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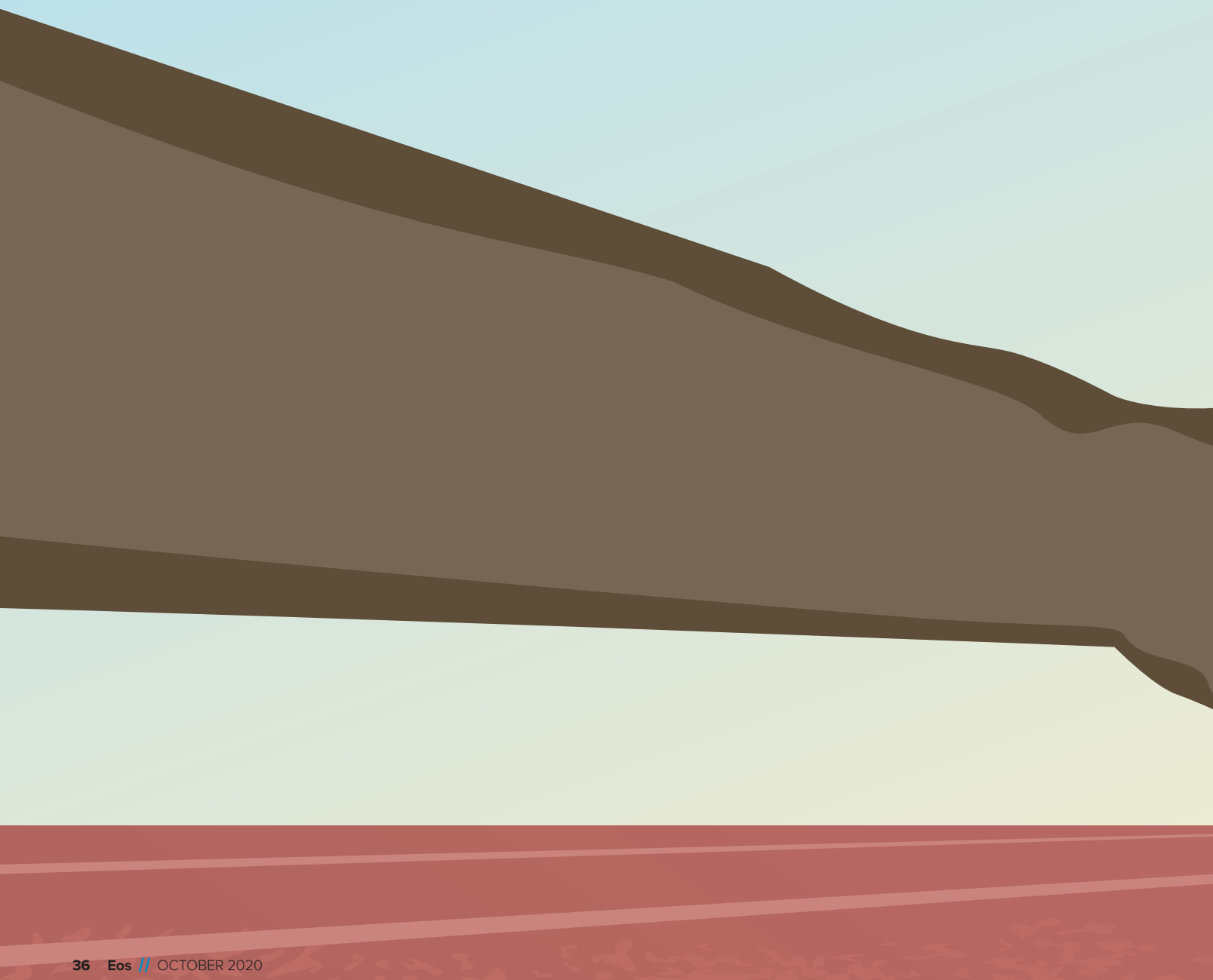

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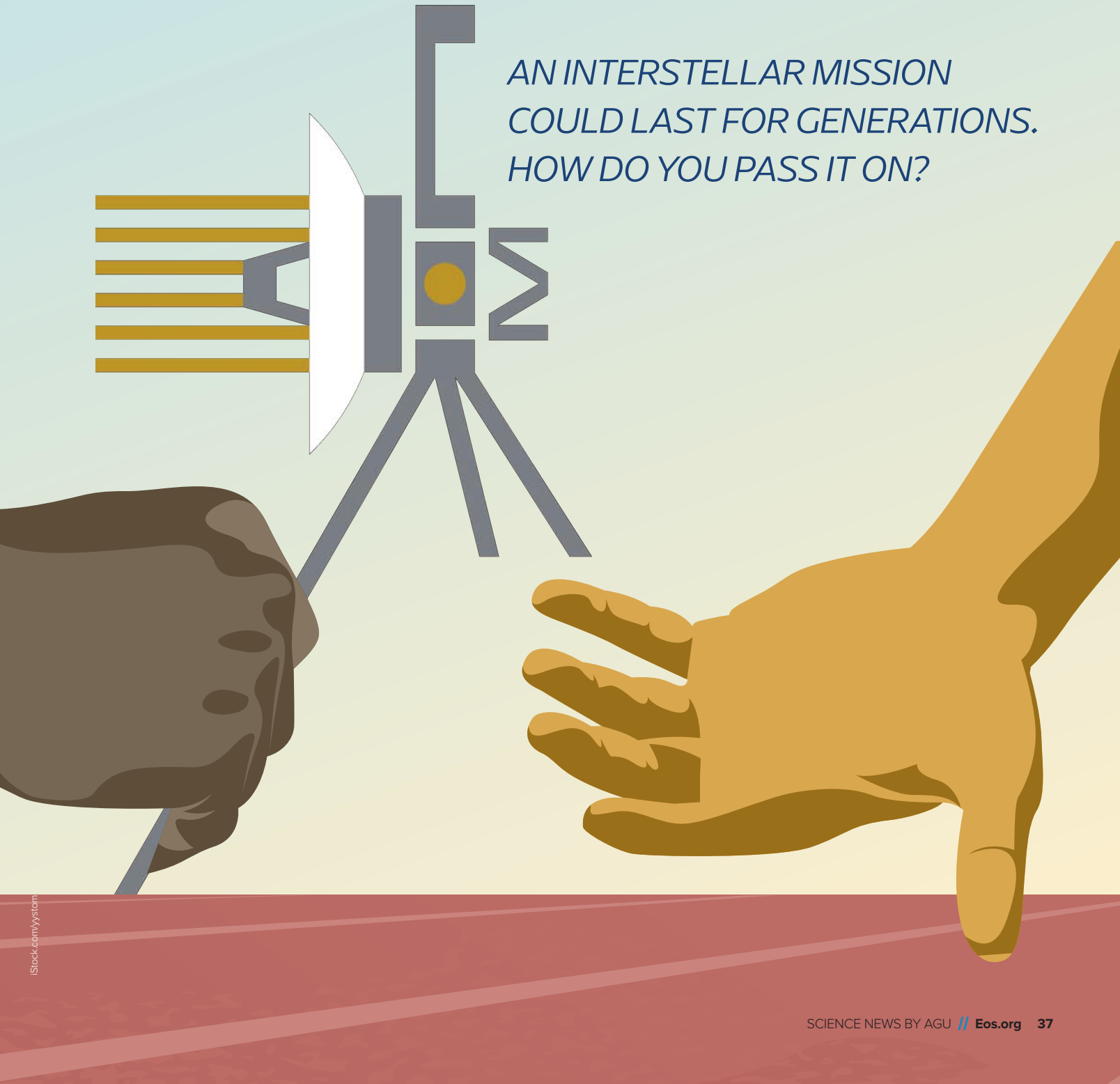
By Damond Benningfield

AN INTERSTELLAR MISSION COULD LAST FOR GENERATIONS. HOW DO YOU PASS IT ON?



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Scientists and engineers preparing Interstellar Probe, a mission to explore the environment between the stars, face an unsettling truth. "They're trying to design a spacecraft to launch around 2030 and get a thousand AU [astronomical units] from Earth in 50 years," said Janet Vertesi, an associate professor of sociology at Princeton University and an adviser to the Interstellar Probe study team. "The problem is, by then they'll all be dead."

Most space science missions have an expected life span of less than a decade—well within the careers of most participants. Some missions last longer than planned, of course. The Opportunity rover trundled across Mars for more than a decade beyond its primary mission, for example, while the twin Voyagers have logged almost 4 extra decades in space.

Interstellar Probe, though, is one of several proposed projects (including the Solar Gravitational Lens mission concept and Breakthrough Starshot) with planned lifetimes of several decades or even longer. Most of the scientists and engineers who design and build the spacecraft and send them on their way will retire or pass on long before the missions end. Such projects will require a management structure different from that of typical missions of exploration.

"This isn't something that people typically think about when they're planning a mission," said Ralph McNutt, principal investigator for the Interstellar Probe study and chief scientist for the space exploration sector at the Johns Hopkins University Applied Physics Laboratory (JHUAPL).

So the Interstellar Probe team reached out to Vertesi, who studies the management of space exploration projects, for help in structuring a multigenerational approach to the mission.

Through workshops and other interactions, Vertesi has outlined several possible steps for the Interstellar Probe project:

- It should plan for a multigenerational approach from the beginning, with all participants understanding that their time on the project will be limited.
- It should nurture mentorships and apprenticeships, making sure that the next generations are well prepared to assume control when their time comes.
- It should develop its own ways of recording knowledge about the mission for future generations.
- It should develop its own rituals to help build continued enthusiasm for the mission.

Creating a Multigenerational Culture

"One analogy I often hear about these projects is that it's like building the great cathedrals of Europe," said Geoff Landis, a researcher at NASA's John H. Glenn Research Center in Cleveland, Ohio, and an adviser to Breakthrough Starshot, an effort to develop the technology to send tiny probes to Proxima Centauri in the coming decades. "Those were enormous undertakings for the time, and it took many generations to put them together. You need an organizational structure that can continue to keep people involved in the project."

Interstellar Probe was conceived decades ago as a mission to study the interstellar medium (ISM), the cosmic rays, wisps of gas and dust, and magnetic fields that fill the space between stars. It also would look back at the solar heliosphere, a "bubble" dominated by the Sun's magnetic field and the solar wind, and monitor the interaction between the heliosphere and the ISM.

A half century after launch, Interstellar Probe would reach a distance of 1,000 astronomical units from the Sun. (An astronomical unit is the average Earth–Sun distance, equal to almost 150 million kilometers.) It would continue to study the ISM until its nuclear-powered generator could no longer supply enough energy to operate its instruments or remain in contact with Earth.

The mission concept "sounds like Voyager on steroids," said McNutt, but the current study team isn't designing the actual spacecraft or selecting its specific science goals. Instead, "we're trying to put together a menu of options for a future science definition team," McNutt explained. "What science would make sense? What instruments would you need, what measurements would you need?… Do you need a couple of miracles, or can you do it with standard engineering?"

The team realized early on that engineering a probe to last for 50 years or longer isn't the only challenge the mission will face. Another is building a project team—a problem not faced by prior missions.

"It's a fascinating challenge," said Vertesi. "There's no tradition of handing off to the next generation—there was no model for doing that."

"The big lesson from the rovers and Cassini is that the way you choose and organize your science team is really important," said Vertesi, who spent 2 years observing the Mars Exploration Rover team as an ethnographer. "People don't typically consider that. Teams just kind of happen depending on the way a mission is funded.… If you're going to be multigenerational, you may need to be more bureaucratic. No scientist loves bureaucracy—they hate it. But you can't have a charismatic [principal investigator] who doesn't want to pass on the baton."

"The ideal thing I would suggest is to make sure it's very clear there are term limits," said Vertesi. "You might turn over [key positions] every 7–10 years. It would be predictable, built in as part of the project."

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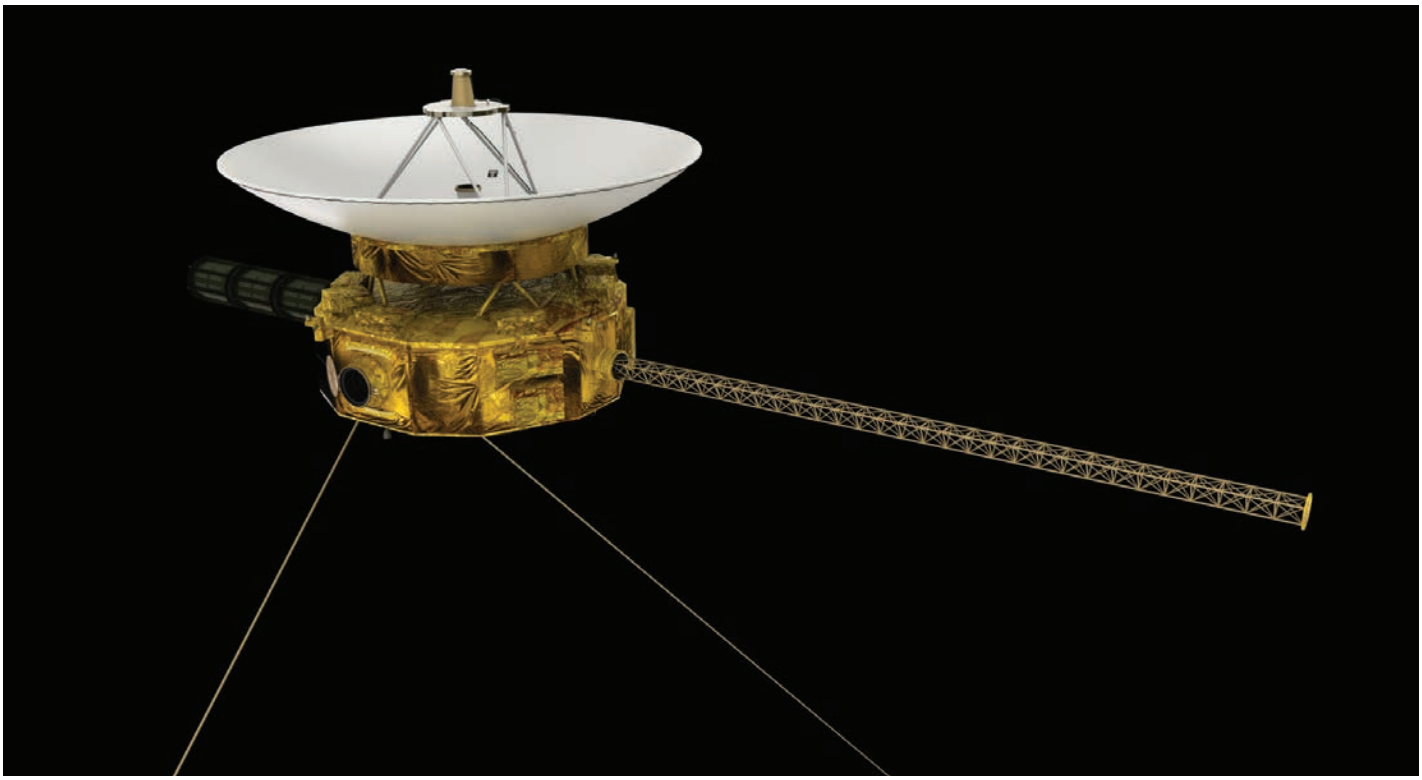
Younger scientists with the project said they accept that concept and even look forward to bringing in new members in the decades ahead.

"I'm a little sad that I might not live long enough to get to the interstellar medium," said Elena Provornikova, who recently joined JHUAPL's professional staff after 3 years as a postdoctoral researcher. "But at some point, I will pass along my knowledge and expertise to the next generation of scientists, and I'll be happy to see their success and the discoveries they will make."

Kathleen Mandt, a member of the study team and chief scientist for exoplanets at JHUAPL, notes that she would be roughly 100 years old by the time Interstellar Probe reaches its target distance. "I may or may not still be alive, and I don't know if I'll still be working," she said with a chuckle. "But I sure don't want the mission to bail because I'm not there."



This preliminary concept for Interstellar Probe shows a strong resemblance to the Voyager spacecraft. The design is likely to change significantly during the study, says Ralph McNutt. Credit: Johns Hopkins University Applied Physics Laboratory

Preparing for the Next Generation

Ensuring that transitions are smooth would require a program of mentorships or apprenticeships, McNutt said. "You'd need to bring people up to speed so that at some point, you could give them the keys to the car with some confidence that they won't wreck it the first time they take it out of the driveway."

Such programs are common in large, long-lasting organizations. Mandt, for example, said it is expected in the U.S. Navy, where she served before turning to academia and space missions. "If somebody is in a leadership role [in the Navy], they have an expected responsibility to train the next generation to take their place," she said. "If not, the military will fail and your mission will fail. That was ingrained from day one.... There's a feeling of accomplishment in that, but you don't see it often in the space community."

Handing off from one generation to the next doesn't mean that earlier team members should vanish, however.

"I highly recommend keeping retirees in close communication with the project, because you will want to call them in when something goes wrong and you have a question," said Suzanne Dodd, manager of the Voyager Interstellar Mission since 2010.

Voyager launched two spacecraft in 1977 that have since entered interstellar space. Voyager 1 left the heliosphere in 2012, and Voyager 2 followed in 2018. Both are projected to continue operating until around 2025.

Neither was intended to study such a distant realm, though, and because of that, no one anticipated that so much of the original knowledge of the spacecraft systems would be lost during their long trek. Although much of that knowledge is preserved in documents, the background details were locked in the minds of the original scientists and engineers—many of whom are gone.

"We built a pretty good Rolodex of retired people we could ask questions of," said Dodd. "Now, at 43 years and counting [since the Voyagers launched], a lot of those people have passed away. So you might be able to get ahold of them when they retire, but you can't have séances with them when they're gone."

"One of the things we've learned is that knowledge capture is important," Dodd said. "People document the decisions that are made, but they don't document the thought processes behind them.... So you have to decide what's the right information to get about how a system operates, and how you capture it—in written form or in a video format or something else."

Vertesi, in fact, recommends "all of the above"—both formal knowledge capture through technical reports, diagrams, and other formats, and informal knowledge capture through institutional storytelling.

"If you talk to people, you find out that every spacecraft develops a personality," Vertesi said. "People know just how and why an instrument has a special flutter, for example. Those kinds of stories help.... But you need to decide what kinds of storytelling are necessary, what kinds of cultural elements [the team needs] to have in place to make sure that stories are passed down from generation to generation."

At a workshop last year, the Interstellar Probe team was split into small multigenerational groups to discuss how team members can talk to each other, how one generation can mentor others, and what kinds of narrative structures they might create.

The exercise wasn't always easy. A younger member of Mandt's group, for example, suggested podcasts as a way to preserve informal knowledge about the mission. "I thought that was great because I'm getting into podcasts and my son even makes them for a living," Mandt said. "But somebody from the boomer generation just wasn't happy about that. He's not into them—he prefers videos. So it was interesting seeing that generational dynamic."

Good records, both formal and informal, will help scientists and engineers maintain and update equipment that while state of the art when the spacecraft was designed and built, will seem antiquated by the time it reaches its target distance from the Sun.

Keeping up with evolving technology isn't easy, though, especially because no one knows what technology will look like decades after a mission is launched. Data from early missions were stored on magnetic tapes, for example, and in many cases the technology no longer exists to play them. So long-term missions must build as much flexibility into their spacecraft's hardware and software as technology will allow.

"We're told to refresh the operating system on our desktop computers every 3 years, but once your spacecraft is launched, it's the spacecraft you have," Dodd said. "The Voyagers were never designed to update or repurpose the software to get to a more recent operating system. So that's another concern—you can't update a spacecraft very much after it's launched."

"You have to keep in mind that these are evolving projects," said Slava Turyshev, a scientist at NASA's Jet Propulsion Laboratory and principal investigator for the Solar Gravitational Lens mission concept, which aims to send a solar sail–powered spacecraft to at least 550 astronomical units from the Sun to use its gravity to image exoplanets. "We need to evolve the project every time we get together. We rely on people who are excited and are united by a common goal. We need to allow human genius to contribute to the project objective. And we need to be flexible—we don't want to constrain ourselves with too rigid a structure."

"WE'RE TOLD TO REFRESH THE OPERATING SYSTEM ON OUR DESKTOP COMPUTERS EVERY 3 YEARS, BUT ONCE YOUR SPACECRAFT IS LAUNCHED, IT'S THE SPACECRAFT YOU HAVE"

Rituals Large and Small

The Interstellar Probe team planned a workshop at the historic Explorers Club in New York to begin fulfilling another of Vertesi's recommendations: Establish rituals.

Meeting at the headquarters of a group whose members included the first people to reach the North Pole, the South Pole, the deepest spot in the oceans, and the surface of the Moon would emphasize the historic nature of Interstellar Probe. The meetings grew so large, though, that the club had to be abandoned.

Rituals can be as small as establishing seating charts for team meetings, working on a certain problem at the same time in each meeting, or allowing junior team members to ask the first questions. Graphics that depict a mission's path might have the ritualistic impact of showing the generation that will navigate it through each milestone, Vertesi said.

Other missions have established more extensive rituals. Because Europa played a key role in Arthur C. Clarke's *2001: A Space Odyssey* series, for example, a Europa Clipper mission team built a large monolith that it rolls out at meetings. "They 'pass the baton' between different work group leads every year by handing over a large bone in front of the monolith," Vertesi said. "They play the music from the movie and everyone laughs, but it's a part of their culture—a part of the way you know you're doing that mission."

"What kind of rituals can [the Interstellar Probe mission] build that will be meaningful over multiple generations? You want continuity that involves new people as they come in and really gets them involved in the wonder of the mission," she said.

Yet Vertesi and others involved with Interstellar Probe acknowledge that despite all the planning, no one can know how the mission will play out or how technology and society will change.

"If there's anything this particular moment in time is teaching us, it's that we really don't know what's going to happen, even in the next few weeks," Vertesi said. "But we do know that things will change, so you plan for change and do the best job you can."

Author Information

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