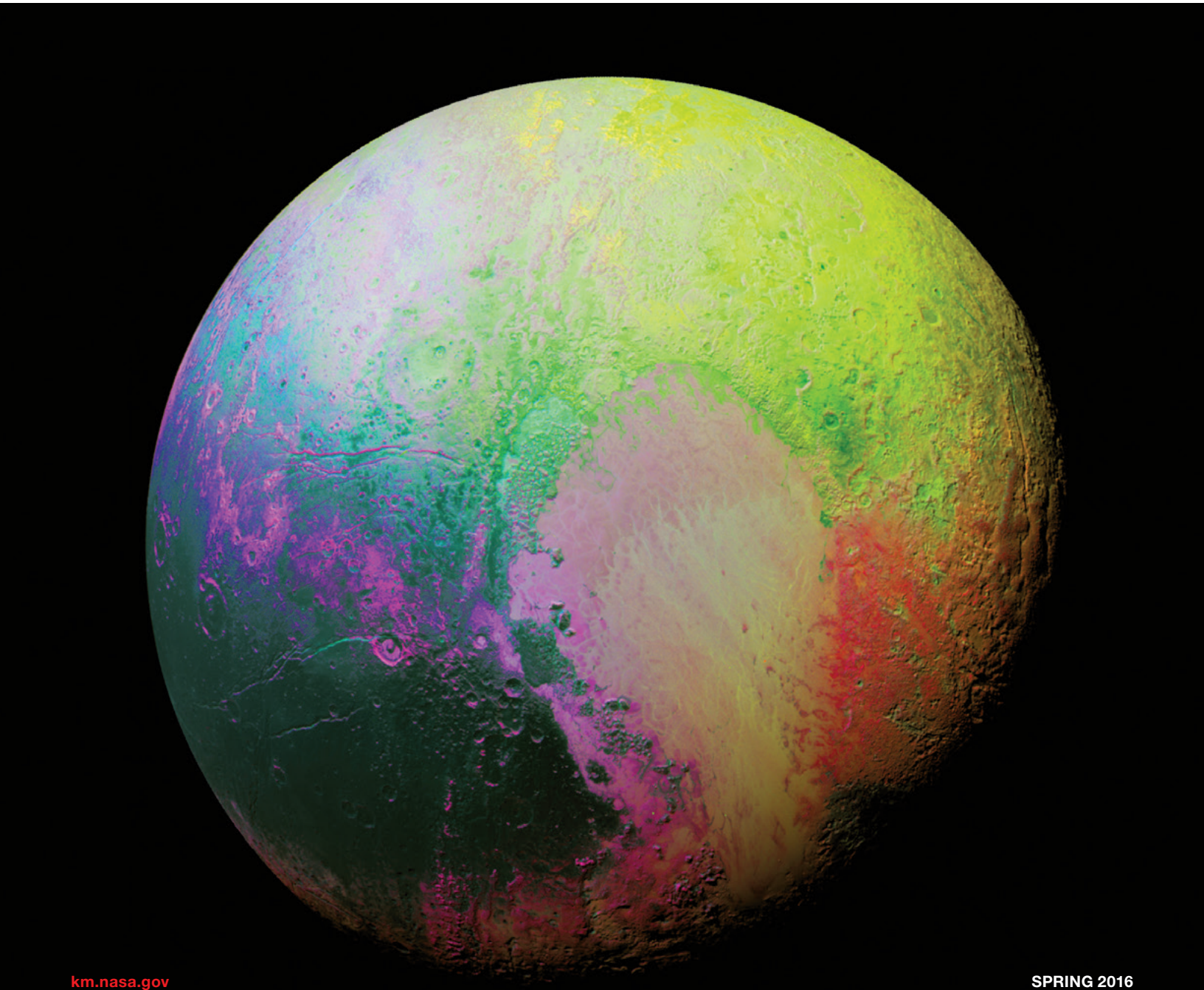
National Aeronautics and Space Administration

NASA KNOWLEDGE JOURNAL

Office of the Chief Knowledge Officer

"To capture and share what we know now to ensure mission success"



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On the cover: New Horizons scientists made this false color image of Pluto using a technique called principal component analysis to highlight the many subtle color differences between Pluto's distinct regions.

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WELCOME FROM

NASA's Chief Knowledge Officer

With this second issue of the *NASA Knowledge Journal*, I believe we have successfully secured yet another medium to promote knowledge sharing. Through this journal we can convey the passion, joy, labor, anxiety, and lessons of working together on and with knowledge services at NASA. If talented and dedicated people have an opportunity to impart their experiences to one another, only great things will happen.

Challenges, of course, always remain. It seems, though, there is one overarching challenge NASA now faces: How do we continue to share knowledge in an environment that seems to be moving ever faster, affording less and less time to talk about what we are learning?

This publication provides a format for sharing knowledge that is accessible, timely, open, and engaging. The stories that appeared in the first issue this past winter offered simple yet powerful advice, insights, humor, and narratives, all of which underscored what makes sharing knowledge so forceful while making NASA projects so meaningful. Within the pages of this new Spring 2016 issue, we continue to discover new ways to make it a little easier for practitioners to continue telling the greater story.

Most often, a greater story is made up of smaller—though not lesser—ones. Ones that reflect only parts of a greater whole. In this journal's second issue, we can learn from a team about the daunting task of applying a formal effort to abstract and largely conceptual knowledge assets, with the goal of identifying and prioritizing the most critical of what we have captured. Another story tackles the conceptual in order to solidify imperatives to move our projects forward.

As NASA is at its core a project-driven organization, it makes sense that the majority of the stories in this issue exemplify knowledge practices: those distilling lessons learned from taking on new projects, those conveying several best practices on projects that have proven their value, and those transferring knowledge through the adoption and alteration of successfully knowledge-sharing projects from other centers. Within these pages we introduce new tools and focus in on mature activities.

These stories—which are essentially about knowledge processes as much as they are about best practices or lessons learned—demonstrate a rich and varied flora of behaviors within a growing learning environment. Each story acts like an indicator for a healthy knowledge culture. We share stated goals, tolerate mistake making, remember lessons learned, and celebrate the contributions of a variety of activities, opinions, and outcomes.

I hope you find what is captured here useful and inspiring. For more information on how to receive paper or electronic copies of this and the first issue, please visit km.nasa.gov.

Warmly,

Ed Hoffman
NASA Chief Knowledge Officer

There's No Shame in Not Knowing: Lessons Learned While Producing NASA's Virtual PM Challenge

BY RAMIEN PIERRE AND DONNA WILSON

Since 2013, the NASA Virtual Project Management Challenge (VPMC) has examined trends in program and program management and shared lessons learned with NASA civil servants, contractors, grantees, and the general public. The VPMC shares lessons via periodic, interactive live webcasts that are recorded, captioned, and made available on demand from the NASA VPMC website. In May 2015, NASA's Academy for Program/Project and Engineering Leadership (APPEL) was presented with an opportunity to become the producer of the VPMC. APPEL's mission is to promote learning among NASA program managers, project managers, and systems engineers. The APPEL team carefully examined this opportunity (see sidebar) and determined it would accept the role of VPMC producer.

As expected, there was a steep learning curve. Even though APPEL had more than 28 years of experience producing learning events for NASA's technical workforce, that previous experience was almost entirely in delivering face-to-face courses. Presenting content live to a virtual audience would require APPEL to demonstrate competency in new areas. The APPEL team accounted for this capacity building in their strategic plan for the initiative. What the team did not expect was the need to plan for re-planning. Further, the team identified a critical meta-lesson learned about the inherent risks in sharing lessons learned live in front of a virtual public audience.

Space Shuttle Endeavour *on Launch Pad 39A at NASA's Kennedy Space Flight Center in Florida, for its final flight, the STS-134 mission to the International Space Station.*

THREE VALUABLE LESSONS LEARNED WHILE PRODUCING THE VPMC

In July 2015, the APPEL team began to enact the strategic plan for producing the VPMC. The first VPMC session that APPEL produced was in September 2015. By the time this article goes to press, APPEL will have produced three VPMC sessions (one in fiscal year 2015 and two in fiscal year 2016) and will be on track to produce an additional three sessions in fiscal year 2016. Along the way, the APPEL team identified a number of lessons learned the team was able to immediately apply while continuing to identify additional lessons.

Fitting content to format using pre-session interviews

APPEL's first VPMC session featured Bo Bejmuk, a retired NASA contractor from Rockwell and Boeing who worked on the Space Shuttle program among other projects. The session was titled "Building Your Systems Mentality: Using Systems Engineering & Integration to Solve Project Challenges" and was held on September 22, 2015. In previous briefings for NASA leadership, Bejmuk had identified 35 distinct lessons learned from the Space Shuttle—more than could be shared in a single VPMC session. The APPEL team had to develop a means to reduce Bejmuk's content to fit into an appropriate VPMC format. Additionally, Bejmuk had presented versions of his Shuttle lessons learned briefing more than 25 times for various NASA audiences. Thus, the APPEL team had to ensure the content presented at the VPMC was fresh for Bejmuk and relevant for the VPMC audience.

The team learned that was it was critical to have face-to-face pre-VPMC session interviews with presenters. These interviews accomplished several tasks. First, they started developing the collaborative relationship needed to support good on-camera rapport during a live webcast. Second, they allowed the presenter and moderator to identify the critical insights around which to build the VPMC session content. In Bejmuk's case, each theme captured aspects of multiple lessons learned he had previously identified. Third, the pre-session interviews supported the development of the VPMC content flow—a tool that outlined the semi-structured interview that would take place on camera between Bejmuk and the moderator. Having this content flow developed in advance allowed the moderator to more effectively facilitate the conversation with Bejmuk and provided content, which the APPEL strategic communications group could use in pre-session and during-session messaging on social media.

Resisting the endemic use of PowerPoint

The APPEL team applied these lessons learned during the second VPMC they produced. This session was titled "Why Don't They Just Give Us Money? Project Cost Estimating and Cost Reporting" and took place on November 17, 2015, featuring Doug Comstock and Mary Beth Zimmerman from NASA headquarters. Lessons learned during the Bejmuk session proved useful. However, the team identified additional lessons learned around the use of slides.

VPMC sessions are webcast live via a user interface that allows the viewer to see the presenters and the presenters' slide decks. Historically, VPMC sessions utilized a large number of slides as a part of panelists' presentations. A critical lesson learned from this second APPEL-produced VPMC session was slide content is secondary to the quality of the on-air conversation among presenters and moderators in terms of supporting the learner experience. Though a reliance on slide decks had become a part of the NASA and VPMC culture, there was substantial evidence that over-reliance on slide decks reduces the quality of knowledge sharing and subsequent decision making. The APPEL team was cognizant of findings from the Columbia Accident Investigation Board report that indicated the "endemic use of PowerPoint briefing slides" (CAIB report, p. 191) was a serious problem for NASA, hamstringing the agency's ability to analyze data and make decisions (i.e., identify and apply lessons learned). For most of this session, the team utilized a nominal PowerPoint format containing only the question/topic being currently discussed during the live webcast. The lesson learned was that focusing on the content of the conversation—instead of the construction, revision, coordination, and required approvals for slide decks—was a more effective use of the team's resources and better supported the VPMC's mission.

Guarding against "magical thinking"

The team producing the VPMC recognized this new-to-APPEL undertaking was similar to the work NASA teams engage in while embarking on a new project. The team, however, failed to also recognize the need to be wary about a critical threat common to NASA projects: the optimistic bias. NASA employees frequently describe how they are involved in "one-of-a-kind missions." This is completely true given the many dimensions of NASA missions including, among other things, the science driving the mission, the technology employed in the pursuit of the science, and the environment in which the technology must operate (e.g., low earth orbit, lunar, Lagrange points).

On the VPMC set with Bo Bejmuk (left) and Ramien Pierre (right).

Though each NASA mission is undoubtedly unique, they comprise activities and products with which NASA has considerable experience. The same applied here for the APPEL team. As noted earlier, though APPEL had never produced a live and interactive lessons learned webcast before, the program had more than 28 years of experience producing learning events. The team leveraged that expertise to develop processes and a schedule of activities. However, when APPEL's production of the VPMC started, the team realized their schedule of activities did not completely capture the necessary effort.

Given the aggressive nature of the VPMC production schedule (i.e., produce a session every other month), the team had to engage in frequent re-planning to account for efforts that took longer than expected or were not predicted. This is not unusual in project management. Neither is the optimistic bias that tends to occur during re-planning efforts when team members routinely overestimate their expected productivity and/or underestimate the challenge of the tasks being re-planned. The result is what is sometimes referred to as "magical thinking" often expressed in language such as:

- "We'll make it work"
- "...and then a miracle will happen, and then we'll…"
- "No problem. We can do that"

As a result of not effectively controlling the optimistic bias during the re/scheduling of activities for the first three APPEL-produced VPMC sessions, the APPEL team resolved to devote time to analyzing and re-estimating the durations of all VPMC-related activities. The end product will be a revised integrated process map and schedule for VPMC session production. The team expects to complete that work by May 2016.

AN UNEXPECTED META-LESSON LEARNED: THE RISKS OF SHARING LESSONS LEARNED

The APPEL team identified an additional lesson learned that merits specific attention because it speaks to the very nature of the NASA Virtual Project Management Challenge, specifically *all lessons learned activities involve some degree of personal and professional risk for the sharer.*

The APPEL team routinely facilitates knowledge sharing on topics that are non-controversial: communicating technical issues, project risk management, scheduling and cost control, etc. What the team did not account for in the planning phase was the degree to which insights shared during the VPMC would present some level of personal or professional risk for VPMC participants.

Examples include:

- Topics identified during pre-session interviews being dropped from the final content flow in order to avoid implying other project managers

or organizations were not effective in executing their duties

- "Minders" reviewing questions asked during VPMC sessions or pre-recorded interview format in order to ensure that nothing too "political" was asked or said

In an article on what successful project managers do, Alexander Laufer, Ed Hoffman, Jeffrey Russell, and W. Scott Cameron made a relevant observation:

"When upper management fosters an organizational climate that embraces problems as an inherent part of the project's progression, project managers are able to detect and resolve problems more successfully."

Based on our experience, a friendly insertion (in italics) would be "...project managers are able to detect, resolve, and *share* problems more successfully." Sharing lessons learned requires identifying where things went wrong on either your watch or your predecessor's watch. One thing the APPEL team discovered is that the ability of VPMC presenters to candidly engage in live webcast conversations can be undermined by presenters' impressions of degree to which their upper management values and embraces the public sharing of lessons learned. The APPEL team is currently identifying ways to support presenters' ability to share lessons learned, as such is critical to the very mission of the NASA Virtual PM Challenge.

CONCLUSION

APPEL has learned many valuable lessons since taking on the production of the VPMC. We have recognized the importance of: providing opportunities to establish a good rapport between the moderator and presenters; having engaging delivery methods focused on the presenters and their message as opposed to their PowerPoint slides; valuing the significance of preplanning for unplanned activities and challenges; and identifying concerns regarding the public sharing of lessons learned. Although many of the processes for each VPMC were repetitive, we learned new lessons with each delivery. We not only focused on what went wrong, but we also captured our successes, which helped motivate the team. Additionally, we found correctly documenting lessons learned during and at the end of a project makes all the difference. We are looking forward to continued learning and successful productions of future VPMCs for our audience.

Ramien Pierre is a member of the APPEL Curriculum Team and moderator of the NASA Virtual PM Challenge.

Donna Wilson is the APPEL Curriculum Manager and has been involved in the APPEL program since 2005.

The Aerospace Safety Advisory Panel (ASAP) made the recommendation that there be a one-click and one-stop shop for finding Lessons Learned (LL) to ensure that website visitors, both from NASA and the public, could easily access LL resources such as the Lessons Learned Information System (LLIS), the Goddard Knowledge Exchange (GKE), and the Human Exploration Operations (HEO) Lessons Learned Video Dashboards. The "Lessons Learned" tab on km.nasa.gov is a direct result of that recommendation.

NASA Academy for Program Project and Engineering Leadership: http://appel.nasa.gov/

NASA Virtual PM Challenge web site: http://www.nasa.gov/offices/oce/pmchallenge

NASA Lessons Learned information system: http://llis.nasa.gov/

APPEL Develops a Strategic Plan to Produce the NASA Virtual PM Challenge

From May 2015 to July 2015, the APPEL team analyzed the opportunity with which they were presented by the NASA Office of the Chief Engineer: Take on the role of producer for the NASA Virtual Project Management Challenge (VPMC). The results of the analysis would determine whether the team would take advantage of this opportunity. The APPEL team's analysis was guided by four questions:

- What is the goal of the NASA Virtual PM Challenge?
- What does it take to be successful at the goal?
- Does APPEL have what it takes to be successful at the goal?
- Based on this analysis, should we undertake this initiative?

WHAT IS THE GOAL OF THE NASA VIRTUAL PM CHALLENGE?

The APPEL team quickly confirmed that the VPMC's goal would not change under its watch: Provide useful and timely insights primarily to NASA program and project managers.

WHAT DOES IT TAKE TO BE SUCCESSFUL AT THE GOAL?

The APPEL team facilitated a number of meetings with members of the VPMC production team, NASA Office of the Chief Engineer, and NASA Engineering Safety Center to identify things that would facilitate the VPMC successfully achieving its goal. Additionally, the team engaged those stakeholders in discussions designed to identify risks and obstacles that would need to be mitigated or overcome in order to successfully meet the goal. The team defined the following as critical capabilities:

- A system for generating/curating content for the VPMC
- Ability to maintain a consistent presence as perceived by audience/key stakeholders
- A learner-focused format that would be used to structure VPMC sessions
- The means to expand the distribution of VPMC sessions

DOES APPEL HAVE WHAT IT TAKES TO BE SUCCESSFUL?

The APPEL team recognized they did not have all of the critical capabilities to successfully produce the VPMC. The team would need to develop some additional capacities and tools, as well as adapt some of its existing capabilities. This was to be expected: APPEL was embarking on an initiative that was related to its historical work but differed in a number of key ways. The APPEL team confirmed that they would need to create a system by which potential VPMC topics could be gathered, vetted, researched, and finalized. The team recognized that APPEL already had an analogous system for developing new APPEL courses. That system was designed to develop new courses or revise existing courses over a period of months. To produce VPMC sessions, the system would need to be adapted to produce content in a matter of weeks. An accelerated development schedule would support the second key to success: maintaining a consistent presence as perceived by audience/key stakeholders. Based on its research, the team set the goal of holding VPMC sessions every other month in order to produce six sessions in fiscal year 2016.

Identifying an appropriate learner-centered format for the VPMC presented a particular challenge for the APPEL team. Historically, VPMC sessions were structured similarly to conference panel sessions. A moderator would introduce multiple presenters who would give discrete but related presentations and then facilitate an audience question and answer session. The APPEL team determined this format was an efficient way to deliver content to a virtual audience, but it might not always be effective in terms of supporting audience learning. Leveraging their experience in delivering learner-centered face-to-face courses, the APPEL team identified the essential characteristics of a learner-centered experience but could not identify the one VPMC session format that would embody those characteristics for all potential VPMC session content. At that point, the team determined the best option was not to have one standard VPMC session format (e.g., panel presentation) but to have *multiple* formats (e.g., panel presentation, interview, news magazine), which would be selected and deployed depending on each session's content. The team predicted an additional benefit of the multiple-format approach, which would be greater audience engagement resulting from the variety in delivery styles.

Additionally, the APPEL team proposed that the VPMC have a consistent moderator, as such would address a number of issues identified during conversations the team had with key stakeholders during the planning phase. Historically, the presenters for each VPMC session would provide their own moderator. The moderator would facilitate the live webcast while also serving as the liaison between the VPMC technical crew and the subject matter experts who would be presenting during the session. This meant there was a learning curve that had to be navigated with each and every VPMC session, since the production team would be different each time. Moreover, it meant that there was not a consistent "face" to the VPMC sessions since the people on camera would be completely different from session to the next. Thus, a consistent moderator would flatten the technical learning curve that had to be navigated from one session to the next. Over time, a consistent moderator would provide a recognizable face for the VPMC audience. Finally, a consistent moderator could add value by identifying content connections across VPMC sessions during the live webcasts.

At the point when APPEL was undertaking production of the VPMC, it already had a robust communications function capability of developing and distributing content to NASA audiences via email and web. The VPMC reboot plan called for the close support of the APPEL Strategic Communications team, including developing VPMC-related content before sessions, to be presented during the sessions, and to be distributed after VPMC sessions.

BASED ON THIS ANALYSIS, SHOULD WE UNDERTAKE THIS INITIATIVE?

As a result of their analysis, the APPEL team decided to pursue the opportunity of producing NASA VPMC sessions. Though the team recognized they would need to navigate a learning curve to be successful, they were confident they had sufficient capability to do so. Further, supporting the VPMC was aligned with the APPEL mission of developing NASA's technical workforce.

Twelve Strategic Imperatives for NASA Knowledge Services

BY ED HOFFMAN AND JON BOYLE

To ensure mission success, NASA remains a project organization and program environment at its dual core. Twelve strategic imperatives enable and direct the design, execution, and evaluation of Knowledge Services (KS) for the agency, supporting its projects and programs.

PROJECT MANAGEMENT (PM)

It begins with PM. All organizations, particularly NASA, require a methodology that allows for rigor and agility in managing both temporary and ongoing processes and operations towards the achievement of defined requirements, project objectives, and anticipated outcomes. All of these must be aligned to strategy, especially in an era of constrained resources. In this context, PM is uniquely positioned as an adaptable discipline that fits the mission and can maximize the speed and application of learning.

ACCELERATED LEARNING

This is a set of tactics employing state-of-the-art online and other digital technologies, as well as more modern knowledge-sharing activities, traditional learning strategies, social media processes and tools, and cross-discipline knowledge into the broadest view of learning for an organization. Fast and relevant knowledge transfer and retention serve to clarify and prioritize organizational and developmental expectations for optimizing findability, accessibility, and searchability of knowledge resources.

DIGITAL TECHNOLOGY

Online and electronic codification makes it possible to examine new frontiers of potential knowledge and access multiple sources of data and information; nonetheless, it simultaneously causes organizations to be increasingly buried in data and to struggle to make time for focusing and reflecting. Technology is essential and necessary, but it is not a panacea for KS. Results can issue from the application of technology, such as open, social network–centric, non-proprietary, adaptable frameworks. Digital tools accelerate learning processes to deliver "the right knowledge, at the right time" for particular needs while respecting context. The proper application of digital technology assists in achieving learning objectives and in making better decisions at a lower cost.

LOW-COST INNOVATION

A frugal mindset views constraints in an era of restricted and diminished resources as opportunities, leveraging a strategy of sustainability and a focus on organizational core competencies that will function to decrease complexity and increase the probability of better outcomes. Sustainability has gained momentum as the availability of resources increasingly impacts business decisions. Organizational requirements for a new product or service involve what must be achieved rather than what can be done with unlimited scope, ensuring organizational capacity in areas such as technological, social, political, economic, and

learning dimensions are part of the frugal innovation process. In a mutually reinforcing perspective, other imperatives, such as Transparency, which allows the team to share knowledge and experience to improve and innovate, support all efforts where "less is more" and streamlining is key.

TRANSPARENCY

Open operations are an important consideration for the portfolio of organizational projects and programs to seem genuine. Numerous team members, customers, stakeholders, strategic partners, suppliers, and others interested and invested in organizational strategies and project processes create a network of trust often advanced through communication and digital tools. Transparency, which is built into the strategic business process, encourages benchmarking, sharing, collaboration, leveraging, and innovation, translating economies of scale and a breadth of lessons learned. Even in a structured environment, nothing is hidden for long: Errors travel at the speed of light. Communications should be carefully defined across boundaries, as intensity and frequency of messaging is managed; for example, "NASA Only" stakeholder communities may expect to be informed about progress at a higher level, but not as frequently or in as much depth as external audiences.

LEADERSHIP

Without effective, supportive leadership, KS fails. True leadership occurs with the insight that things should change, but also the realization that the reasons for change may be clear to leaders themselves but not necessarily clear to others. Effective leaders align projects with organizational strategies, missions and goals; this is admittedly easier said than done in the modern environment of information overload and rapid change. Successful implementation happens with a carefully communicated vision, leadership focusing on that vision, and attention to detail on implementation. There exists an external stakeholder community, as well as an internal project team, whose development, skills, and talents need to be understood and managed by leaders.

TALENT MANAGEMENT

For NASA, talent management is organizing the variables in abilities, assignments, attitudes, and alliances (4 A's). Each addresses the specification, identification, nurturing, transfer, maintenance, and expansion of the competitive advantage of practitioner expertise and competence. Diversity goes beyond the classic categories of color, race, religion, and national origin to domestic and international variables important to geographically dispersed and cross-discipline teams, as well as divisions in work sectors, such as government and industry. Diversity allows groups to leverage experience, knowledge, focus, passion, and to bring talents and interests to the table. These characteristics strengthen both inductive and deductive problem-solving approaches, affording innovation, and developing individuals and teams, informally and formally.

CERTIFICATION

Objectives and curriculum development of learning standards establish both validations and functions in benchmark achievement in defined categories of practitioner performance and capability. Formalized learning also provides organizations and practitioners the means to create trust with senior leadership, colleagues, team members, customers, and stakeholders and to provide a lexicon, pedagogy, and framework for change, as well as methods to address emerging or evolving performance requirements. For KS and PM practitioners, certification provides a clear roadmap for individual and team development, reflected in diverse and reinforcing projects and programs.

PORTFOLIO MANAGEMENT

Process integration of projects with strategy creates an organizing framework that drives organizational purpose and activities. Diverse projects and programs provide a centralized function that promulgates a systems view of knowledge, whereas stove-piped disciplines and activities can transcend boundaries to enable greater discovery. Portfolio management leverages cross-disciplinary knowledge to increase competitive advantage and achieve optimal results. Outcomes and organizational expectations can also be tested against project realities at ground level and can be communicated and quickly adjusted to mitigate errors and achieve better decision-making.

PROBLEM-CENTRIC APPROACH

Problems should be seen as another outcome of project and program processes, as well as positive, forward-leaning solutions in the form of lessons learned and leading practices. Emphasis on a non-partisan, non-biased, non-judgmental, and pragmatic orientation towards problems and solutions keeps the focus on achievement, improvement, and agile innovation. Organizational expectations are kept pragmatic and constructive when aligned with problem-centric approaches. At the end of the day, it is about problems, communications, power, and building communities of support focused on credible solutions to challenges. This orientation serves as the thrust for both change and innovation while also addressing competing agendas, administrative barriers, and issues of bias and heuristics, which, when not addressed, could introduce error in decisions.

GOVERNANCE

Business, administrative, and operations management provides for pragmatic alignment, oversight, approvals, and implementation of project and program operations and establishes rigor and opportunities. In an era of low-cost innovation, management of the budget and clarity of funding requirements that support the overall effort must be visible and valued by the leadership and the workforce. Nothing invites trouble faster than mismanagement of funds and a lack of focus on funding flow; therefore, the oversight, tracking, and execution of project activities need definition. Defined governance addresses the issue of fragmented implementation and increases executive awareness, as well as formalizing successful and localized grassroots efforts. Senior leadership and advisory bodies understand the cost of KS is a bargain compared to the cost of lost knowledge or not learning lessons.

KNOWLEDGE

The essential element for the creation of successful physical and virtual products, services, and processes is knowledge. It can be viewed as an organized set of content, context, skills, and capabilities gained through critical experience, as well as through formal and informal learning that organizations and practitioners apply to make sense of new and existing data and information. It can also be shared as previously analyzed and formatted lessons, practices, cases, and stories that have been captured and applied to new situations. The ascendance of leaders validates the realities of projects and programs to which knowledge can be applied and can be the basis of good decision-making.

All of these imperatives reinforce other imperatives, allowing for various broader objectives of KS to improve and innovate in terms of products and services, thus supporting the efforts and outcomes of projects and programs.

Ed Hoffman is NASA's Chief Knowledge Officer.

Jon Boyle is NASA's Senior Knowledge Sharing Consultant.

The Knowledge Toolbox—located on km.nasa.gov—contains tools, resources, and information for individuals and teams to enhance their knowledge-sharing efforts on real-life projects and programs. Analogous to how imperatives enhance and reinforce other imperatives, the tools, both conceptual and practical, found in the toolbox work together to create a stronger knowledge-sharing strategy.

BEST CASE FOR CASE STUDIES:

An Interview with Jennifer Stevens, Chief Knowledge Integrator

BY SUSAN SNYDER

Jennifer Stevens, Chief Knowledge Integrator at Marshall Space Flight Center (MSFC), supports Center and Agency Chief Knowledge Officers and interfaces with the NASA knowledge community. She develops policy and procedures at MSFC to define and implement Systems Engineering (SE) policy and practices. Specifically working in the Lessons Learned Committee, she has been involved in developing MSFC knowledge strategy and planning, coordinating and integrating grass roots knowledge-fostering initiatives, and creating and teaching courses designed to cultivate a knowledge asking and sharing culture. Stevens developed the Marshall Distilling Process, a cross-center team that works to operationalize lessons learned that the Lessons Learned Committee has approved for implementation.

Susan Snyder, Managing Editor of the *NASA Knowledge Journal*, sat down with Stevens to talk about her most recent work: case study efforts that she has been leading at MSFC and the story of the cross-center collaborations that helped launch this rich learning offering at her center.

SUSAN SNYDER: WHAT ORIGINALLY SPARKED YOUR INTEREST IN BRINGING THE CASE STUDY LEARNING APPROACH TO MARSHALL?

JENNIFER STEVENS: A couple of years ago, the Marshall CKO (Chief Knowledge Officer) team, led by Dale Thomas—the former Associate Center Director, Technical and Chief Knowledge Officer at MSFC—participated in the Return to Mission Success (RTMS) forum at Goddard Space Flight Center and saw how successful it was. Dr. Ed Rogers, Goddard's CKO, leads RTMS, a multi-day learning event that has enormous impact on employees' understanding of NASA, the organizational culture at GSFC, and the way things work. RTMS uses the case study approach to many of the learning modules. My team and I experienced firsthand the engaging, deep learning through case studies. It really enriches the classroom experience. Ed Rogers is also a renowned expert in developing and facilitating case studies for NASA, and he was willing to support other organizations in running case study–based learning sessions.

SNYDER: WAS THIS YOUR FIRST EXPERIENCE BEING IN A CASE STUDY DISCUSSION?

STEVENS: In my Master's and Doctorate programs in Engineering, we had to write case studies, but we had no guidance. We would be given a topic like "management style" and had to look at two companies and write about their management styles. We would write about it in a scenario and then analyze it. Unfortunately, we were so focused on the course topic when developing the scenarios that we would write the case study to support the analysis results. We didn't use case studies as a knowledge-sharing tool. And they could be pretty boring too.

Students learn about all kinds of case studies, and how those other forms can be used in teaching, storytelling, or knowledge capture.

SNYDER: HOW DID THE CASE STUDY LEARNING APPROACH DEVELOP AT YOUR CENTER?

STEVENS: Well, when we left Goddard's RTMS program, and we unanimously decided to make Marshall an organization that learns through cases. Our challenge was that none of us was experienced in teaching people how to develop a case, and we needed writers to be skilled in that ability. So, Dale Thomas and I asked Ed Rogers to help develop and present a course on developing case studies. Ed and I developed the learning plan and course agenda, and Ed provided guidance, suggestions, material, and content. Ed taught the one-and-a-half-day pilot course at MSFC in June 2014. He's a wonderful teacher who also modeled good teaching practice for me. I recruited interested people from different organizations to take the pilot. We videotaped Ed's presentation for future reference. I then worked with three writers over the next six months to write two case studies. After that, it was only a matter of time and preparation before we did our first full workshop in April 2015, with six teams starting the case study writers experience, and five teams finishing in August of that year.

SNYDER: HOW DID YOU APPROACH YOUR FIRST CASE STUDY PILOT SESSION DESIGN?

STEVENS: The first thing I did was take what Ed had written on "How to Write a Case Study"[1] and evaluate how to teach that to a class. I put structure around teaching those steps. I incorporated the key things he taught us in the pilot, such as concept mapping and interviewing skills. Those are two things I didn't have a lot of experience with, so having Ed teach us and then having the video to review later helped a great deal. We adopted Ed's teaching design. We kept in mind that we are teaching a specific kind of case study, so we made sure that we illustrated different kinds, and explained how they are used and how they differ.

These teaching- or decision-oriented case studies are set up so readers can do the thinking. You give the reader information and background, but you don't lead them to a specific answer. Case study–based learning is basically a simulation of a situation without having to go through it for real. Instead of learning principles from a textbook or learning in the job environment while everything is going on, you can go through the simulation and not have to pay attention to all the noise. The richness of context helps people think through the situation and come to conclusions. That's where the learning happens.

When we say we are doing "decisional" case studies at Marshall, I have to be careful because it doesn't always have to be about a decision. It can just be about a situation. They might better be described as "instructional" or "teaching" case studies. We have to keep the length and focus so that we can use them in about a one-hour segment in our other courses.

Explaining our end goal for using the case studies lets the writers understand the *why* of this particular type of writing. It explains why we talk about what the story should look like and how they themselves might be teaching it. Students learn about all kinds of case studies and how those other forms can be used in teaching, storytelling, or knowledge capture. They learn how to deconstruct them, so they learn how to look for information and how to organize it. Organizing a narrative is a skill that people need to learn, so they can construct how they put evidence together in a case.

SNYDER: HOW DID YOU MARKET YOUR COURSE TO GET TRAINEES TO COME?

STEVENS: For the pilot I advertised through normal training channels, plus I let the students who attended RTMS at GSFC know. I also invited people from the History Office and the Engineering

Directorate that I thought would be interested. One person who had taken RTMS at Goddard and fell in love with the idea of writing case studies came prepared with several ideas she got from talking with her management months before the class was announced. I was pleasantly surprised by the interest in writing given that we have so many engineers here. In fact, Jim Turner, the Technical Assistant in the Engineering Directorate, which employs more than 50% of the people working at the center, took part and is a real advocate now. You just never know where the interest will come from.

For the full course, I again used normal training announcement channels, but I also invited specific senior people to ensure I had experienced senior partners. Dale Thomas is an example. He took the full course where I paired him with two younger students. I found that senior partners really have to be committed personally to producing the case study. Dale made time to work with his junior partners. He invested his time in them. I'm dedicated to making sure I have advocacy and senior people to pair up with junior people.

What surprised me was that people came out of the woodwork. They told me, "I like to learn that way" and "I have ideas for several case studies I'd like to see written." In one instance, one of our senior managers wanted to present a case study at our Real World Marshall Mission Success course to help structure his discussion. A pair of writers, one from his organization, crafted a case study originated from a detailed outline he had made. He has since asked us to help him write another one. We will pair someone in our next course with the senior writer on the first case to develop this second case with this manager's attentive guidance, knowledge, and invested commitment.

SNYDER: IF I SIGNED UP FOR THE COURSE, WHAT WOULD I BE COMMITTING TO?

STEVENS: You would attend the two-day Case Study Writers Workshop for training in understanding the different types of case studies, the purpose and use of decisional case studies, the basic process and schedule, researching and interviewing techniques, and crafting and editing for effectiveness. Then you would participate in the Case Study Writer's Experience, which is actually optional, but highly encouraged. The Writer's Experience is a team-based, hands-on case study writing effort with coaching throughout the development.

It takes the partners some in-depth discussions between them to craft a story they're both happy with.

SNYDER: DID YOU HAVE A FORMAL APPROACH TO WORKING WITH THE WRITER'S EXPERIENCE TEAMS?

STEVENS: I try to keep it to 16 to 18 weeks. I meet with them first every week, and then space it out to every two weeks, and then to every three weeks. I try to be flexible to the business need and the writers' workloads. That can slow things down. Work gets in the way. The process gets bogged down. It gets hard, but if the teams don't meet, they don't get the work done. Major project events affected our progress this year. There were two teams I coached that got stalled by the senior partner going on a detail. On one I ended up partnering with the junior member. The other writer I had to encourage independently. Fortunately, his senior partner was able to do enough before he left so that the junior partner was able to finish with an excellent case study.

SNYDER: WHAT ARE THE KEY PARTS OF A CASE STUDY?

STEVENS: First, there is the opening in which you set the stage. Then, you set the context—the project, location, who is doing what, and the history, issues, and conditions. It funnels the context from the broader picture down to the specific situation. Next, the writers, having written the opening and scenario details, illustrate a decision point or conundrum. At a certain point, the writers may include a "Stop and Think" or a "You Make the Call" question to prompt the reader to pause and reflect on the situation. The "Stop and Think" is good, but sometimes it creates too many breaks in the story. It is sometimes better to stop and end. Or not ask a question. It depends on their goal with the story's use and scope.

The trick isn't how to fill up the space but how to write a concise package. I help the writers refine their narrative. We're still adjusting the process. In editing, you can't love something so much you can't leave it on the table. And our writers get a massive amount of information after interviewing key people. It takes the partners some in-depth discussions between them to craft a story they're both happy with.

SNYDER: HOW LONG ARE YOUR TYPICAL CASE STUDIES?

STEVENS: Typically about three to six pages with pictures and references. However, there's no right or wrong. For instance, the "Columbia Return to Flight" case study is 17 pages with three sections—there were two Return to Flights. The length of the story can be short or long, depending on the case and what you are trying to teach with the case.

SNYDER: ARE THERE SKILLS OR COMPETENCIES THAT HELP SOMEONE BE SUCCESSFUL IN WRITING CASE STUDIES?

STEVENS: There are so many skills that go into it. I never realized how many. Ed Rogers developed his process for writing a case study as an individual, and he isn't an engineer. He's more of an Organizational Development (OD) person. He's mentally not as constrained by process as we technical types might be when trying to write a targeted case study on a schedule in teams. Ed is highly skilled in writing case studies, so the tangential skills or competencies that we teach in this course weren't obvious to us before we started. He just does them naturally.

The first thing you have to do when you write a case study is know a little about the area you are writing about. We need the writing team to be conversant in an area that they may not have a lot of knowledge of, so we pair more experienced practitioners with less experienced practitioners to enable better knowledge flow. At least one partner should be conversant about the subject.

The second important skill is interviewing skills. We teach this to some extent. Interviewers have to listen for understanding, not judgment. However, they also have to manage their time to get the facts needed for the story. There is a balance between letting a person talk, which may result in a keen insight, and asking guiding questions to stay focused.

Sometimes the best story isn't the one you thought you were going to write. In some interview situations, more case studies topics can emerge. The compelling one that emerges might become *the* case study. Then the team has to go back and interview again to build out the new case study. Interviewers have to listen for the things that correlate with this different focus—then they have to go back and reconcile all of the data gathered to tell the story. They have to be flexible. They might really have wanted to tell a specific story. We are not natively used to giving up our biases. It's a matter of listening for the right information, not the bias-confirming information. People just have to restrain themselves, be aware, and listen. It's a skill, and it's not a cultural norm.

The writing team interviews people who were intimately involved in the situation or case. It can be surprising that emotions can be so strong even after a decade. Interviewers have to learn to be sensitive to repressed trauma, but not be afraid to ask about the emotional experience. The emotional experience is a huge part of the real-world experience, and perhaps harder to appreciate than the technical details.

Note-taking skills help. Ed Rogers taught us a unique type of interviewing/note taking using concept mapping, where the interviewer draws a map of the different concepts that are being gathered in an interview. The end product is a map of related thoughts. It is much more visual and memorable than a long Word document. We tried to use the concept mapping, with mixed success because it is a different way of thinking. Some of our younger people like it; linking things helps to remember them. I tried it, and it really does help.

Another skill is the ability to pull all the information down to a coherent point so people can make decisions on different options. It's presenting a conundrum without giving an answer. I do let the writers write questions, but I encourage them to avoid leading the reader to the writer's conclusion. They need to write to a point, to bring the learner to reflect on what is happening. I have a lot of people who want to give "the answer." In reality, there usually is no single answer. That is why it is a case study and not a mishap investigation. What worked or didn't work might not be the only answer to what could have worked or would not have worked.

[1] http://www.nasa.gov/centers/goddard/pdf/292342main_GSFC-Methodology-1.pdf

"Rocket Park" at Marshall Space Flight Center in Huntsville, Ala.

The final skill is so hard. It's editing. Editing out great information to tell a clear story. It's "crafting" a narrative. It's more like "Case Study 201." Editing is a refining skill. This is what we struggle with— and what our writers are struggling with. At the end of the Writer's Experience, we may or may not have mastered story crafting. I sometimes tweak the case myself and ask them to review it. I'm okay with the students getting to a certain level of polishing that is good enough. Good enough is when other people can read the case, maybe come to a classroom discussion, and learn from what the writers have developed, even if it is an imperfect final draft.

SNYDER: WHEN THE CASE DEVELOPMENT IS IN FINAL DRAFT, DOES IT GO THROUGH A REVIEW PROCESS?

STEVENS: Yes, and the review process can be a challenge. We fact check rigorously, and we ensure that graphics are not copyrighted anywhere. We coordinate with Legal, Export Control, and other management to ensure that the case is consistent with policy and guidance.

The draft always goes to key players, the interviewees. It can go through any number of iterations. We really strive to get balance in the case. People's perceptions of the same event can differ widely. Sometimes that is the whole point of the case study: Two sides see something completely differently, and that's why things went awry. We try to represent both sides without blaming. In the end, the case study is not a news report or historical document of record; it's a narrative of recollections and factual evidence that reflects our history and common experience.

As a side note, one of our cases is about two project leaders with two very different perspectives. During the review process, both parties finally learned what the other person had been thinking, how they saw the situation. Pieces of the puzzle started falling together, leading to greater understanding on both their parts about what was really going on at the time.

SNYDER: DID YOU HAVE ANY HELP FROM OTHERS AT MARSHALL OR OUTSIDE OF MARSHALL—TO REVIEW THE CASE WRITINGS, TO HELP DEVELOP THE FACILITATION GUIDE OR WORKING GROUP QUESTIONS?

STEVENS: Ed Rogers was our go-to coach. He was always a big help—he would tie in on some of our meetings. His guidance in setting up the pilot class and providing feedback was essential. He provided encouragement and advice on next steps. Ed came down for the pilot, and he tied in on the next year's class by Adobe Connect. He especially helped with how to edit, how to wrap up the case, and performing the interview. It was great to have him support that; he is a great resource for learning how to engage in the finer details of case study writing.

SNYDER: DOES ANYONE NOT SUCCEED IN WRITING A CASE STUDY?

STEVENS: Some. It helps to have some background in what you are writing about. They have to learn a lot if they don't know the topic or understand the context at all. They get fire-hosed with so much information, so it helps to have some kernel of knowledge to put structure on the case. Without some knowledge, they might never figure out when to end the questions and focus on a topic. The deeper they go, the deeper it gets.

Some people come into it wanting to do a case study that is something other than what we teach (instructional case studies). The course never gels with their idea of what it was going to be. Also, I had one student who added the class the day before we started. I didn't have time to examine his knowledge areas and find a suitable partner to pair with him. He had specific ideas about what he wanted to do, which didn't align with anything on the docket at the time. This, combined with a limited amount of time he was allowed to give to the course, resulted in his not finishing.

The course also takes time: time to interview, time to think about what you have been told, time to write. Work can overtake the time they can spend. They can't complete the development, but at least they learn the principles. Even if you just take the workshop, the exposure to the skills, methods, and the cases we review are enriching and applicable to everyday work.

SNYDER: WHAT ARE THE TYPES OF LEARNING THAT YOU ARE CURRENTLY FOCUSING ON?

STEVENS: One we are crafting now is on highlighting the different perspectives of a Principal Investigator running an innovative, low-budget project that the Center wants to manage at a programmatic level with the systems engineering tools. So, how do you marry small, agile project approaches with big program management techniques when you aren't used to doing that? The project needs the programmatic approach, because when you are in the middle of the project, you aren't always looking at the future. By working at a programmatic level, you will have the tools and process you need to plan for the future because there is a process. But putting effort into conforming to PM and SE requirements can be seen as overly burdensome to small projects with very little budget. Flexibility is essential to be a good project manager, but there are reasons why we have a structure for managing work.

Even if you just take the workshop, the exposure to the skills, methods, and the cases we review are enriching and applicable to everyday work.

There is also a case being developed on Teaming, concerning a young, inexperienced team that is given a hands-on project. It illustrates the challenges they have coming together as a team. That one needs more work, more focus. We have one more about a project that suffered communication problems because of a lack of role definition and adaptation to a changing budgetary environment. It is more of a conundrum story than a specific decision point narrative.

SNYDER: DO YOU CHOOSE TOPICS AND POCS BEFORE THE CLASS?

STEVENS: I make sure I have them. If students come in with some topic or idea, that is great. In our last class we had one student come in with an idea for a case on the Return to Flight (RTF) after Columbia. It is fascinating. I shared that with Patrick Johnson, Human Exploration's CKO. The gentleman who came in with the idea was one of our most senior people who had gone through RTF. He took the course because he enjoyed learning from case studies—reading them really engaged his curiosity. To foster idea generation, we seed the class with experienced people, who usually propose ideas in class. Also, management brings us topics. I love it when people are already engaged with learning from case studies and want to share the knowledge they consider important through storytelling.

What I would really like to do is get more cases in procurement and other institutional support areas. I know they infuse some lessons learned into some courses, but I think we could really amplify our business process courses with more case studies about the real world of NASA. I'm working on developing more ideas and POCs for those institutional organizations.

SNYDER: HOW MANY TIMES HAVE YOU RUN THIS COURSE, AND WHAT ARE YOUR PLANS TO RUN IT IN THE FUTURE?

STEVENS: We ran the pilot in 2014, the first full course in 2015, and this will be the second year of the full course. I am revamping the design to improve it based on lessons learned these past two years. I am trying to get familiar with Adobe Connect because other Centers have expressed an interest in having this there, so I am toying with the idea of tying them in virtually, maybe next year. I can teach the course, but to run the program there, the post-class Writer's Experience—where case studies are actually developed—has to be done at the host center because it is a high-touch process. There would need to be someone who can mentor students through the process without me being there. As for Marshall, we plan on continuing to offer the course every year. My hope is that we can enable the other Centers to adopt and adapt the course to augment their knowledge capture and sharing also.

SNYDER: ARE THE CASES THAT WERE DEVELOPED IN THE COURSE OFFERING BEING PRESENTED AT MARSHALL?

STEVENS: Yes, at the Marshall version of Goddard's RTMS. We call it *Real World Marshall Mission Success (RWMMS)*, which we first offered in August 2015. Five of the nine case studies presented last year were from the Case Study Writer's Experience. They were very successful. We will continue a yearly offering of RWMMS using our Marshall case studies.

The writers themselves get to present their cases at RWMMS. This has had a great motivating effect on them to polish their cases to a level that others can learn from them. It has been great for our writers. They figure out how much they really do know

about the subject, and it also brings up questions or comments that they hadn't thought of or known about. They may decide to revise their case study to bring in a little more information or present a point in a slightly different way. One of our junior writers took his own initiative to dry run his case in his staff meeting. The branch engaged in a great discussion and brought up some points he then clarified in his case before when he presented it at RWMMS. Overall, it has been a privilege to watch their growth and the satisfaction at having produced something that is used immediately and appreciated by their peers who are learning about the real world of Marshall as we strive for mission success.

SNYDER: WHAT ARE THE UNEXPECTED BENEFITS OF THE CASE STUDY APPROACH?

STEVENS: Five things:

- The incredible amount of information each student gains about a subject, even if they were involved in the situation themselves. The learning can be incredible.
- The struggle to wrangle and distill all that information into a balanced narrative based on the evidence at hand. Isn't that what we have to do daily at NASA?
- Cross-generational knowledge sharing. This includes senior members learning new skills from junior members.
- Contextual learning; it makes knowledge stick.
- Exposure to experienced and senior managers in a positive and engaging, outside-of-the-workday forum. They find out who you are and that you're proactively pursuing relevant knowledge.

SNYDER: WHAT DOES YOUR LEADERSHIP SAY ABOUT THESE ACCOMPLISHMENTS?

STEVENS: Dale Thomas is very pleased with it. He plans on using cases we produce for the Systems Engineering courses he teaches at University of Alabama in Huntsville. As I said earlier, one senior manager requested we prepare case studies for him to present at Real World Marshall Mission Success. As my students have produced really good, relevant case studies, I am seeing management being more impressed with the clear benefits of this kind of learning. I am working with some to identify cases they would like to see done and encourage their staff to participate in the course. They seem to have no shortage of ideas for potential case studies. You just have to ask the question.

SNYDER: WHAT'S THE GREATEST LESSON LEARNED ABOUT THIS JOURNEY?

STEVENS: Be brave. Because nobody had ever done this before, and even Ed Rogers, who wrote numerous cases, hadn't done this before. We weren't sure you could teach case study writing and successfully produce any that could be used. And this is case study writing with *engineers*. The cliché is that we engineers became engineers to avoid writing. The reality is you find wonderful people, with wonderful insights and a wondrous array of talents and interests. NASA people are so diverse. Just because it's outside the box doesn't mean that nobody is going to enjoy it. You can't assume that just because you don't see it happening, you shouldn't do it. There's such wonderful diversity here.

Jennifer Stevens is Chief Knowledge Integrator at Marshall Space Flight Center.

Susan Snyder is the Managing Editor of the NASA Knowledge Journal.

Right: By March 16, 1961, enough work had been completed to formally dedicate the new NASA research center named in honor of America's great rocket innovator, Robert H. Goddard. Before the dedication ceremony actually took place, though, Goddard's always innovative employees were once again put to the test. A week before the event, the Secret Service told Goddard's Director of Administration, Mike Vaccaro, that he had to install a fence because President Kennedy might attend the dedication, and the campus was not secure. Although it rained for a week, Vaccaro found a contractor who worked 24 hours a day in the rain and mud cutting down trees and installing a chain link fence. But Vaccaro's troubles did not end there. Someone then noticed the Center did not have a flagpole. Vaccaro had three days to find one and still comply with government procurement regulations. An employee located a flagpole at a school that was closing down, and Vaccaro wrote a specification that described the pole so precisely that only the school could fit the bill. Workers moved the flagpole to the entrance gate where it still stands today.

Goddard's Road to Mission Success I and II: An Overview

BY MOSES ADOKO

Space and Earth science missions are complex. In fact, mission complexity can be defined by various factors—science objectives, technology requirements, cost, procurements, project and funding structures, partnerships, stakeholder relationships, etc. In order to achieve mission success, technical know-how should be carefully balanced with leadership strategies for complex decision-making. The NASA Goddard Space Flight Center has a rich record of successful space and Earth science missions.

The Road to Mission Success (RTMS) I is a series of workshops designed specifically to transfer the experience, wisdom, and values embedded in Goddard Space Flight Center (GSFC) policies, procedures, and processes to emerging leaders and managers at GSFC. Participants learn more about GSFC and the Agency, particularly how GSFC works—"how and why we do the things we do and why we are successful." These open discussions and facilitated "case studies–based" instruction are designed to transfer critical knowledge required to achieve mission success.

RTMS I leverages the experience and know-how of over 20 GSFC senior management personnel to convey technical best practices and lessons learned from missions. Each RTMS I class is composed of 55 participants. The classroom time of the program consists of six full days spread over a six-week period. Since its inception in 2005, a total of 17 sessions or classes have been offered, graduating a total 848 GSFC employees as of 2015.

The Road to Mission Success II: Leadership for Complex Decision-Making (RTMS II) is designed to address challenges associated with complex decision-making on the senior leadership level. NASA scientists and engineers have excellent technical backgrounds. However, in order to fully prepare them for mission implementation challenges, there is a need to equip them with leadership strategies for handling complex decision-making.

RTMS II leverages the reflections by senior leaders on decision-making lessons and the experiences and know-how of outside experts on leadership, decision-making, and communications. The classroom time of the program consists of three full days spread over a three-week period, with selected books and case studies handed out before sessions as pre-reads.

For both RTMS I and RTMS II, case studies are used to assist participants becoming better decision-makers, not to second guess the decisions made in the case studies. The case study teaching method is a means for developing systems thinking skills needed by a learning organization such as NASA. Some resistance to case learning with its inherent ambiguities can be expected from technical experts more accustomed to finding "the right solution" than exploring multiple paths to outcomes. By the end of either RTMS course, participants should recognize case studies as an effective vehicle for knowledge transfer.

Moses Adoko is the Deputy Chief Knowledge Officer and Senior Fellows Coordinator at NASA Goddard Space Flight Center.

Towards a Critical Knowledge Index

BY ROHIT BHATIA, RONALD REALUBIT, AND ERIKA VARGAS

It began with a project goal of recommending a method for **identifying, capturing, prioritizing,** and **transferring** critical knowledge. This challenge of applying a continuous and formal effort to an abstract and largely conceptual knowledge asset was presented to a team of three graduate students of the Information and Knowledge Strategy program at the Columbia University School of Professional Studies.

The team assigned to the task—headed by Dr. Michael Bell, Chief Knowledge Officer of the Kennedy Space Center—included professionals spanning several industries. Rohit Bhatia is an Integrated Systems Team Leader for the Research and Development division at Corning Inc., Ronald Realubit is a Research Officer specializing in High-Throughput Screening for drug discovery research at the Columbia Genome Center, and Erika Vargas is a Knowledge Management Strategist at the Social, Urban, Rural and Resilience Global Practice at the World Bank in Washington, D.C.

There were three overall objectives for the project:

1. Ensure that NASA knowledge, which is at risk of being lost, could be discovered and evaluated
2. Support the NASA workforce in successfully carrying out NASA's missions
3. Expand the reach and access of the agency's intellectual capital across NASA's enterprises, communities, and generations.

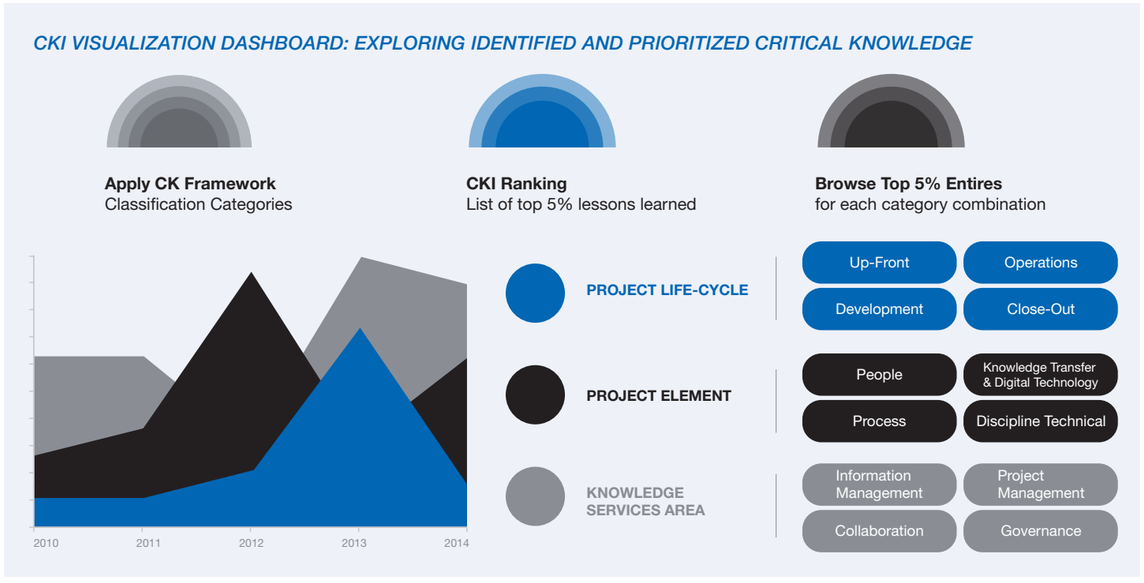

Figure 1: CKI Dashboard

Building on the ongoing NASA critical knowledge initiative as outlined in the Critical Knowledge compendium[1] and critical knowledge presentations by the NASA Chief Knowledge Officer, Dr. Ed Hoffman, the definition of critical knowledge is "…broadly applicable knowledge that *enables mission success, stimulates critical thinking, and helps raise questions* that need to be addressed at various phases in a project life-cycle." Furthermore, critical knowledge represents the top 5% of updateable knowledge that is most important for programmatic and engineering missions to learn and implement. Finally, it includes knowledge that keeps evolving toward new applications and missions, lending itself to a formal process for incorporation into appropriate policies and technical standards.

Now with an agency-wide definition of Critical Knowledge in place, the next step for the team was to develop a continuous and formal method for elevating knowledge generated at NASA to critical knowledge. The development of the Critical Knowledge Index (CKI) began as an exercise in scoring.

The CKI uses a scoring system based on specific critical knowledge criteria, and the scores allow for calculation of a quantifiable index that, in turn, enables ranking or prioritization. Before calculating the CKI, however, the knowledge would first have to be classified under three categories: Project Life-Cycle, Project Element, and Knowledge Services Area. Following the structure of the Critical Knowledge Gateway initiative, Project Life-Cycle has four options: Up-Front, Operations, Development, and Close-Out; Project Element has four options: People, Process, Discipline Technical, and Knowledge Transfer/Digital Technology; and finally, the knowledge is placed under four appropriate Knowledge Services Areas: Information Management, Project Management, Collaboration/Network, or Governance (See Figure 1).

The team chose lessons learned from the Kennedy Space Center as the unit of analysis to serve as examples of NASA knowledge for defining the set of CKI criteria and for developing the CKI formula. Under the direction and qualitative evaluation of Bell, the following criteria were developed for identifying knowledge as critical to all of NASA:

RISK (R): Situation, process, or behavior involving some exposure to danger (e.g., High Risk vs. Low Risk)

BROADLY APPLICABLE (BA): Extent to which knowledge can be deployed in diverse contexts across the agency (e.g., marginally applicable vs. broadly applicable)

IMPACT (I): Knowledge that has a substantial effect on enhancing project outcomes (e.g., Low Impact vs. High Impact)

BENEFIT (B): Comparative organizational advantage gained from acquiring knowledge (e.g. Marginal Benefit vs. Substantial Benefit)

INNOVATION (IN): Viewed as the application of better solutions emanating from new knowledge that meets evolving requirements (e.g., Blind Spot vs. New Insight)

The scoring system would be on a scale from 0 to 5: "0" for *Not at All*, "1" for *Minimally Relevant/Low*, "2" for *Somewhat Relevant*, "3" for *Average/Middle*, "4" for *Relevant/Applicable*, and "5" for *Definitely Relevant/Highly Applicable* (See Figure 2)

The following formula was used for calculating the CKI, stressing Risk and Broadly Applicable:

CKI = (1/4 • R) + (1/4 • BA) + (1/6 • I) + (1/6 • B) + (1/6 • IN)
(See Figure 3)

Lastly, the team envisioned a CKI dashboard for browsing through the knowledge and its calculated CKI. The user could apply filters on what categories they would like to see and the top 5% (based on CKI values) for the filters chosen would be displayed.

On December 3, 2015, at the Ames Research Center in Mountain View, California, the team presented its findings to the NASA Knowledge Community at an event called Knowledge 2020 (K2020). The most valuable outcome of the presentation was that it ignited a lively discussion among the NASA knowledge community about the overall concept of agency-wide critical knowledge.

The team successfully presented the difficult thought process of evaluating what is critical to the organization by introducing the CKI methodology. The team received thoughtful questions about the process, and the conversation was a testament to increased awareness of agency-wide critical knowledge. The knowledge community thought through the meaning of "Broadly Applicable"

[1] http://km.nasa.gov/critical-knowledge-gateway/

Knowledge ID	Subject	Knowledge (KSC Lessons Learned)	Project Life Cycle	Project Element	Knowledge Service Area	Risk	Broadly Applicable	Impact	Benefit	Innovation	CKI
12901	Procurement of Nonconforming Titanium Alloys	As counterfeiting of aerospace parts and materials has become increasingly commonplace, flight system and instrument developers must exercise a high level of vigilance and institute screening processes that are sufficiently rigorous to counter the risk.	Operations	Discipline Technical	Project Management	5	5	5	5	3	4.67
11501	Mars Science Laboratory Actuator Design Process Escape	Demand a higher standard of proof-of-readiness prior to incorporation of risky new technology. This proof did not exist at the time the MSL project chose to implement titanium gearing (for mass reduction) and dry lubricant gear coating (for cryogenic operation without active heating).	Up-Front	Process	Project Management	4	5	4	5	5	4.58
12901	Procurement of Nonconforming Titanium Alloys	Assure that a thorough review of all Certification Data Packages accompanying received Ti alloys is performed by trained and experienced Materials & Processes (M&P) engineers, Procurement Quality Assurance (PQA) specialists, or equivalent personnel.	Up-Front	People, Process	Project Management	4	5	5	5	3	4.42
12901	Procurement of Nonconforming Titanium Alloys	Material suppliers should be Nadcap (National Aerospace and Defense Contractors Accreditation Program) certified, and they should be audited and approved by PQA and M&P engineers and placed on an Approved Suppliers List (ASL).	Up-Front	Process	Project Management	4	5	5	5	3	4.42
12901	Procurement of Nonconforming Titanium Alloys	All procurements should require that the material type and specifications be listed in the contract.	Up-Front	Process	Project Management	4	5	5	5	3	4.42
12901	Procurement of Nonconforming Titanium Alloys	Material testing should be performed on a sample basis to validate the supplier's material test reports.	Development	Process	Change Management	4	5	5	5	3	4.42
5006	Evolution and Management of Spacecraft Configuration	The effects of baseline changes on budgets need to be understood before new baselines are accepted.	Development	Process	Project Management	4	4	3	3	1	3.17
6358	Thermal Environments Data File Format	It is preferable to use a simple, easy-to-read-and-understand file format so that it can be reviewed in any text viewer. Also its contents can easily be plotted.	Up-Front	Process	Information Management	1.5	2.5	2	3	1	2

Figure 2: Scoring

knowledge at NASA and further discussion ensued about its applicability to a complex organization with deep specialties spread out in multiple Centers, Mission Directorates, and supporting organizations. There was also a comment on handling risk as a simplified number in a formula, which is a different approach (especially in an engineering organization), but this might aid in focusing on the knowledge's overall value to the organization. The real value, in the team's opinion, was the passionate and generative discussion this concept sparked. This illuminated the need for, and provided a stepping stone to, *designing* critical thinking in the way projects are carried out at NASA and to positioning the management of critical knowledge as a core value of the organization.

The team also shared with the NASA Knowledge Community that the CKI method could be customized by changing the classification categories, the criteria themselves for defining critical knowledge, and the weights assigned to these criteria in the CKI formula. This capacity for customization resonated among the community: Some of the K2020 attendees expressed interest in experimenting with and implementing the CKI method in their own departments. A final comment the team received was that the CKI and CKI dashboard are basically a knowledge codification tool, and it could prove useful for an active community of practice at NASA.

The CKI remains a visual and applied implementation of capturing a difficult theoretical concept such as Critical Knowledge. With this method in place and in trial, NASA could differentiate itself as an organization that would at least have a system in place mitigating knowledge challenges such as organizational silence, lack of prioritization, and knowledge loss.

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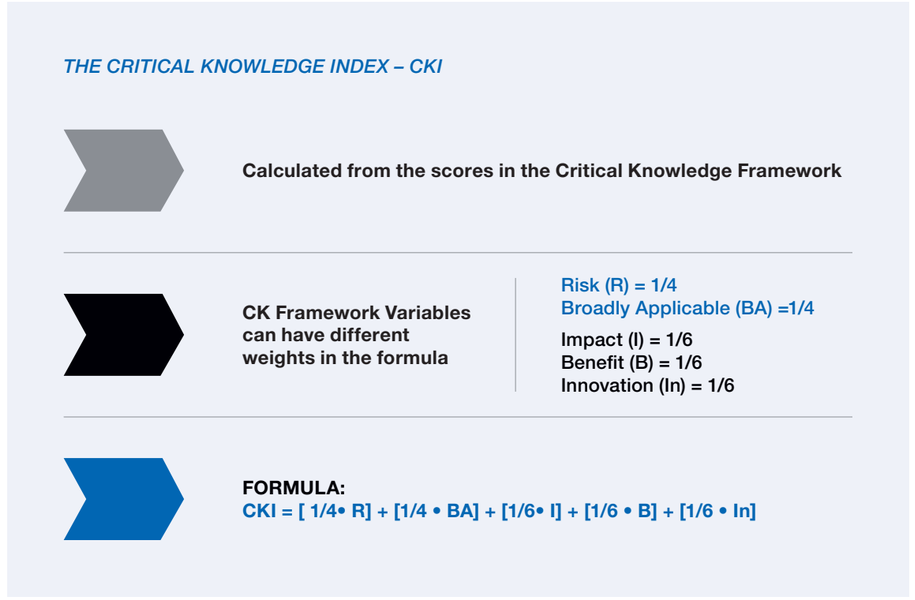


Figure 3: Formula

Focusing in on Masters with Masters: Communication

BY MARK SCHWARTZ

For nearly seven years, NASA Chief Knowledge Officer (CKO) Ed Hoffman has hosted Masters with Masters (MwM). MwM is a series of videoed interviews that bring together two master practitioners to reflect on their experiences, lessons learned, and thoughts about past, current, and upcoming challenges. These conversations yield fresh insights, promote open sharing, and serve as a learning resource for NASA's workforce, creating a community of practitioners across and beyond NASA. One of the most critical topics—among dozens covered—is that of the importance of communication.

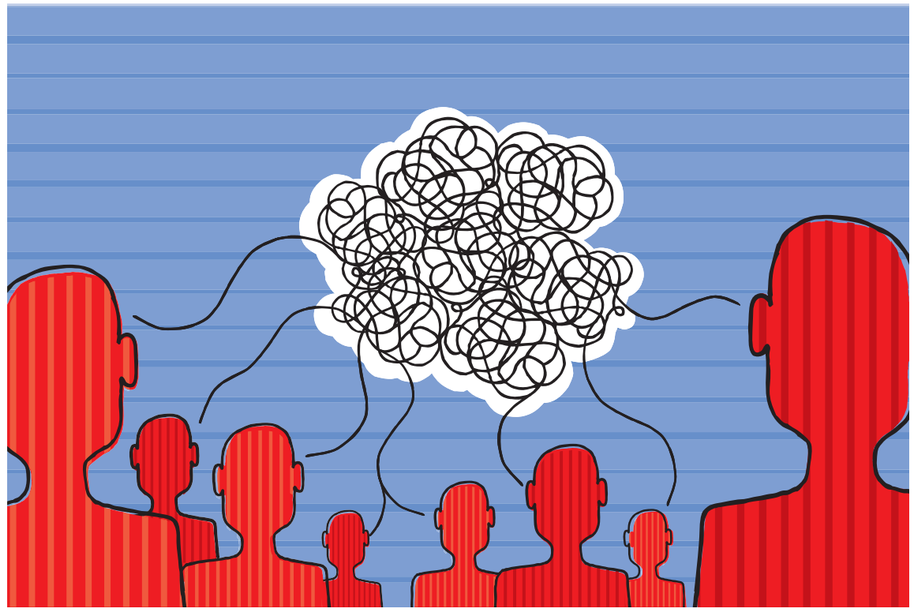
Regularly, the master practitioners share experiences in their communications within or across organizational and even geographical cultures, including international space agencies. Furthermore, there are many cultures within NASA, such as the engineers and scientists who need to "speak the same language" while working together, and the project managers who are experts in Science, Technology, Engineering, and Management (STEM) but must learn to communicate to team members whose expertise may be more procedurally or organizationally based.

The MwM focusing in on communication begins with MwM 1, with two senior leaders at NASA, both of whom stress the first and most important message about communications: its inescapabilty. The first lesson, gleaned from MwM 1, is the foundation on which all else is built: the omnipresence of communication. This idea is particularly important to NASA, as the agency is a project-driven organization. In an MwM filmed in 2009, Chris Scolese, who was then the Acting Administrator of NASA, said, "You often hear people say that the most important thing is communication, the next most important thing is communication, and the next most important thing after that is communication."

The second lesson could be grandly called the *prominence of self-reflection and self-identification*. In MwM 1, Scolese candidly continued his train of thought, that communication "is something that engineers aren't terribly good at—that is why we're engineers, probably." Of course, there was good humor infused in this self-effacing confession, but the point was made nonetheless. Working backwards, we also remember that the messenger must always identify and understand the audience for the message.

In MwM 2, Hoffman interviewed John Mather, a Nobel Prize–winning scientist, and Dennis McCarthy, one of NASA's top project managers. They also stressed the importance of communication, both written and spoken, and McCarthy shared the effectiveness of using weekly meetings, even informal lunch meetings, to catch up. Wanting to make a point of stating your needs through communication, Mather took on the point of view of someone engaged in the actual task of *persuasive communications*: "'OK, world, this is why we're doing this.'" Mather continued, "It's not that hard, but you have to do it well. I think the key is, what John pointed out, is communication. Writing it down and also communicating it."

Another point can be gleaned from this dialogue about persuasion: the *preeminence of the written*. What is written down is taken more seriously than what is only spoken, especially in some cultures like the scientific and academic communities. The "codified word" is on top of the communication hierarchy—such as when it is published—more than if it were merely spoken. The reason for this might spring from the fact that speaking occurred earlier than writing in human development. Most cultures, even those that are incessantly texting, think that if someone took the time to write it down, they must believe in what they are communicating: *This must truly be important, since someone committed it to writing.* A final, related



point worth making here, though not made explicitly in MwM 2, is that managers often notice that members of their workforce will retain information better if they read the information, as opposed to merely hearing it.

In MwM 3, Mike Hawes, Associate Administrator, NASA Office of Independent Program Cost and Evaluation, and Lynn Cline, Deputy Associate Administrator of Space Operations and U.S. negotiator for the International Space Station, both shared stories of their need to alter communications tactics. Cline learned early on while dealing with international communities the benefits of *indirect but tactical communications.* She noticed that if a proposal came from the United States, then the proposal was likely to be dismissed by the international partners. "So I got quite good at behind-the-scenes negations," Cline admitted. "We got Germany to propose the plan... it was a U.S. proposal, but since it came from a country other than the U.S., the proposal went through."

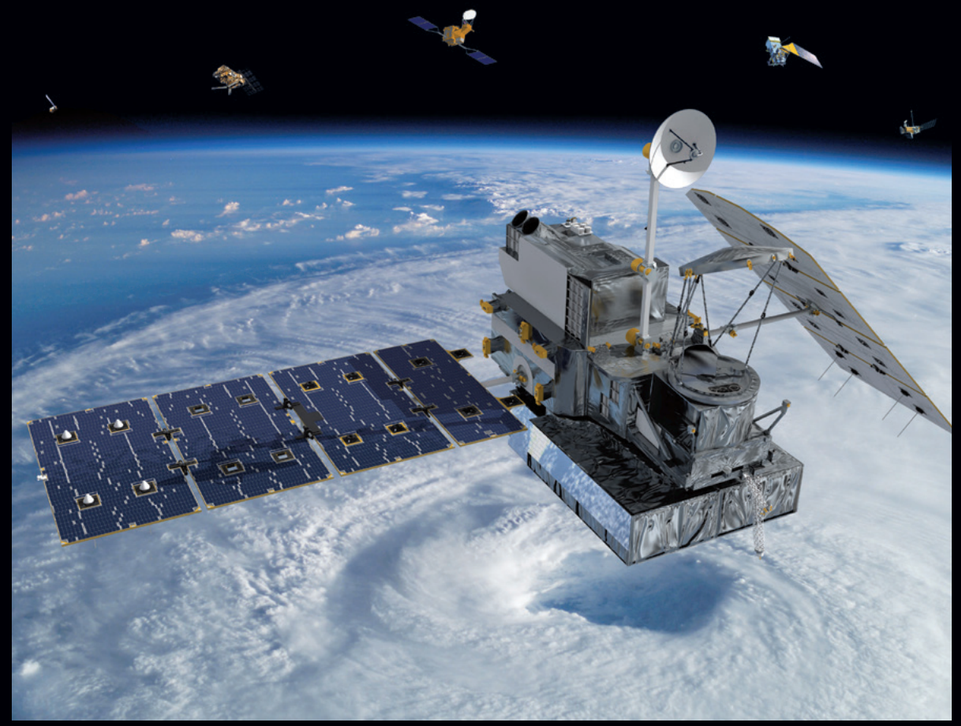
The final lesson serves as a capstone: *Communication is collaboration*, all within the medium of trust. The formula for communication is well known: There is a sender, a receiver, a message, and a medium (airwaves, paper and ink, digital code, etc.); however, the often-overlooked element in this equation is trust. In MwM 5, Jean-Jacques Dordain, who led the European Space Agency, and Charlie Bolden, who currently heads NASA, spoke of the *communicative criticality of trust.* Dordain stated that there must be transparency, to which Bolden added that lack of trust creates overburdening bureaucracy, and both men agreed that new digital tools do not mitigate that bureaucracy, if trust is not present.

So what creates trust? The answer lies in diversity of thought, of cultures, and of communication styles that all have trust as the essential element. Bolden communicates something not easily explained but seen as outcomes:

> What makes the family of space-faring nations today so strong and what, for me, makes the International Space Station perhaps the greatest example of what you get when you put nations together of diverse interests and backgrounds: You get an absolutely phenomenal technological achievement never before done by humankind.

Well said and captured herein. The Masters with Masters interviews—those mentioned above and 20 others—are accessible through km.nasa.gov and APPEL's YouTube channel.

Mark Schwartz is the Editor-in-Chief of the NASA Knowledge Journal.



Above: A visualization of the Global Precipitation Measurement (GPM) Core Observatory satellite and partner satellites. The GPM mission, initiated by NASA and JAXA, comprises a consortium of U.S. and international space agencies, including the Centre National d'Études Spatiales (CNES); U.S. Department of Defense, Defense Meteorological Satellite Program (DMSP); European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); Indian Space Research Organisation (ISRO); and the U.S. National Oceanic and Atmospheric Administration (NOAA). The satellites pictured here are expected to form the GPM satellite constellation.

Left: This commemorative was presented on the occasion of the signing of the International Space Station Agreements.

The International Project Management Program as a Leading Practice

BY DALE CROSSMAN

Approximately 80% of the projects in which NASA is engaged require collaboration with international partners. Increased effectiveness of that collaboration has always been a concern of the involved managers. To assist in addressing that concern, the International Project Management (IPM) Program was developed by NASA in conjunction with the International Project Management Committee (IPMC). The objective was to enhance the effectiveness of the member countries' collaborative project management efforts with each other.

In 2010, the International Astronautical Federation (IAF) established the IPMC, chaired by NASA's Chief Knowledge Officer, Dr. Ed Hoffman. It comprises a group of more than 25 participating space agencies, companies, and professional organizations. Prior to the founding of the IPMC, there was no mechanism for involving and incorporating inputs from NASA's international partners. Since the establishment of the IPMC, the IPM course has been held by NASA, acting as the host agency, 11 times at NASA's Kennedy Space Center in Florida. To date, over 500 participants—including NASA, international partners, and affiliated business organizations—have taken the intensive six-day course. The IPM course is now considered a core course of the Academy of Program/Project and Engineering Leadership (APPEL) project management curriculum.

Eight critical elements have been associated with the establishment of this program: a strong sponsor, a clear mission statement, measurable and specific program objectives, relevant content development, selection of exceptional presenters, selective participant nominations, comprehensive evaluation processes, and committed and integrated administrative support.

STRONG SPONSORS

The NASA Office of the Chief Engineer (OCE) provides strong, stable management oversight to NASA APPEL and to the Chief Knowledge Officer (CKO). Without the commitment of senior NASA management, along with the IPMC, the IPM course could not have flourished as it has for the past six years. The CKO has often stressed that only with support from senior leadership can knowledge-sharing activities be effective and efficient.

THE IPM MISSION STATEMENT

This program will provide project management practitioners with an understanding of cultural challenges, legal concerns, and teaming issues that are likely to be encountered when working with international partners. Participants will gain insights into the characteristics of international teaming that have the potential to make or break a project. Two distinct facets of successful international project management will be addressed: technical knowledge of how projects are managed and enhanced cultural understanding. Development modalities should include the use of lectures, small group discussion, individual cultural awareness feedback, hands-on

practical exercises, case studies, and opportunities for participants to learn from each other.

SPECIFIC OBJECTIVES

The following objectives were developed to support the provided mission statement:

- Recognize critical elements used in effectively managing projects with international partners.
- Describe significant issues that support or detract from team effectiveness when working with international partners.
- Recognize and appreciate the project management approaches of the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), and NASA, as well as other space agencies and companies that support them.
- Understand behaviors associated with the "softer" side of cross-cultural relations that are needed to be effective in the International Project Management arena.
- Explain the experiential and theoretical knowledge base that discriminates one culture from another.
- Discuss perceptual differences of "ethics" and how such differences can impact international team effectiveness.
- Recognize the legal, regulatory, and other management constraints that project teams must consider in pursuing international projects.

RELEVANT CONTENT DEVELOPMENT

As a first step and in order to achieve the above mission and meet the objectives, the content of previous NASA international project management programs was reviewed. Selected content included: effects of cultural differences, ethical standards in different cultures, functional aspects of the negotiation process, teaming with international partners, negotiating agreements between the United States and other countries, and legal parameters that limit some NASA project manager behaviors. Additionally, sessions had to be developed to provide understanding and insight as to how international partner agencies conducted their projects, capture and share knowledge, and managed their project risk. Examples include the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), and NASA, as well as other space agencies and companies that may support them.

PRESENTER SELECTION

All selected course presenters were able to demonstrate extensive international experience, held postgraduate degrees, and were acknowledged experts in their content areas. Presenters understood the importance of fostering a collaborative and participative environment. It was considered important that participants had opportunities to learn from one another through an open exchange of ideas, knowledge, and best practices.

PARTICIPANT NOMINATIONS

Each participating space agency or NASA center developed a nomination vetting process to screen potential program participants. Senior international space agency managers or NASA Center Directors were solicited directly for potential program nominees. A limited number of seats for each session were made available. If participants were unable to attend for the entire course, they were requested to reschedule until they were able to do so. The goal was to create a community that had the potential to extend international friendships and mutual support for years to come.

To minimize travel costs for non-NASA participants, the partners of the IPMC nominate and prepare participants who could both attend and present at the IPM course. An emergent benefit of participant presenters is their continuing availability during informal times to discuss matters face-to-face and clarify their presented material with other course participants.

CONTINUOUS REVIEWS

Three levels of evaluation are performed for each IPM. Each provides opportunities for participants to reinforce individual learning, identify valuable ideas for their improved performance and/or contribute to the improvement of the IPM.

- **Level 1: Pre-Course Evaluations:**
  This pre-course survey is included to determine a participant's entry level of knowledge and perceived level of importance to them of the specific IPM content.
- **Level 2: Evaluation of Each Session and Presenter**
  An evaluation of each session provides an enriched basis for analysis and informed program modifications and presenter recommendations as appropriate, allowing for lessons learned to be distilled.
- **Level 3: Post-Course Evaluations**
  The Post Course Evaluation is included to determine the participant exit level of knowledge and perceived level of importance to them of the specific IPM content.

Participants listening to a presentation at the International Project Management course, Kennedy Space Center.

COMMITTED AND COMPETENT ADMINISTRATIVE SUPPORT

No program can be successful without continuous attention being given to the details required for the program's success. The discussion and negotiation of these details may extend for as long as six months between program offerings. The administrative team must be considered as full participating members with the program designers and faculty. They provide critical insights when support activities require coordinated efforts.

In summary, the Critical Elements associated with the development of a highly successful International Project Management Development program are:

- A strong sponsor
- A clear mission statement
- Measurable and specific program objectives
- Relevant content development
- Selection of exceptional presenters
- Selective participant nominations
- Comprehensive evaluations process
- Committed and integrated administrative support

CONCLUSION

The attention and support to excellence, demonstrated by the NASA OCE, the IAF, and members of the IPMC, the NASA CKO, and NASA APPEL, has supported the development of greater levels of cooperation between international partners and associated industry professionals. As the program continues, lessons learned are distilled as they arise and are infused back into processes for upcoming courses. Responses from participants have clearly established this program as a leading practice in the development of international project management cooperation and understanding.

Dale Crossman has been instrumental in developing a wide range of NASA management and project management programs over the last 30 years.

This image of the northwest corner of Australia was snapped by a student on Earth after remotely controlling the Sally Ride EarthKAM aboard the International Space Station. The program allows students to request photographs of specific Earth features, which are taken by a special camera mounted on the station when it passes over these features.

Backdropped against the blue and white Earth 130 nautical miles below, astronaut Mark C. Lee tests the new Simplified Aid for EVA Rescue (SAFER) system.

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