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Houston, We Have a Problem: NASA and Open Innovation (A)

It was January 2011 and Jeff Davis, director of the Space Life Sciences Directorate (SLSD) at the National Aeronautics and Space Administration (NASA), and Elizabeth Richard, senior strategist with Wyle Integrated Science and Engineering Group, stood at the back of the auditorium watching the workshop they had spent several weeks preparing. The workshop—"Open Innovation: Lessons Learned and Next Steps"—featured several professors well known for their research in open innovation.[1]

When dramatic budget cuts in 2005 forced Davis and Richard to rethink SLSD's research and work processes, open innovation presented itself as one tool SLSD members could use to continue to collaborate on their research and technology for the efficacy of human health and performance in space. In 2008, as part of a larger strategic plan to ensure that SLSD operated within the new budget paradigm, Davis introduced open innovation, presenting it as one of several ways to enable SLSD scientists and engineers to continue to pursue research and innovation with partners outside SLSD. Since 2008, Davis had made continuous efforts—both formal and informal—to seed open innovation as a viable approach in SLSD research and technology development (see **Exhibit 1** for a timeline).

Davis and Richard had organized the workshop to present insights from dramatically successful SLSD open innovation pilots conducted the previous fall. About 60 members of the SLSD leadership team were invited to the workshop. Several of these members had been early adopters of open

[1] "Open innovation" is an umbrella term describing an approach led by scholars and practitioners who argue for shifting knowledge creation and innovation outside the boundaries of the traditional organizational processes. The empirical anomaly that triggered this approach was "open source" methods of organizing for innovation, which have demonstrated the possibility of innovating successfully outside of traditional economic and organizational boundaries. Worldwide, thousands of individuals have developed highly sophisticated products based on this approach, successfully competing with the dominant design of the industry. The number of open source projects has exploded from only a handful in 2000 to over 250,000 in April 2014 (http://SourceForge.net), and the phenomenon is continuing to grow in influence. Some famous examples include Linux, the Apache server, Freemail, and Mozilla Firefox. The model has spilled over to other industries beyond software and has been referred to as "open," "peer production," or "distributed" innovation.

Professor Michael Tushman, Doctoral Student Hila Lifshitz-Assaf, and Associate Director Kerry Herman (Case Research & Writing Group) prepared this case. This case series is based on Hila Lifshitz-Assaf, "Shifting loci of innovation: A study of knowledge boundaries, professional identity and innovation at NASA" (DBA diss., Harvard Business School, 2014) and Lifshitz-Assaf, "From Problem Solvers to Solution Seekers: Dismantling Knowledge Boundaries at NASA," SSRN Working Paper, May 2014, available at http://ssrn.com/abstract=2431717. It was reviewed and approved before publication by a company designate. Funding for the development of this case was provided by Harvard Business School and not by the company. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

innovation and were enthusiastic about its promise as a way to pursue research and experimentation. Many others, in contrast, had shown little interest, had been confused about the approach, and were generally resistant and skeptical.

Davis and Richard were excited about the workshop, especially the presentation of the challenge[2] results. The results were spectacular; they showed how effective and efficient open innovation at SLSD could be. Davis and Richard hoped the results specifically, and the workshop more generally, would persuade SLSD members to integrate open innovation into their day-to-day SLSD research. They had been laying plans for weeks, anticipating that the pilot results would persuade their skeptical colleagues.

Instead Davis and Richard stood stunned at the back of the room as some colleagues resoundingly rejected the results as unrelated to their work. They were surprised by the emotional reaction to these open innovation pilots. Some were skeptical that outsiders and nonexperts could help solve big science problems; others resisted integrating an open innovation approach into their labs, calling it ill-suited to their specialized research. Many expressed reluctance to incorporate the approach into their day-to-day work. Back in his office, Davis remarked, "I just really didn't expect that response. We've been providing information about this approach for two years. It was like the air slowly coming out of a balloon." Richard said, "No. It was worse. It was like a lead balloon crashing with a deep thud."

NASA and the Space Life Sciences Directorate[3]

On July 20, 1969, NASA put a man on the moon. Since that monumental achievement, NASA had been the locus of innovation in space exploration, producing technological and scientific innovations with significant implications for both space and earth. In 1972, the Apollo program sent the last astronaut to walk on the moon. From 1981 on, the Space Shuttle (Shuttle) program helped build the International Space Station (ISS). From the late 1990s, the ISS operated as a research base for partner nations' astronauts and continued space research. NASA led the development of the ISS with 14 other countries, continued to fly astronauts and shuttles, sent robotic exploration rovers to Mars, and deployed the Hubble telescope, all contributing to human understanding of the universe. With the scheduled completion of the ISS in 2010 and the planned retirement of the Shuttle program on the horizon, NASA announced its next ambitious goal: the Constellation program, which called on industry partners to explore and refine concepts that would "help America return to the Moon, and ultimately travel to Mars and beyond."[4]

Life Sciences had always been an integral part of Johnson Space Center (JSC), the heart of NASA's manned spacecraft operations. Located in Houston, Texas, JSC was first operational in 1963. It included research laboratories, test facilities, an all-weather airport, launch facilities, and other infrastructure needed to coordinate and monitor all human space flight for the U.S., as well as provide planning and training facilities for the astronaut corps. NASA's research and development (R&D) labs had a long history of developing innovative products, including memory foam, scratch-

[2] A challenge was a research problem formulated in a way that could be shared with other solvers.

[3] The SLSD was renamed NASA's Human Health and Performance (HH&P) Directorate in 2012.

[4] "Taking the Vision to the Next Step," NASA press release, October 5, 2005, https://web.archive.org/web/20041101205026/http://www.nasa.gov/missions/solarsystem/vision_concepts.html, accessed November 2013.

resistant lenses, adjustable smoke detectors, ear thermometers, and many others. The current SLSD had been organized in 1977.

The SLSD mission was to be the world's leader in understanding the space frontier and the opportunities, capabilities, and limitations of humans living and working on that frontier. SLSD scientists, researchers, and doctors studied the best ways to optimize astronaut health throughout all phases of space travel. These were the doctors that made sure astronauts stayed healthy while on a mission. The directorate managed and implemented a broad range of scientific research and technology development to fulfill this mission, focusing on human health and productivity in space before, during, and after actual spaceflight experience, and included support for ground-based functions. The directorate oversaw the many disciplines and the research implicated in humans and spaceflight. These included biomedical research and operations, with labs focused on bone loss, immunology, muscle loss, neuroscience, nutritional biochemistry, spaceflight analogs, and exercise physiology. The directorate also oversaw program and project support for research programs in advanced food technology and ISS flight integration as well as clinical services, including flight medicine, industrial hygiene, and occupational medicine. (**Exhibit 2** provides an overview of the SLSD organization.) In 2002, Davis was named director of SLSD; previously he had served as flight surgeon, chief of the Flight Medicine Clinic, and chief of the Medical Operations Branch.

Doing Research at SLSD

Research was accomplished using ground-based laboratories, microgravity environments, and space-analog facilities. SLSD comprised approximately 1,000 professionals in medicine, science, engineering, and strategy development; about 80% of SLSD employees were contractors, many from Wyle Integrated Science and Engineering Group.[5] Contractors worked across all kinds of projects and activities at NASA. All procurement and budget-related activities were the sole purview of NASA.

Research and engineering at SLSD focused on the human system, including standards and requirements related to crew health; solutions included countermeasures such as exercise protocols and pharmaceutical regimens, diagnostic tools and medical products, extra-vehicular activity suits, and hardware such as air- and water-monitoring systems.

Experts in Their Domain

SLSD was an experienced technology-oriented organization, with significant knowledge of how to work with people outside its boundaries. Space exploration was a well-defined field with only a small number of public players (government agencies, universities) as well as private ones (aerospace industry contractors), many of whom knew of or worked with each other over decades of research. For many in the life sciences community, SLSD represented a pinnacle of space engineering and research know-how. Success in the field required a high level of expertise and professional and educational specialization (see **Exhibit 3**). Clear hierarchies and processes at the organization reinforced these elements. Outsiders often viewed all NASA scientists as miraculous problem solvers working on life-or-death issues in dangerous environments—such as the safe return of the Apollo 13 crew in 1970 after a serious malfunction threatened the mission. Organization members quietly celebrated these heroic efforts, typically with a sense of humor: "Actually, it *is* rocket science," proclaimed member T-shirts and bumper stickers on cars in the NASA parking lot (see **Exhibit 4**).

[5] Wyle provided specialized engineering, scientific, and technical services to the federal government and a variety of commercial customers, with services in test and evaluation, systems engineering and information technology, life-cycle and acquisition program management, life sciences research, space medical operations and engineering, and qualification testing for natural and induced environments.

Scientists and engineers were drawn to SLSD to work on big, exciting problems in space science. One said, "I've been attracted to places that allow you to access a problem, come up with a plan and execute a solution, and then be able to think and solve greater problems." Many of them chose to work at SLSD rather than pursuing more lucrative jobs in industry, and they saw themselves as "the brains" behind the vehicles that allowed safe manned travel and exploration in space. A researcher explained, "A lot of people who come to work here, it's certainly not because they couldn't make money elsewhere. Perhaps even more money elsewhere and have a successful career. It's because they wanted the opportunity to be innovative. They want the opportunity to contribute to something that nobody's ever done before."

SLSD researchers tended to approach research problems from two different perspectives: engineers focused on *how* to make a machine, system, or device work. In contrast, scientists focused on understanding *why* the machine, system, or device worked. One researcher explained, "For example, we have failure of a piece of equipment; half the people in the room are saying 'Fix it now, fix it now, fix it yesterday!' The other half is saying, 'Why did it fail? What's really wrong? Is there even something wrong?'" The researcher added, "You have to figure out how to balance those two approaches so that you get a quick but meaningful response to the complicated problems we face day-to-day." Research problems typically had long time horizons, often several years, and required collaboration with experts from across the field. SLSD had a long history of working a well-developed network of collaboration with public and private organizations. Davis noted, "Most of the research budget is sent out in grants, with research carried out at JSC and multiple collaborating institutions."

SLSD had always held itself to the highest quality and safety standards; as one scientist noted, "You make a mistake here, people die." Indeed, since the early 1990s, the organization had become obsessed with safety, introducing a new level of risk aversion, which some worried was a destructive environment for innovation. Some worried that SLSD's structure and processes had become too complex over time, and some complained that these were stifling to innovation. One researcher said, "You almost hate to have a new idea—all the people you'll then have to talk to." Regarding the bureaucracy, another noted, "They don't do research, they just have to fill out all these forms."

A Burning Platform

In 2005, despite the ambitious vision of the Constellation program, SLSD saw deep budget cuts trim 45% off its R&D budget (from approximately $330 million to $175 million), eliminating 13 full-time equivalents and about 80 contract positions. The cuts meant a loss in some core capabilities through reductions in personnel, contracts, and grants. Yet despite the budget cuts, SLSD was expected to continue to drive innovation in solutions to complex problems.

The cuts forced Davis and the SLSD leadership to rethink how SLSD conducted research. Constrained funds raised concerns over how to continue certain critical research pursuits. They created distractions and constant worry about funding. Many researchers experienced a diminished sense of freedom around taking risks and experimenting. "I thought, 'What am I going to do? How will we continue to foster innovation?'" Davis recalled.

Bringing Open Innovation to NASA

From mid-2006 to 2010, Davis and his team pursued several formal and informal organizational efforts to help install an environment at SLSD that would enable research and innovation under the new financial regime (refer to **Exhibit 2**). In early 2006, Davis gathered his leadership team on a retreat for a visioning exercise designed by Richard and to brainstorm strategies. From the data collected, Davis, with support from Richard, formulated a strategic plan. The strategic plan focused on increasing collaboration and alliances with external organizations in order to maintain the volume of SLSD's R&D activity despite the decreased budget.

From 2007 to 2009, Richard designed a process that she and Davis used to benchmark 20 academic, industry, and government organizations to learn about other models of innovation and collaboration with outsiders. The team organized the Innovation Lecture Series to bring in external speakers to discuss open innovation. An August 2008 workshop featured a T-shirt company where artists submitted T-shirt ideas, and the most popular ones, as indicated by customer pre-orders, were produced. But there were many skeptics. One scientist recalled, "We *were* innovative. Why did we need to have lectures about it, or special meetings and initiatives?" Richard added, "Technical experts could not relate a T-shirt company's experience with open innovation to spaceflight research, development, and operations. They questioned the connection to space flight and their work." The next day, JSC human resources conducted a day-long session for directorate leadership on culture change. Most of the scientists viewed the culture-change workshop as low priority.

In the spring of 2008, Davis attended an executive education course where he learned more specifically about open innovation as a way to collaborate and foster innovation on a thin budget. Soon after, back at SLSD, two enthusiastic project leads, curious to learn more, volunteered to conduct a market study to identify which open innovation service providers[6] might be a good fit for SLSD research interests and undertook a market survey of open innovation service providers.

By mid-2009, the benchmark study was completed and written up by Richard. The findings presented some surprises. Richard noted, "When asked why they pursued strategic alliances, 100% of the benchmark participants responded that they *had* to collaborate to innovate. They could not achieve their strategic goals on their own." The benchmark interviews revealed that these alliances supplemented internal resources and competencies; helped acquire novel ideas and approaches to problem solving; brought in needed services, licenses, or patents; and helped to further develop and execute plans. "This is something we already knew we did well," Davis said, adding, "The use of open innovation service providers to seek solutions to some of the challenges we worked on external to SLSD gained further traction as a serious strategy."

In July, Davis and Richard invited another professor to conduct a workshop for R&D members based on a *Harvard Business Review* article, "Which Kind of Collaboration Is Right for You?" Davis noted, "We solicited for about 12 challenges and challenge owners to go through the workshop to see if open innovation might be a path for them to close the gap on their challenge." Although the benchmark findings echoed SLSD's own long tradition of collaborative efforts with outsiders, collaborating via open innovation continued to strike many members as nontraditional. Some worried about sharing confidential research, some were skeptical of finding unknown qualified experts outside the organization, and others complained about having to do "additional work" on gaps and open innovation. Davis said, "We communicated constantly that our job was to find the best solution, not do all the work ourselves." Richard recalled, "Some continued to see this as Jeff's pet project. It felt like extra work to them, and they were already working under constrained resources."

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[6] Open innovation service providers fell into two categories. Some acted as intermediaries who, along with hosting the challenge(s) and providing access to an established community of "solvers" or participants, might also provide dedicated tools, a platform for the challenge(s), and methods, as well as education and process consulting. The second group worked with the organization to build their own open innovation capabilities to manage direct collaboration with outsiders.

The Pilot Challenges

Davis and Richard decided there was no better way to learn more about open innovation and assess its fit to their organization's needs than to gather evidence. In the summer of 2009, Professor Karim Lakhani, who had run an innovation seminar for SLSD earlier in 2008, contacted Davis. Crowdsourcing platform TopCoder was analyzing its platform to understand the dynamics of solver participation and had asked Lakhani for some help. Lakhani thought sourcing more interesting challenges would increase TopCoder participation and reached out to Davis to see if SLSD might have challenges for the crowdsourcing platform. Davis had met Lakhani during his executive education course and thought the proposal had merit.

Davis and his team decided that running several pilot open innovation challenges could help persuade organization members. Through a competitive procurement based on the earlier market survey, InnoCentive and yet2.com were selected as open innovation platforms. InnoCentive had a solver network of about 300,000 individuals spread around the globe; yet2.com operated slightly differently, acting as a matchmaker between organizations with a challenge and organizations with the capabilities to solve the problem. TopCoder focused specifically on software challenges and had about 300,000 registered problem solvers, software developers, and creative artists globally. Each provider ran training sessions for SLSD.

In November 2009, Davis and Richard held an introductory workshop led by InnoCentive and yet2.com, inviting about 30 SLSD researchers and physicians from across the R&D units to learn more about the platforms and approach. Davis noted in his introductory comments to the workshop, "Open innovation is a toolkit for future problems. With it we can react more quickly—instead of waiting for research and technology calls, we can get out with our challenge in a week, or a few weeks." Some were enthusiastic, and others saw it as a way to gain additional support from within the organization. Most teams expressed a willingness to experiment with solving strategic R&D challenges for the upcoming year via open innovation. Several volunteered to join Davis and his team to learn about open innovation and help foster understanding about the approach across other members. One researcher explained, "I see it as a win-win. The funding for this approach is coming from his pocket." Another member said, "I want it as an advertisement for my research so clinical people outside NASA will start pursuing the issues I'm interested in." Yet amid the interest from some, most remained unclear about what open innovation really was.

In 2010, the Constellation program was cancelled, and the entire organization experienced a shock. One scientist recalled:

> It's tough. NASA is a really stressful environment now. I've heard from people that have been here for 25 years that it was never like this. A lot of change is going on. Budgets are getting tighter and tighter, layoffs—all of that's got people stressed. They are losing a lot of their money for their research. So it's hard to have this innovation thing. It's kind of cloudy; you are trying to understand, especially when you are talking about platforms. Nobody has time for that; they don't understand "what does it do for me?" They have to lose people, lose work, and now you are coming at them with this innovation thing, and they have to wrap their mind around, "I have to do this *on top* of what I am already doing?"

Davis, Richard, and the team worried that SLSD morale would take a hit, that researchers would be concerned about the security of their jobs and their research, and that maintaining innovation would become even more challenging. Davis said, "I knew other organizations had dealt with such challenges by spinning out their innovation organizations. But my intuition was to keep things integrated within the directorate."

The team continued to push for ways to remain innovative in the face of these budget constraints. By the fall of 2009, the team chose 12 challenges, based on SLSD's current list of knowledge and technology gaps. Each challenge was refined into a challenge statement that could be addressed by a broad range of disciplines and technical expertise. These challenges were then run on one or more of the available platforms. [7] One challenge sought an algorithm to predict a solar particle event (or solar flare). Solar flares were powerful bursts of radiation that affected crew health in low earth orbit or deep space; could significantly disturb GPS systems, satellites, and other radio equipment; and could create geomagnetic storms. Decades of NASA and academic efforts could predict a flare only 1 to 2 hours in advance; this challenge sought an algorithm that could predict an event up to 4 to 24 hours in advance, with 50% accuracy and a two-sigma confidence interval.[8]

InnoCentive hosted seven challenges, yet2.com hosted six, and TopCoder ran an additional challenge to find an optimization algorithm for packing a lunar medical kit.[9] The challenges were run for short periods of time (usually over a few days to a few weeks), with participants working virtually from around the globe in short, fast-paced R&D cycles (see **Exhibit 5** for geographic distribution of participants and **Exhibit 6, Exhibit 7** and **Exhibit 8** for challenge results by provider).

Through a competitive procurement, SLSD also launched an internal open innovation site—NASA@work—that coordinated NASA challenges on an InnoCentive-based platform open only to the NASA community. The team ran 20 challenges, two for each of NASA's 10 centers. One scientist said, "NASA@work made sense to me. How embarrassing would it be to find that someone else is working on exactly what I am working on, but I don't know it? We need to at least know what's going on inside NASA." The initial NASA@work pilot ran challenges from June to October 2010.

In concert with the pilots, Davis and Richard established a strategic planning and implementation team to continue to support strategic and innovative initiatives. To enhance their efforts to communicate and educate regarding open innovation, they continued the Innovation Lecture Series on a quarterly basis, bringing in experts in accelerated research, nonprofit approaches to advancing innovation, open innovation, gamification, and other methodologies for advancing innovation in corporate, government, and academic sectors. After the first few lectures, attendance dwindled.

The Challenges and Their Results

Over 2,800 solvers from over 80 countries participated in the InnoCentive and yet2.com challenges (see **Exhibit 5**). Cash prizes were awarded for each challenge. The InnoCentive challenges returned many hits of interest followed by submissions (see **Exhibit 6** for more complete results). The winning solution submitted for the challenge to more accurately predict a solar flare was accurate to within eight hours, with 85% accuracy and three-sigma confidence interval—well beyond the expected result and orders of magnitude improvement on the existing predictive capabilities. The solution was provided by a semi-retired radio frequency engineer living in New Hampshire. The story was picked up by the national press and even U.S. Chief Technology Officer Aneesh Chopra highlighted it in a

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[7] One of the challenges was run on two platforms.

[8] A confidence interval is a type of interval estimate of a population parameter, used to indicate the reliability of an estimate. The higher the sigma, the more accurate the estimate.

[9] This challenge resulted in the writing of 3,500 lines of code and drew more than 1,800 entrants.

YouTube video on open innovation.[10] Other challenges found a unique material (flexible graphite) to analyze for food packaging for very long-duration space missions. InnoCentive's CEO remarked, "Until now, many around the world did not have an opportunity to help solve some of the problems facing NASA. Now, anyone with interest and ability can impact how the U.S. explores the final frontier. NASA Space Life Sciences' commitment to open innovation is a testament to exploring solutions from any contributor."[11]

The yet2.com pilot returned 5,621 hits, or initial interest, and 234 total replies. At the close of the challenge, yet2.com had 30 active leads for the six challenges (see **Exhibit 7** for more complete results). One challenge lead identified several new approaches for imaging the architecture of bone in space and had the potential to lead to the formation of a consortium of academics and industry players to develop new technologies.

The TopCoder challenge resulted in an optimization algorithm for the space travel medical kit (see **Exhibit 8** for challenge results). The algorithm was incorporated into the existing Integrated Medical Model (IMM) and improved the design capabilities of this model for future medical kits. In early 2010, Davis forwarded the TopCoder results to Jason Crusan, chief technology officer of the human exploration program at NASA's Washington, DC, headquarters. The challenge piqued his interest, and he and Davis discussed the opportunity to conduct more challenges. Crusan and Lakhani codeveloped a white paper to articulate the theory behind open innovation in terms that could speak to NASA researchers and scientists, describing the benefits to NASA in exploring this new model of innovation and its potential for novel social science research. Lakhani recalled:

> Open innovation approaches, and contests in particular, offered a whole new way of organizing innovation and problem solving. While there were some commercial examples of a systematic use of open innovation, there were no examples of their use in government science- and engineering-driven agencies. In addition, while there was a lot of economic theory about the optimal design of tournaments, actual empirical evidence from innovation settings was not yet widely available. This is a new way of solving problems. It involves a real process change, including defining problems in ways that people outside of technology domains can solve them, setting up solution criteria in advance, and thinking about how to evaluate solutions as they are submitted. The white paper provided the case for solving real algorithmic and computational challenges for NASA while simultaneously pushing the frontiers of our knowledge about contest design.

Later in 2010, NASA and Harvard University's Institute for Quantitative Social Science (IQSS) established the Harvard-NASA Tournament Lab (NTL) to continue exploring challenge opportunities with Lakhani as the principal investigator. At that time SLSD also launched the NASA Human Health and Performance Center (NHHPC), a virtual center to facilitate exchange of open innovation best practices and collaborative innovation of member organizations across NASA and other federal agencies, industry, academia, and nonprofits.

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[10] "Aneesh Chopra (U.S. Government CTO) on Open Innovation," http://www.youtube.com/watch?v=3oZVzLMumNg, accessed November 2013.

[11] Dwayne Spradlin, cited in "NASA Open Innovation Pavilion: Space Life Sciences and InnoCentive," http://www.nasa.gov/centers/johnson/slsd/about/announcements/announcement-innocentive-pavilion.html, accessed July 2013.

Failure to Launch

In January 2011, Davis and Richard pulled together all of the data on the challenges to present to SLSD. "We knew the results were spectacular," Davis said. "We were very excited about how persuasive these results were that open innovation could be an important way to do work at SLSD."

Once the challenge results were presented in the workshop, Davis shifted gears by discussing how to execute next steps: moving from experimentation to integrating open innovation into members' day-to-day projects and research. This prompted a wave of reactions. Some were intrigued by the approach, noting it as a "win-win" or a "great way to get out of our bubble," and others saw it as valuable for some situations and said that it "added another tool to our toolkit." But others were highly skeptical. One member concerned about the confidentiality of the organization's research asked, "Isn't there a problem with using this and us being NASA?" Another was highly skeptical about the idea of having a dialogue over the web about his challenge. Several cautioned that as an approach, open innovation could present a false confidence that the platform provided a comprehensive search for relevant solutions outside their boundaries. "You put this out there, and then there's nothing else out there, and people say 'Oh no, we did it on InnoCentive and we didn't find anything, so it's not out there.' InnoCentive isn't the whole world. Yet2.com isn't the whole world. . . . People have to realize it's not the golden bullet or silver bullet."

Many in the audience felt the experiment raised broader concerns. One lab member said, "Why do we need to expand our external partnerships to innovate? We're NASA. We are the only ones who know space. And we already innovate." Another pointed out the conflict open innovation as a research model presented to their education and professional training: "The history of the scientific method goes against open innovation. In our training, trying to solve problems in the scientific method was: 'I take in all this information, I synthesize it, I do analysis, and I come to some conclusion.' So to reach out to other people to solve it, it's like cheating!" Another noted, "We already solve difficult science problems. We *are* NASA." Another researcher observed that open innovation would require a change "in their heads on how they do their jobs," as he put it. "They are not used to going out and saying, 'Hey. We have a problem and we don't know how to do it, can you guys do it?'" He added emphatically, "These guys, *it's all they do.* They are not doing a billion other things for space flight. They make flight hardware. And they make the best ones. *That's what they do*. They are NASA; they are the brains behind the vehicles, and they are the ones. There isn't anyone that's going to know better what they need to know to go do what they do. They are the ones." Relying on solutions from outside could imply that the researcher was no longer the expert on the problem being studied and/or that they might lose control over the problem and its potential solution.

Davis and Richard slowly headed back to his office. The overall reaction to the workshop had been a highly disappointing "so what?" across the audience. "I just couldn't understand why everyone wasn't as excited as I was," Davis said. "The results suggested we could do great development for a fraction of the cost, and who knew what new and exciting ideas might come from these kinds of collaborations?" Instead, except for a few, the responses had been almost uniformly negative. "The not-invented-here syndrome was strong," said Richard. Davis and Richard sat quietly with their notes crumpled beside them. "Just how did this happen? How could the reactions be so negative, and what should we do?" Davis asked.

Exhibit 1 Timeline of Open Innovation Initiatives

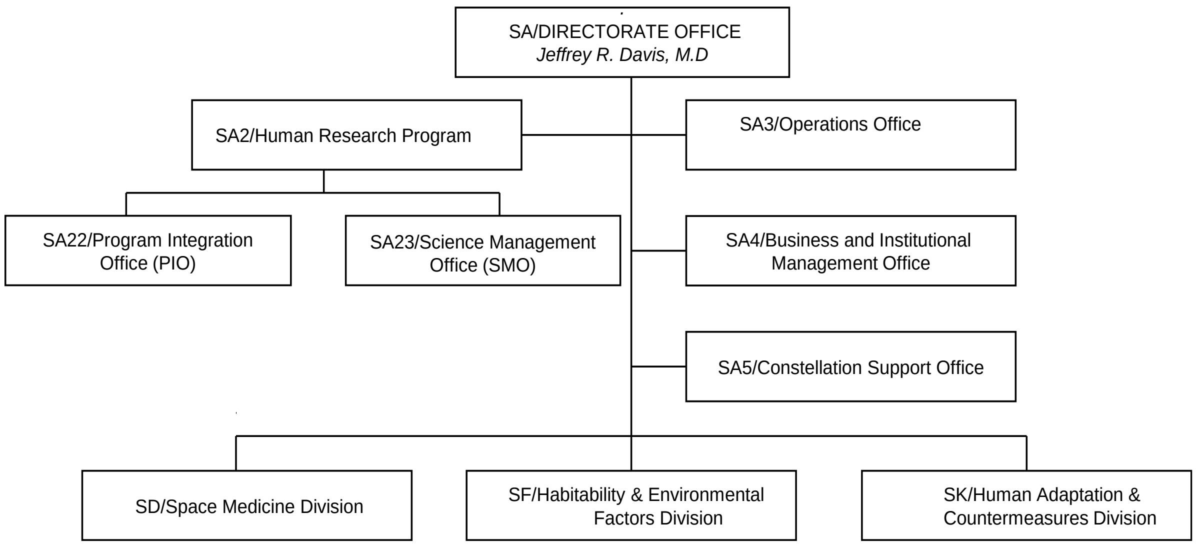
Year	Action
May 2006	Visioning retreat for SLSD Leadership (NASA, Wyle, NSBRI and USRA) to examine possible scenarios to move forward and continue to meet SLSD mission with limited resources. (Assessed scenarios driven by SWOT analysis; conducted environmental scan; developed draft vision and mission, identified primary characteristics needed to achieve vision.)
May 2007	Space Life Sciences strategy published. (Four specific goals developed: definition and management of the SLSD portfolio; driving advances in health innovations; driving advances in human system technologies; creating enduring support and enthusiasm for space exploration).
2007–2008	Benchmarking on strategic alliances. Conducted interviews with 15 organizations.
Early 2008	Formed four cross-disciplinary innovation development teams, charged with evaluating and proposing options for open innovation, venture entrepreneurship and industry engagement, institutional change and barriers, and social innovation in SLSD.
March 2008	Davis attended Leadership Change and Organizational Renewal (LCOR).
April 2008	Established formal risk management process and Human System Risk Board to identify and address gaps in the Spaceflight Human Systems portfolio. This drove the development of a risk mitigation management tool (RMAT) to track the research, operational and other approaches to risk mitigation, and to serve as a forum to enhance integration of SLSD research and operations. Identified gaps in SLSD knowledge, technologies, research and clinical services which could be targeted for closure.
July 2008	Introduction to open and disruptive innovation. SLSD developed an approach for implementing its strategic plan to address both types of innovation, evolving the capacity to be an ambidextrous organization. This required merging two diverse cultures while developing the means to manage them, requiring a strict risk management approach for incremental change versus a more open process for high-risk development to spur disruptive innovation.
August 2008	Conducted workshop on open innovation (all-hands). Workshop featured Threadless Tees' open innovation approach to designing and manufacturing t-shirts. JSC Human Resources conducted culture change workshop.
Fall 2008	Initiated discussions with InnoCentive. Established the Space Life Science Innovation Prize for the Rice Business Plan Competition. Began exploring partnerships with GE and Philips based on benchmarking interviews.
October 2008	Launched MBA student project on collaborative approaches for SLSD.
November 2008	Formed Strategy Execution and Implementation Office (SEIO), a new office created at directorate level to institutionalize and facilitate innovation and implement change. The SEIO focused on five main areas: strategic alliances; human systems integration; innovation; education; and strategic communication. It aimed to advance innovation methodologies, facilitate collaborations and foster culture change in alignment with the May 2007 strategic plan.

Year	Action
	Established SLSD Strategic Communications Team, under leadership of SEIO strategic communications lead (Richard) to address the opportunity to enhance internal and external communications as specified in 2007 strategy.
March 2009	Harvard Business School (HBS) student-MBA team proposed models for managing open collaboration/innovations within SLSD.
April 2009	Launched Innovation Lecture Series; series continued on a quarterly basis bringing in experts on accelerated research, non-profit approaches to advancing innovation; open innovation; gamification; and other methodologies for advancing innovation in corporate, government and academic sectors to speak to directorate.
July 2009	Conducted workshop for senior leadership team on collaboration methodology. Based on "What Kind of Collaboration is Right for You?"[a] Identified gaps, worked with 12 gap owners to work through criteria for open collaboration; mapped portfolio using gaps identified in risk management process.
Summer 2009	Secured funding for open innovation pilots; assessed open innovation service provider market and procured InnoCentive and yet2.com.
October 2009	Benchmark with NSF on sandpit (Idea Lab) as a possible accelerated/leveraged research model.
November 2009	Introductory workshop on innovation platforms, led by InnoCentive and yet2.com. Ran onsite training for both providers. Launched pilot phase I of InnoCentive and yet2.com challenges. Designed and conducted TopCoder pilot challenge.
February 2010	Launched pilot phase II of challenges.
February–April 2010	Results from first seven challenges put into a lessons-learned report by InnoCentive highlighting successes. Competed and procured NASA@Work.
June–October 2010	Ran 20 challenges on NASA@work (2 challenges to each of the 10 NASA centers).
October 2010	Established NASA Human Health and Performance Center (NHHPC). NASA Tournament Lab (NTL) launched by NASA and Harvard.
January 2011	Conducted workshop with challenge champions with NASA and contractor leadership. Launched first attempt at strategic framework, but stopped soon thereafter as attempt was too academic and not functional.

Source: NASA.

[a] Gary Pisano, "What Kind of Collaboration Model Is Right for You?" workshop based on his December 2008 *Harvard Business Review* article.

Exhibit 2 The Space Life Sciences Directorate (2008)



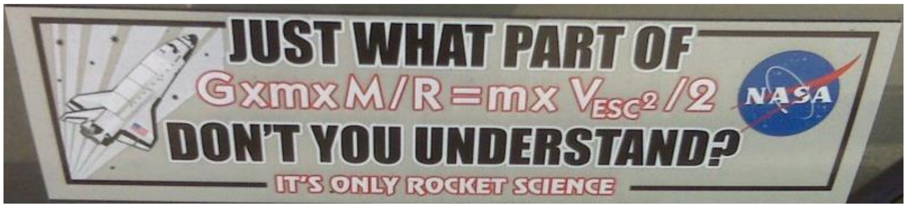
Source: NASA.

Exhibit 3 Demographics of NASA/Johnson Space Center/Space Life Sciences Directorate

Educational Background	
Science	37%
Bio-medical Engineering	8%
Engineering	30%
Medicine	9%
Other	14%
Gender	
Male	63%
Female	37%
Age	
Average age in years	41
Tenure	
Average tenure in years	13

Source: NASA.

Exhibit 4 NASA R&D Members' Artifacts



Source: Hila Lifshitz-Assaf, "From Problem Solvers to Solution Seekers: Dismantling Knowledge Boundaries at NASA," SSRN Working Paper, May 2014, http://ssrn.com/abstract=2431717.

Exhibit 5 Geographic Distribution of NASA Challenge Solvers

Source: NASA.

Exhibit 6 InnoCentive Pilot: Challenge Data Statistics

Challenge Title	Ctr	Posted	Deadline	Proj Rms	Sub	Award Date	Award Amount
Improved Barrier Layers…Keeping Food Fresh in Space	JSC–SLSD	12/18/09	2/28/10	174	22	5/7/10	$11,000
Mechanism for a Compact Aerobic Resistive Exercise Device	JSC–SLSD	12/18/09	2/28/10	564	95	5/14/10	$20,000
Data-Driven Forecasting of Solar Events	JSC–SLSD	12/22/09	3/22/10	579	11	5/13/10	$30,000
Coordination of Sensor Swarms for Extraterrestrial Research	LRC	2/27/10	4/26/10	423	37	6/4/10	$18,000 (3)
Medical Consumables Tracking	GRC	5/17/10	7/27/10	365	56	10/28/10	$15,000 (3)
Augmenting the Exercise Experience	JSC–SLSD	5/27/10	7/27/10	229	18	9/20/10	$10,000
Simple Microgravity Laundry System	JSC–EA	5/27/10	7/27/10	598	108	9/21/10	$7,500

Source: NASA.

Note: LRC = Langley Research Center; GRC = Glenn Research Center; EA = JSC Engineering; Proj Rms = project rooms opened for challenges; sub = solutions submitted.

Exhibit 7 Yet2.com Pilot: Challenge Data and Statistics

Technical Need	No. of Total Replies/Leads	No. of Hits (initial interest)	Active Leads
Bone Density Measurement	51	793	5
Monitoring of Water and Biocides	61	2003	8
Radioprotectants	28	475	6
Exoterrestrial Life Differentiation	31	1596	1
Food Packaging/Protection	29	173	5
Portable Imaging	34	581	5

Source: NASA.

Exhibit 8 TopCoder Pilot Challenge Results

- Opportunity presented to NASA by Harvard Business School
- Research project to compare outcomes of collaborative and competitive teams
- NASA provided the problem statement
- Optimize algorithm that supports medical kit design
- Competition began on November 4, 2009, and lasted approximately 10 days
- 2800 solutions were submitted by 480 individuals
- Useful algorithm developed and incorporated into NASA model
- Team felt this process was more efficient than internal development

Source: NASA.