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Investment in Open Innovation Service Providers: NASA's Innovative Strategy for Solving Space Exploration Challenges

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In an effort to expand routes for open communication and create additional opportunities for public involvement with NASA, Open Innovation Service Provider (OISP) platforms have been incorporated as tools within NASA's problem solving strategy. NASA engaged the services of two OISPs, InnoCentive and Yet2.com, to test this novel approach to problem solving and its feasibility for solving NASA's spaceflight challenges. The OISPs were chosen based on multiple factors including: network size and knowledge area span, established process, methodology, experience base, and cost. InnoCentive and Yet2.com each met the desired criteria; however, each company's approach to Open Innovation Services is distinctly different. InnoCentive focuses on posting individual challenges to an established web-based network of ~200,000 solvers; viable solutions are sought and granted a financial award if found. Based on a specific technological need, Yet2.com acts as a "technology scout" providing a broad external network of experts as potential collaborators for NASA. A relationship can be established with these contacts to develop technologies and/or maintained as an established network of future collaborators. The results from phase one of the pilot study have shown great promise for long-term efficacy of utilizing the OISP platforms. The challenges posted with the InnoCentive pilot have yielded 11awarded solutions out of the seven challenges posted. A total of 2 proposals were granted full award and 9 proposals were granted a partial award. The six technical needs posted for the Yet.com pilot have yielded a substantial number of contacts not previously identified by NASA and are of great interest as potential collaborators for solving our technology needs. The results from the current open innovation efforts have promoted public involvement, awareness of the United States space program, and created an environment where one person can make a substantial difference.

Operating in the information era brings with it a required shift in traditional strategies and philosophies for any organization's research and technology development efforts, including NASA. NASA's human health and performance challenges associated with long duration space flight require NASA to remain on the cutting edge of the world's leading developments in health care, performance, and environmental health, and the technologies that support living and working safely and effectively in space. To remain at the cutting edge in these areas, strategies that extend our network of experts to encompass as much of the world's expertise as possible are required. However, harnessing the power and expertise of a global community challenges long-standing cultural barriers such as the "not invented here" philosophy and opening the problem solving space to diverse and talented individuals outside of NASA. In a world that is ever expanding, it is impossible to "own" all of the experts and expertise in the world. To internally acquire every expert needed to solve all of the problems faced by an organization is cost prohibitive, resource intensive, and reduces effectiveness of existing personnel. The goal of utilizing open innovation techniques, such as crowdsourcing, takes advantage of the power of groups of people/experts outside your organization to help solve problems or bring in new and novel ideas. The goal is not to replace valued internal expertise, but to add to the problem-solving capabilities of the internal cohort. This approach allows organizational expertise to focus on spaceflight specific implementation of the solutions and problems that are more efficiently solved by internal NASA expertise.

To take advantage of new opportunities that crowdsourcing can offer, such as the ability to leverage global expertise and create opportunities for the public to solve some of NASA's toughest challenges, the Space Life Sciences Directorate (SLSD) at NASA has developed new strategies that incorporate the use of open innovation platforms and support services to implement its strategic plan. To test the feasibility of using open innovation platforms and service providers to help solve NASA's human health and performance challenges, two pilot programs were initiated with InnoCentive and Yet2.com. Open Innovation Service Providers (OISPs) approach problem solving by using the internet to tap into communication flow within and between virtual technical communities.

In general, the open innovation philosophy is that innovation comes from where you least expect it. This means that someone from an unrelated field may have a novel approach to solving the problem, which is unbiased and unconventional but very applicable. The OISPs were chosen based on multiple factors including: network size and knowledge area span, established process, methodology, experience base, and cost. InnoCentive and Yet2.com each met the desired criteria; however, each company's approach to Open Innovation Services, i.e. crowd sourcing, is distinctly different.

InnoCentive focuses on posting individual challenges to an established web-based network of ~200,000 solvers; viable solutions are sought and granted a financial award if found. Yet2.com's operational platform is based on specific technological needs, Yet2.com acts as a "technology scout" providing a broad external network of experts as potential collaborators for NASA. To maximize the ability to make improvements based on lessons learned, the pilot programs were divided into two phases with each OISP.

I. INNOCENTIVE PILOT METHODS

InnoCentive's approach to open innovation is structured around a series of training workshops that are conducted to introduce the seeker organization to what it means to be an open innovator. Specifically, how to facilitate open innovation within the organization's framework, identify and develop potential challenges, and to demonstrate the general processes and techniques for making the challenge process a success for the seeker, NASA, and solvers.

A challenge posted with InnoCentive can take the form of one of four different types of challenges: ideation, theoretical, reduction to practice or a request for proposal (RFP). An ideation challenge is a request for new and novel ideas. A theoretical challenge is more difficult than an ideation challenge and requires solvers to submit a proof of concept and validation that the solution has merit; this could be accomplished with data, engineering drawings, or low fidelity mock-ups. A reduction to practice challenge is much more difficult and requires more time than a theoretical challenge. This challenge requires a working model or prototype and not just an idea or concept with preliminary validation. A request for proposal (RFP) can be utilized if the seeker organization, in this case NASA, desires a concept or technology that is fully developed or co-developed. With this type of challenge the solver and the seeker can enter into an agreement to work together to develop the concept or technology.

The InnoCentive pilot program encompassed seven total challenges, with four challenges from the NASA Johnson Space Center (JSC), one challenge from the Langley Research Center (LARC) and two challenges were a multi-center effort between JSC and the Glenn Research Center (GRC). The pilot consisted of two phases. Phase one challenges included: solar forecasting (reduction to practice challenge), improved food packaging (theoretical challenge), compact resistive exercise device (theoretical challenge), and sensor swarming (theoretical challenge).

The solar forecasting challenge focused on the future exploration of the solar system and the significant radiation exposure risk to both humans and hardware. Energetic particles emitted by the sun during Solar Particle Events (SPEs) increase exposure above background levels and could be mission limiting. There is no method available to predict the onset, intensity or duration of an SPE. Of particular interest for mission operations is the ability to predict or forecast periods from 4 to 24 hours of low probability of having an SPE, i.e., an 'All-Clear' forecast. Multiple observational platforms currently exist to monitor solar activity. The improved food packaging challenge was looking for food storage technology that met mass, volume and consumable exploration requirements. New food packaging technologies are needed that have adequate oxygen and water barrier properties to maintain food safety and quality for a three-year shelf life. The compact resistive exercise device challenge was interested in a novel engineering mechanism for a compact, effective aerobic and resistive exercise device. Specifically, the challenge sought an engineering mechanism that could deliver the proper resistance and work load in microgravity while meeting restrictive mass and volume requirements. The sensor swarming challenge was concerned with determining the optimal methods for coordinating the activity and locomotion of a sensor swarm while a exploring a planetary body.

The phase two challenges included: augmented exercise experience with audio-visual inputs (theoretical challenge), medical consumables tracking (theoretical challenge), and a simple microgravity laundry system (theoretical challenge). The augmented exercise experience challenge sought a system that would enhance the exercise experience and capture psychological and physiological measures while the crewmember participated in prescribed exercise regimens. The medical consumables tracking challenge sought a method/process to track attributable medication and medical consumables usage from a common medical kit. Specifically, the challenge sought the capability to track items to a specific user with minimal participation by the individual, and which items need to be replaced due to use or expiration. The simple microgravity laundry system challenge requested solvers to conceive of new methods of cleaning clothing such that they could be performed either on the International Space Station or aboard a vehicle that travels beyond low-earth orbit.

II. INNOCENTIVE PILOT RESULTS

All phase one and two challenges were posted on the InnoCentive website for 3 months within the NASA pavilion. The NASA pavilion is a custom location on the InnoCentive website that identified NASA's challenges and included information about each participating Center as well as a link to each participating NASA center's homepage. All phase one challenges received solutions that were then granted full or partial awards. The solar forecasting challenge closed with 579 total project rooms representing 53 different countries. Project rooms are opened by individual solvers or teams expressing interest in the challenge topic but are not indicative of the total number of proposals a seeker organization can expect to receive for any given challenge. A total of four individual proposals were selected for final review, and one proposal from a retiree in New Hampshire was chosen for a full award. The solution was a mathematical model that predicted Solar Particle Events (SPE) using ground based data.

The improved food packaging challenge closed with 174 total project rooms representing 33 different countries. A total of sixteen proposals were reviewed and a partial award went to one proposal submitted by a Russian scientist. The solution was utilization of graphite foil as a barrier in food packaging to extend the shelf life of food products. With further testing this material may provide the barrier properties needed to extend shelf life for exploration missions.

The compact resistive exercise challenge closed with 564 project rooms representing 52 countries. A total of 60 individual proposals were received and one proposal from a mechanical engineer in Massachusetts was chosen for full award. The solution was for a compact pneumatic suction exercise device similar to an exercise device that is currently on the International Space Station (ISS), the Advanced Resistive Exercise Device (ARED). However, the proposed device is much more compact, lighter weight, and novel in terms of how the exercise device and its components were packaged.

The sensor swarming challenge closed with a total of 423 project rooms representing 49 individual countries. A total of 22 individual proposals were reviewed and three proposals from solvers in Italy (2) and California (1) were awarded partial awards. The solutions were novel ideas for how sensor nodes could make decisions autonomously and without coordination with other swarms. The ideas also helped re-characterize the original problem statement for future research and collaboration efforts.

All phase two challenges received proposed solutions that were granted partial awards. The augmented exercise experience challenge closed with a total of 229 project rooms representing forty-three individual countries. A total of 13 proposals were reviewed and one proposal from a solver in Canada was chosen for a partial award. The medical consumables tracking challenge closed with a total 365 project rooms representing fifty-seven different countries. A total of 36 proposals were reviewed and 3 proposals from solvers in Virginia, Ohio, and Switzerland were chosen for partial awards. The simple microgravity laundry system challenge closed with a total of 598 project rooms representing fifty individual countries. A total of 70 proposals were reviewed and one proposal from a solver in Massachusetts was chosen for a partial award.

III. YET2.COM PILOT METHODS

Yet2.com works as a network search agent over a three-month period, using their network of experts to seek solution providers for an identified technical need. The organization seeking a solution, in this case NASA, receives either a contact or network of contacts that may be able to work with NASA on development of a solution for the technical need. Yet2.com may also find a contact that already has a viable solution. Once the contacts/network has been delivered to NASA, it is up to NASA to establish a working relationship to develop the solution. There are two distinct differences between the Yet2.com and InnoCentive business models. First, there are no financial awards made to contacts identified by Yet2.com to NASA. However, NASA may choose to enter into a collaborative relationship with one or more of the contacts provided and terms of the relationship would be negotiated by NASA and the contact(s) engaged. Secondly, Yet2.com clients are not typically identified to their contact networks; the seeking institution remains anonymous until a number of preliminary discussions are conducted. These discussions help determine the utility of a specific contact of interest for NASA in solving the technical need. Yet2.com utilizes several methods to identify contacts of interest for each technical need: each technical need is posted anonymously on the Yet2.com web market place and Yet2.com searches actively through multiple databases of contacts at universities, small firms, entrepreneurs, and venture capitalists. Similar to InnoCentive's challenge development process, Yet2.com assists with technical need statement development.

Like the InnoCentive Pilot, the Yet2.com pilot was completed in two phases, phase one technical needs included bone density measurement, real-time microbiological monitoring of water biocides, and radioprotectants for human exposure to chronic and acute radiation. The bone density measurement technical need was a clinically-useful technology with enough sensitivity to assess the microstructure of "spongy" bone that is found in the marrow cavities of whole bones. The real-time microbiological monitoring of water biocides technical need was for a technology that allowed monitoring of the microorganism content of stored potable water in real-time and the ability to report the water's status to assure its continued potability even after storage times as long as a year. The second part of this need addressed the need to decrease and maintain the microbial concentration in acceptably clean drinking water. The radioprotectants technical need required a biological, pharmaceutical, or dietary countermeasures to act as radioprotectants for humans exposed to radiation; either chronic exposure or acute exposure.

The phase two Yet2.com technical needs included exoterrestrial life differentiation, portable bone imaging capabilities, and improved food packaging. The exoterrestrial life differentiation technical need sought a protocol to determine whether life found on other planets or in space is indigenous to its locale, or is the result from contamination from probes sent by Earth. The second part of the exoterrestrial life differentiation need addressed the need for a system or method for qualitative analysis of microorganisms that could then classify the organisms by their taxonomy. The portable bone imaging challenge sought a miniaturized (less than 50 pounds) portable device to perform magnetic resonance imaging (MRI), computerized tomography (CT), X-ray, and other non-ultrasound diagnostic scans. To test the type of results yielded from both platforms, InnoCentive and Yet2.com, the improved food packaging need was also posted with Yet2.com during phase two. The improved food packaging need sought a commercially available, flexible, non-foil food-grade packaging that offers high oxygen and moisture barriers. The packaging must withstand high temperature processing, high pressure processing, or microwave processing. It should be light in weight, and able to protect food for up to five years.

IV. YET2.COM PILOT RESULTS

All phase one and two technical needs were posted on the Yet2.com website for approximately 3-4 months. For proprietary reasons, we are unable to identify the individual contact names NASA received for each of the technical needs. All phase one needs identified multiple leads that NASA is currently investigating for potential partnerships. The bone density measurement technical need received a total of 758 website views and 51 contacts from 12 countries that were identified as promising leads. Although five of the contacts were of strong interest, only one company was chosen for immediate collaboration. The real-time microbiological monitoring of water biocides technical need received a total of 1741 website views. A total of 61 contacts from 18 countries were identified and showed potential for addressing the need. Five candidates are currently under further consideration for collaboration. The radioprotectants need received a total of 437 website views. There were a total of 28 leads identified representing 9 countries; six of the contacts are under further consideration for future collaboration.

Similar to phase one, the phase two needs identified multiple leads that NASA is also considering for potential partnerships. The exoterrestrial life differentiation need received a total of 1460 website views. A total of 31 leads of interest were identified representing 10 different countries; one contact is under consideration for future collaboration. . The portable bone imaging device need received a total of 581 website views. A total of 34 leads were identified representing 5different countries; 5 contacts are under consideration for future collaboration. The improved food packaging technical need received a total of 173 website views. A total of 29 leads of interest were identified representing 11 different countries; 5 contacts remain under consideration for future collaboration. All resultant contacts from phase one and two are under evaluation for their ability to address the technical needs in partnership with NASA.

V. DISCUSSION

Like any large organization, NASA has challenges that require creative solutions that may not be solved through traditional means such as grants, small business innovative research funding, NASA Research Announcements, requests for proposals, and internal projects. While the traditional routes draw from a knowledgeable group of experts, expertise and disciplines not already linked to the spaceflight community may be missed and cross discipline problem solving may be underutilized. Traditional problem-solving methods may only be available on an annual basis and may commit greater funding than required. In the past, an innovative solution or collaboration may have resulted from a serendipitous professional relationship or networking at a conference and may not be repeatable.

The key to driving innovation for space exploration is to establish a systematic approach that builds upon our internal expertise to blend traditional problem-solving tools with newer techniques such as OISPs. The use of OISPs is a novel strategy by NASA to reach a global audience to find solutions to space flight challenges. This process facilitates cross-discipline synergies, and provides NASA with the opportunity to supplement its internal expertise with a broad community of experts that NASA would not otherwise be able to access. The results from the current open innovation efforts have promoted public involvement, awareness of the United States space program, and created an environment where one person can make a substantial difference.

VI. CONCLUSION

The OISP methodology allows NASA to publicly issue challenges to seek innovative solutions and build awareness and collaboration with a global public. OISPs also represent a potentially cost effective and efficient way to seek solutions to NASA's challenges.