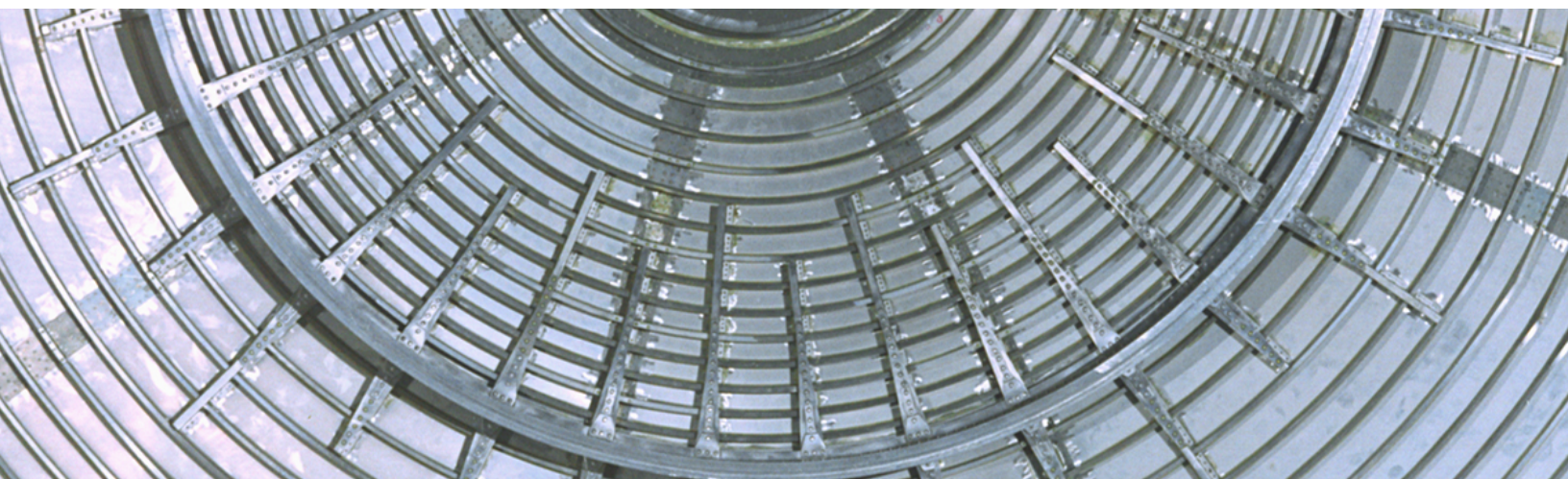# NASA KNOWLEDGE 2020:

Imagining the Future of Knowledge Services

What do we want our knowledge services to look like in the future?

Ed Hoffman, NASA Chief Knowledge Officer (CKO), posed this question to attendees of the Knowledge 2020 conference at Kennedy Space Center in October 2014. To begin to shape an answer, speakers and participants from the NASA knowledge community, organizations including Merck and Ecopetrol, and experts in the field of organizational knowledge explored the aims and activities of knowledge services practitioners in complex organizations.

Speakers agreed that knowledge management is an ongoing process of learning, adjustment, and improvement. Several remarked on their organizations' knowledge management "journeys of discovery" that revealed the shape of effective approaches over time. Author Larry Prusak's overview of the different emphases of multiple generations of knowledge management similarly described a gradually maturing discipline that moved from a relatively unproductive concentration on knowledge "objects" and individual knowledge workers to a subtler view of knowledge as part of the social fabric of organizations. This new perspective, which has led to a focus on communities, active on-the-job learning, mentoring, and storytelling, can help point the way to the future.

Aims and Challenges

Participating organizations have similar aims and challenges in providing effective knowledge services to geographically dispersed units and partners carrying out complex projects. The promise of their knowledge work is that transferring valuable knowledge to individuals and groups who need it will lead to improved results that can include savings in money and time, fewer errors, and more innovative solutions to problems.

The principle problems that need to be solved to get these benefits are these:

• Knowledge possessed by one group is not available to others who need it. For instance, knowledge developed in the course of a project is not documented or otherwise shared with other projects. The reasons for this failure may include lack of time and resources for knowledge sharing, difficulty recognizing what knowledge can be useful to others, and distrust, fear, or other cultural conditions that discourage collaboration.

• Knowledge is "walking out the door" with retirees or others who leave. Ecopetrol estimates that more than half of all professionals in the reserve oil industry will reach retirement age in the next decade. The aerospace industry is similarly experiencing the retirement of a generation of experienced professionals.

• Knowledge is not in a usable form. For example, Johnson Space Center has an extensive library of videotapes and transcripts that capture some of the expertise of retirees, but the material has not been edited and organized in ways that would make it easily findable, so it has generally not been used.

Knowledge 2020 Speakers. From top left then clockwise: **Larry Suda** (Palatine Group/Management Worlds, Inc.), **Dr. Ed Hoffman** (Office of the Chief Knowledge Officer, NASA), **Marty Lipa** (Executive Director, Knowledge Management Center of Excellence, Merck Manufacturing Division), **Dan Rasky** (Chief Portal Office, NASA), **Jon Cowart** (Commercial Crew Program, NASA), **Don Cohen** (Writer and consultant), **Rob Guenard** (Director, Knowledge Management Center of Excellence, Merck Manufacturing Division), **Dr. Carla O'Dell** (CEO, American Productivity & Quality Center), **Oscar Guerra** (Knowledge Management and Innovation Strategy, Ecopetrol), and **Larry Prusak** (Founder of the IBM Institute for Knowledge Management and author).

ImageThink created posters to capture presentations and discussions as they occurred live at Knowledge 2020 Conference. This poster captured the "Problem-Centric NASA Issue" of how to share critical knowledge most effectively cross-agency.

Some Key Principles and Approaches

The experience of knowledge practitioners—some of whom have worked in the field for a decade or more—has generated some solid practical knowledge: the "how-to" of knowledge work. There was near unanimous agreement among participants on a few basic principles and approaches:

• Focus on people (and fostering a culture of trust and cooperation). As Carla O'Dell, CEO of American Productivity & Quality Center (APQC), said, "People approaches make system approaches work." Tools need to serve people, not the other way around; technology should support knowledge behaviors, not define them.

• Knowledge techniques and tools should be appropriate to the work. For instance, the taxonomy of a repository should reflect how expert users actually think. And the tools should be built into the flow of work as much as possible.

• A federated model works best in diverse organizations. Knowledge services need to be in harmony with how people actually work; local efforts should be tailored to the behaviors and needs of individual units and locations by people close enough to the work to understand it. The central knowledge "government" can support those local efforts and facilitate communications to share widely useful practices.

• Metrics that show the value of knowledge work remain important. Hard data on savings and efficiency, success stories, and surveys make the case for investments in knowledge services. We seem to be making some progress on this perennial issue.

Findings from APQC

Carla O'Dell presented results of APQC's study of knowledge issues and approaches in fourteen organizations with large technical workforces—the majority of them facing rapid changes in critical knowledge and technology and the retirement of experts.

Effective knowledge practices identified by APQC's survey of more than 700 individuals in these organizations are consistent with the experience of knowledge practitioners at NASA and other organizations participating in Knowledge 2020. "People approaches," including in-person training, mentoring and apprenticeship, and communities of practice, are the most successful ways to transfer knowledge. Formal approaches to knowledge capture are the least successful. Nevertheless, many knowledge management efforts over the years have focused on collecting content—especially and not surprisingly those directed by IT departments. O'Dell said it is important to balance "collect" and "connect."
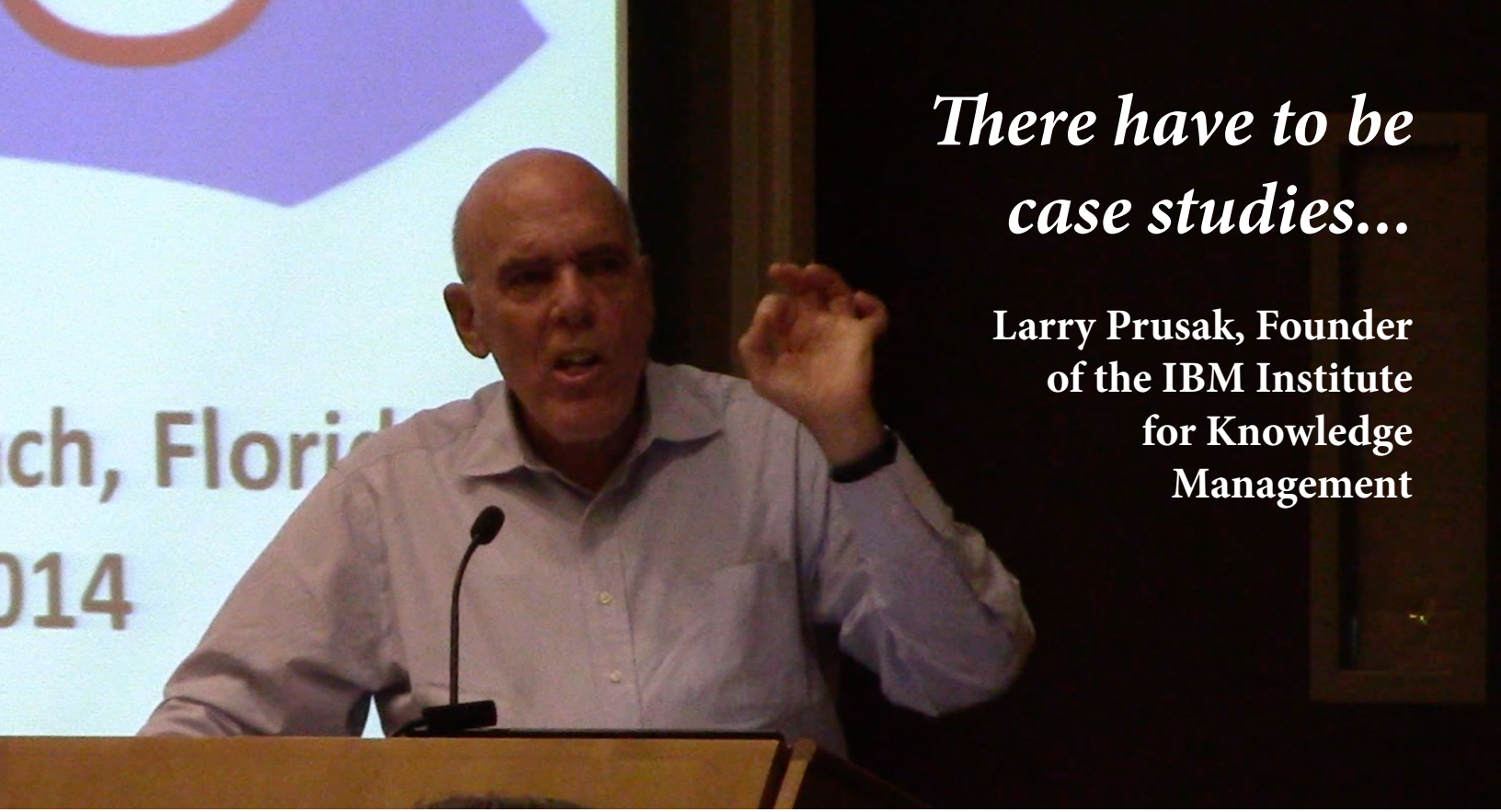

People approaches make system approaches work.

Carla O'Dell, CEO of American Productivity & Quality Center (APQC)
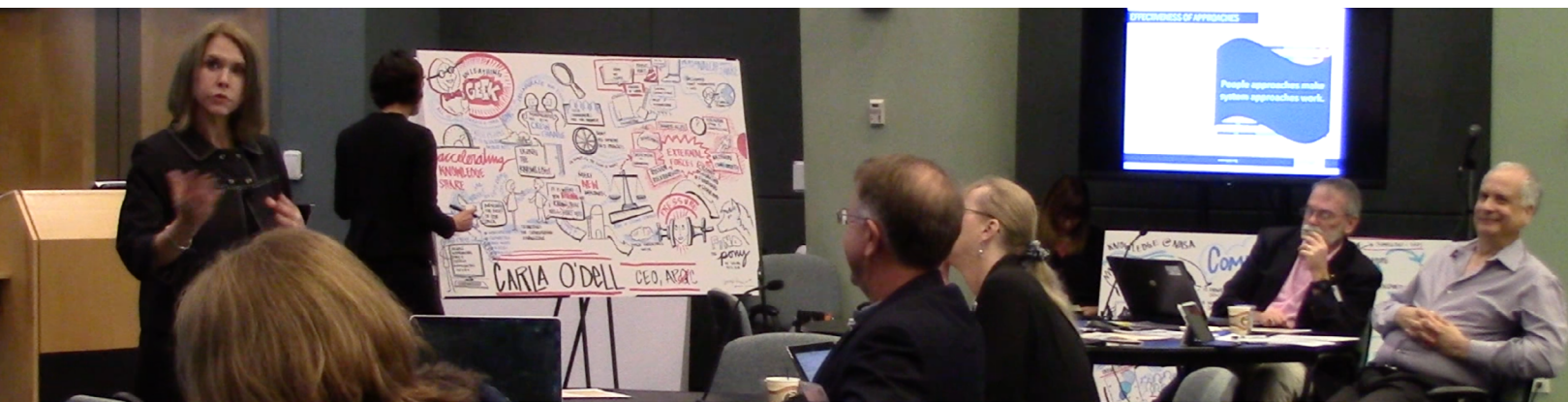
There have to be case studies...

Larry Prusak, Founder of the IBM Institute for Knowledge Management

Communication

As Larry Prusak indicated, the first generation of knowledge management, lasting possibly until 1998, was typically carried out by IT groups and was not so different from information management, emphasizing making knowledge "objects" (documents and database entries, for instance) available through information technology. The focus was largely on collecting content and expecting potential users to recognize its value. This approach had very limited success.

That relative failure had multiple causes. Ignoring the importance of developing a culture of trust and collaboration was a big one. Developing one-size-fits-all knowledge systems (really one-size-fits-none) was another.

Lack of attention to forms of communication was also a problem. Second-generation knowledge efforts, which included cases and stories, recognized that some kinds of communication worked better than others, especially in conveying subtle knowledge of how to do complex work.

Author and Consultant Don Cohen's "Knowledge and Narrative" presentation noted some of the qualities of stories that make them effective. Stories can provide technical and especially organizational and social context that most documents ignore. And because stories are typically made up of a linked series of events, they are better at revealing the shape of processes—the chains of cause-and-effect that characterize projects—than technical memos and other traditional knowledge objects. Perhaps most important, stories evoke the human element that mere documentation leaves out. They illustrate the values of determination, honesty, and resourcefulness that challenging projects require; they portray a "hero" or heroes overcoming obstacles that can inspire listeners to face challenges in their own work.

Various presentations and discussions made clear that not all communication is verbal. In apprenticeships and other forms of guided learning-by-doing, for instance, showing how work is done is more important than telling how it should be done. It is even possible to see failure as a form of communication in which the work product itself tells you something important. A growing recognition of this can be seen in the software development proverb that encourages practitioners to "Fail fast." (See the section below on SpaceX.)

Cases: Ecopetrol

Oscar Javier Guerra, Unit Head of Knowledge Management and Innovation Strategy at Ecopetrol, said that the main impetus for knowledge management at the Colombian oil company was the looming retirement of as many as half the experienced professionals in the industry and the need to transfer their most valuable knowledge to younger employees.

Like NASA, Ecopetrol has developed a federated model, with a twenty-five-person cross-unit team coordinating and sharing more local knowledge practices.

Key to Ecopetrol's knowledge efforts has been participation and support at all levels, from company leaders' explicit commitment to the direct involvement of the Vice President of Innovation and the operational units to individual responsibility. Learning and knowledge activities are required, not optional; performance objectives used to evaluate Ecopetrol employees include specific knowledge behaviors.

Knowledge tools and activities include technical forums, case studies, and a portal that shares lessons learned and success stories. In additional to technical improvements—such as a new method to stimulate wells and increase production and techniques for reducing the cost of well abandonment—successes include a forum that developed an important change in company strategy.

We know that more than half of all professionals in reservoir oil will reach retirement age in the next decade poses a real challenge for the industry.

Oscar Javier Guerra
Head of Knowledge Management and Innovation Strategy
Ecopetrol

Cases: Merck

Work at the pharmaceutical company has much in common with what happens at NASA: projects that are technically complex and lengthy (a new vaccine typically requiring twelve years of development, testing, and approval to get to market) carried out by a complex organization and involving extensive partnerships.

Merck's early knowledge management efforts experienced some common problems, notably disappointing IT-based "solutions" devised with a lack of attention to process and culture and absent or insufficient senior sponsorship.

Using the lessons of these experiences, along with tools and techniques of Six Sigma process improvement and support from APQC, the company has built a strategy to focus on incorporating knowledge processes in the flow of work and defining critical needs—especially the human element.

A Success Story

An important product of these efforts has been Merck's Virtual Technical Network (VTN), which has 4,000 members in twenty-seven communities. In 2013, network activity includes more than 3,000 answers to 1,000 posted questions and generated tens of millions of dollars in business benefits.

VTN members recently engaged rapidly to locate a spare tablet press turret in Singapore within one business day to replace a damaged turret used to produce a key product in the UK. As a result, the unit was operational again in four weeks; getting a new turret from the vendor would have meant a twenty-four week hiatus. In addition to this direct benefit, the response built credibility with the partner and strengthened an important relationship.

Start small, but start...
move from adoption
to expansion.

Robert Guenard
Director
Knowledge Management Center
Merck Manufacturing
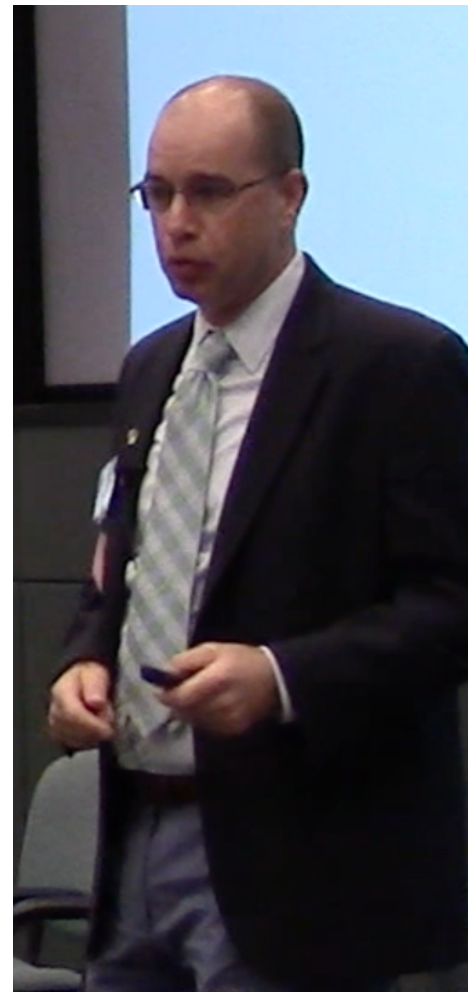
Link to organizational
performance goals.

Marty Lipa
Executive Director
Knowledge Management Center
Merck Manufacturing

Important Lessons

Rob Guenard, Director of the Knowledge Management Center of Excellence, Merck Manufacturing Division, emphasized starting with people. That means, among other things, behavioral coaching to foster intrinsic motivation. Guenard said, "Start small, but start" and then work to move "from adoption to expansion." "Meet people where they are," he advised, "but don't leave them there." Successes of the early adopters, those already motivated to engage in knowledge sharing, can provide stories of success that encourage others. But, he added, "Early resisters may be your best advocates in the end."

Starting with people has also meant mapping knowledge networks at Merck, seeing where knowledge flows and where it doesn't, identifying encouragers and discouragers—people whose provide energy to others and people who sap energy.

Among other important lessons offered by the Merck journey so far are these:

• Senior sponsorship and stewardship are essential.

• Change happens both from the top down and the bottom up.

• Knowledge efforts must be aligned with business priorities.

• Treat knowledge work as a small business—give clients what they want and show value.

• Becoming an effective knowledge-sharing organization is a transformational change, so change management must be part of the effort.
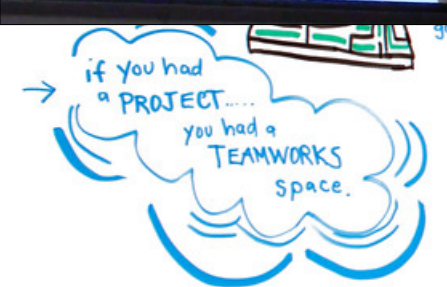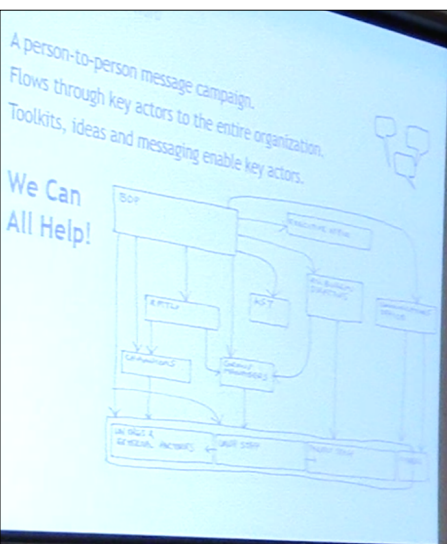
Cases: The Teamworks Extranet

Larry Suda, President and Founder of Palatine Group, described Teamworks, which the United Nations is using to share knowledge among 65,000 users. Suda said the technology balances human, technical, and business dimensions and emphasized the human-centric design of the technology. It includes profiles of users, wikis, community area, and question-and-answer features and serves to connect people to people, not just people to documents. Suda said Teamworks helps provide a "water cooler awareness" of what colleagues and other teams are doing.

Teamworks enables key actors

**Larry Suda
President
Palatine Group**
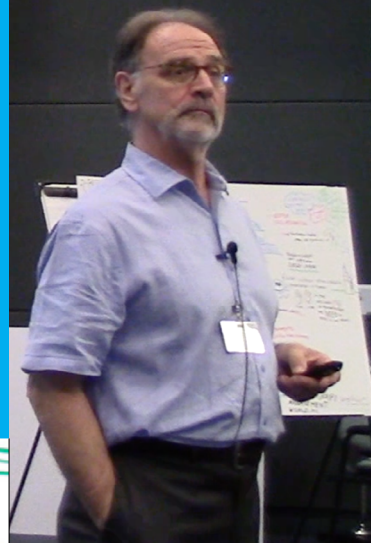
Cases: NASA and SpaceX

Dan Rasky, NASA expert on entry and thermal protection systems, and Jon Cowart, Deputy Partner Manager working with SpaceX, discussed NASA's collaboration with the company that has developed the Falcon launch vehicle and Dragon spacecraft since its founding in 2002. Their collaboration with SpaceX suggests insights into ways to share complex knowledge. It also helps define the nature and potential benefits of NASA's partnership with small and emerging aerospace companies.

At Ames Research Center, Rasky was instrumental in developing the PICA heat shield used on NASA's Stardust and Mars Science Lab missions. When SpaceX decided to use the relatively lightweight thermal protection material on Dragon, Rasky spent six months at the company working alongside SpaceX staff. He had his own cubicle in a work space where everyone, including CEO Elon Musk, worked in cubicles to enhance easy interaction. Being part of SpaceX for that length of time made it possible for him to pass on his expertise in the course of work, a fuller and more effective knowledge transfer method than would be possible through technical documents and lessons learned, no matter how skillfully produced.

Cowart described a SpaceX culture very different from NASA's. Derived from the process of software development, their mode of working is to "fail fast and often." They rapidly build and test prototypes based on just enough information to show that an approach is worth trying and then learn from both failures and successes. The company demands dedicated, creative work. "Find the best way to do the work," says Cowart, "or you're gone." Bureaucracy is kept to a minimum, with only one standing meeting a week.

In addition to exchanging technical expertise, the two very different organizations can benefit from exchanges of process knowledge. Cowart suggested that SpaceX could teach NASA "that you don't always have to dot all the I's."—that sometimes working faster and accepting more risk is the best way forward. At the same time, NASA could show SpaceX that you sometimes need to slow down in the interests of safety and careful analysis. Rasky noted that the relationship between the two is a partnership, not a contractor agreement—not a case of NASA dictating requirements and SpaceX fulfilling a contract, but a collaboration seeking long-term benefits for both organizations.

ImageThink rendering of the interview with Dan Rasky and Jon Cowart
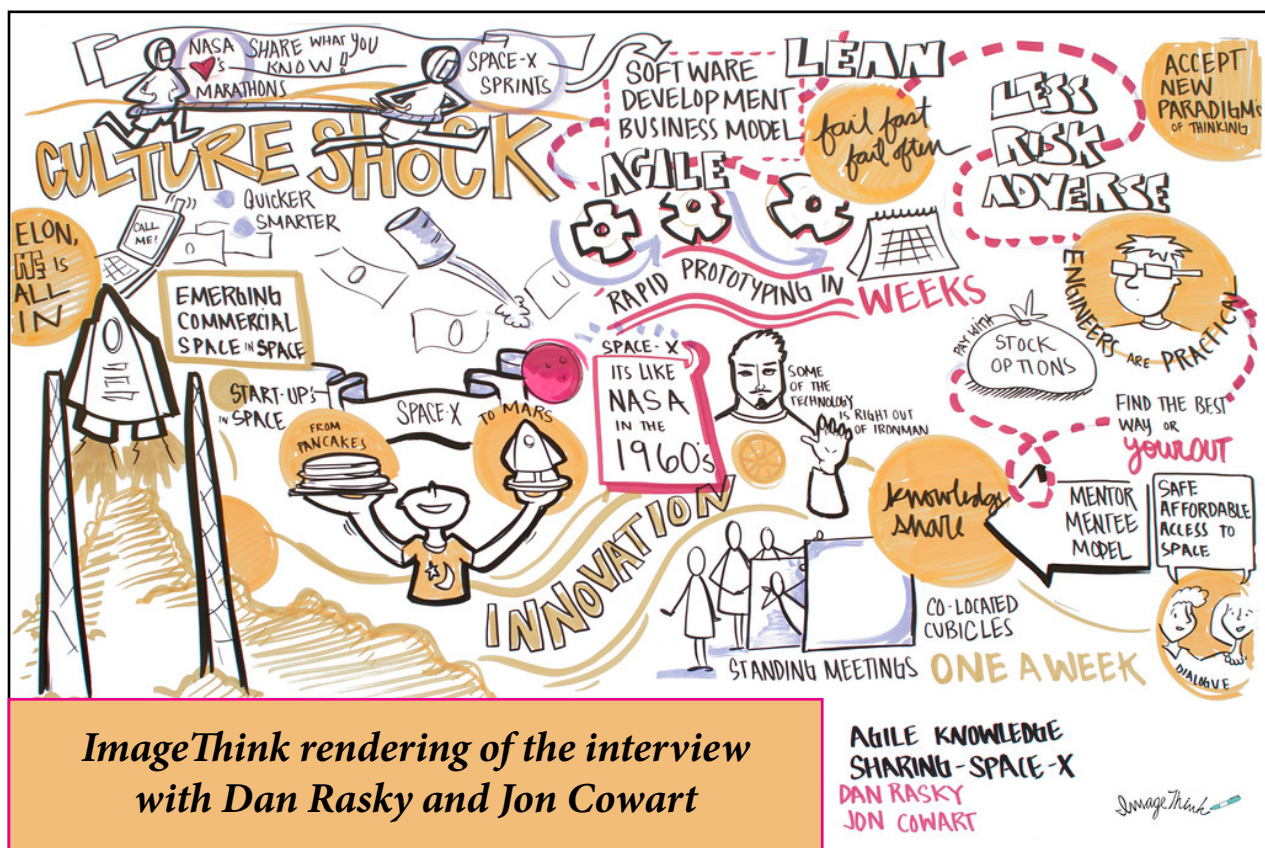
Measurement

Developing hard data to show the return on knowledge management investment has been a long-standing problem. There are few (or no) controlled experiments in business or government to compare results of similar units with and without knowledge services. It is difficult to precisely measure the contribution of such services to successes that have multiple causes. But knowledge programs need some means of determining their value, both in order to improve and to maintain executive support.

Some speakers at Knowledge 2020 did describe some instances where the value of knowledge work was directly measurable.

An Ecopetrol community of practice that developed and shared techniques for improved well stimulation measurably increased the instantaneous production of barrels of oil per day from 276 in 2005 to more than 30,000 in 2012. Similarly, a community that studied and developed techniques for proper well abandonment saved Ecopetrol $2 million a year.

Carla O'Dell provided the example of Rockwell Collins, the aerospace company that found a direct correlation between number of lessons shared and fewer manufacturing defects—a clear measure of value.

In these cases, the processes to which knowledge techniques have been applied are repeated over and over, making it relatively easy to measure improvement. It is much harder to measure the effect of knowledge work on unique or variable projects. The contribution of knowledge initiatives to a successful NASA mission, for instance, does not lend itself to straightforward statistical analysis—how do you measure a failure that did not occur in a one-off mission?

Similarly, knowledge sharing among scientists or engineers may eventually lead to an innovation that proves hugely valuable years down the road.

"Measurement" in these cases is much more likely to take the form of anecdotes about a problem solved or an innovation developed through collaborative knowledge sharing. Surveys of professionals that ask them to rate their ability to get the knowledge they need and the value of services offered are also valid measures of knowledge value.

Stories and survey are not traditional Return on Investment (ROI) metrics, but they are important and valid measures of knowledge services success. Organizations whose leaders only trust and therefore demand dollars-and-cents results are probably not hospitable to knowledge work.

*C*enter in the panel interview, Oscar Javier Guerra, the Chief of the Strategic Unit at Innovation and Knowledge Management at Ecopetrol, explains participation and support at all levels is key to Ecopetrol's knowledge efforts.

Knowledge 2020: The Future

Prusak's analysis of the generations of knowledge management and the speakers' stories from the successes and failures of their knowledge work suggest the potential for continued improvement in the next five or six years. Organizations have been shedding or de-emphasizing the approaches that have proved ineffective and investing in the ones that work. That process should continue.

A perennial and continuing issue is scalability—how to support wholesale knowledge sharing in large organizations when it is clear that the most effective techniques are retail—one-on-one mentoring, in-person story-telling, reliance on personal networks.

Continuing improvements in communications technology will likely create some opportunities for effective scaling, enabling people at a distance to have a fuller sense of "being there" at knowledge sharing events and distributed work sites. Technology should also continue to make it easier to provide necessary context for lessons learned documents and to offer the lessons at the key moment in the course of work. But it seems clear from the experience of participants that small-scale knowledge sharing—mentoring, various forms of learning by doing under the guidance of experts, in-person storytelling—will remain essential, especially in teaching the subtle "how-to" of complex professional work.

The federated model of knowledge services in place at NASA and elsewhere is still developing. How best to support local knowledge activities and give them sufficient autonomy while sharing best and leading practices throughout the organization remains an open question. The next few years of experience with the model may help to answer them.

NASA KNOWLEDGE 2020: Imagining the Future of Knowledge Services

Written by Don Cohen, Matt Kohut, and Mark Schwartz