Cube Quest Challenge

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I. Abstract

The area of emphasis for this project is to develop products that support Centennial Challenges' technical development needs by creating a comprehensive communications strategy, maintaining a compelling web presence, and public engagement activities to recruit teams. This project will present a comprehensive approach to promoting the Cube Quest Challenge, including website improvements, technology development and transfer, commercial applications, social media, exhibits, public engagement, creating a new-competitor package, and post-challenge resources.

II. Introduction

Centennial Challenges uses competitions to advance technologies for NASA and the nation. The program develops challenges that target technology needs in different areas as described by NASA's technology roadmaps, and allocates prize pursues as incentives. The goal of the challenges is to attract competitors from diverse backgrounds to participate and introduce innovative approaches. Prize purses provide winners with funds and public visibility to push their projects further, developing them into technologies NASA and the private sector can use.

Centennial Challenge's slogan along with their objectives consist of the following:

- Dream It / Innovation (i.e. larger vision)
    - The program challenges the public to innovate and solve problems with no known solutions, pushing state-of-the art technology into the future.
    - Past winners, such as Peter Homer in the Astronaut Glove competition, have gone on to patent their creations and create or contribute to larger companies.

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- Make It / Opportunity (i.e. specific tasks for competition)
    - The public is a part of the scientific process, with citizen inventors, academia, and small businesses contributing to space exploration.
    - Technologies developed by the 3D Printed Hab, Mars Ascent Vehicle, Space Robotics, Sample Return Robot and CubeQuest Challenges allow the public to join NASA on the Journey to Mars.
- Win It / Communication (i.e. engaging the public)
    - Prizes incentivize innovation, and give winners the funds to push their projects further, developing them into technologies NASA and the private sector can use.
    - Since 2005, there have been 16 challenges with 36 competitions and over $6.5 million awarded.

NASA's CubeQuest Challenge (CQC) hopes to accelerate the technological capabilities of tiny satellites, known as CubeSats, that may help the space agency achieve future mission goals faster and more affordably. CQC reaches out to amateur inventors and technology enthusiasts to deliver CubeSats that can get to the moon and beyond. These objectives are concentrated into a series of stages: the Ground Tournaments, Deep Space Derby and Lunar Derby. A prize purse of $5 million is being offered to teams that meet the challenge objectives.

III. Task Implementation

A. Presentable Statistical Information

- My task for this area was transferring challenge summary data of the program to Excel and encompassing this information into pie charts or bar charts that represent the impact the overall program has had with regard to percentage of competitors from US regions and countries, number of teams that have registered and competed, and affiliation of competed teams. By organizing this information in such manner, we can analyze how well the program is targeting a wide variety of competitors from consortiums, universities, high schools, LLCs,

academic and industry located at various US regions and countries with the ultimate goal of pinpointing regions or countries that the program should target more in future competitions.

B. Researching State of the Art

Current CubeSat technology has only been able to withstand Low Earth Orbit (LEO). Challenges preventing CubeSats from venturing through deep space include their size and weight as it impacts possible room for radiation shielding in order to survive in the radiation environment, and solar panels in order to generate more power based on their distance from the sun. Additionally, the fact that currently these satellites are restricted in relying only on GPS or force magnetic field for possible deep space navigation.

There is a need for improving current state-of-the-art CubeSat communication systems in order to maintain high signal power regardless of the increase in transmission distance. Thus, for deep space missions, CubeSat communications systems must rely on either higher frequency communication bands such as: X-band and Ka-band transmitters with arrayed and deployable high-gain antennas, or software-defined radio and lasercom systems, which represent the new frontier of CubeSat communication systems. CQC will push competitor teams' CubeSat communication systems even further in its Lunar and Deep Space Derby stages by offering cash prizes to competitors who's CubeSats communicate at the fastest rate and transmit the largest amount of data over a period of time while in lunar orbit or from greater than 4 million kilometers, which is 10 times further than the moon.

In regards to power management, photovoltaic single junction cells are the main method that CubeSats rely on for power generation. Unfortunately, they are associated with a relatively low efficiency, usually less than 20%. As a result, it is necessary to replace these cells with either 46% four-junction cells, lightweight flexible solar cells at 20% efficiency, cells that make use of cheap organic electronics, and possibly, thermo-nuclear or fuel cells, which will increase the efficiency and/or reduce the cost and weight of solar cells.

Another critical area is propulsion. As future CubeSat missions will be targeted toward deep space, there is a need for in-space safe and simple compatible propulsion systems that will live up to the complexity of these missions without impacting overall cost negatively and endangering the primary mission. Such propulsion systems will allow these nanosatellites to change altitude, conduct proximity operations, disperse and form arrays, including cold gas, monopropellant, liquefied gas, solid rocket, Hall Effect and electrospray thrusters.

If small sats are able to overcome these obstacles, CubeSats will be able to accomplish feats such as these in space in 10 years from now that conventional satellites will have difficulty accomplishing:

- They will be able to go to the Moon and serve as precursor missions doing site surveys for future manned or robotic missions going to Mars for the same purpose.
- Another application is approaching an asteroid or near earth object and take multiple images from different sides at. In addition, by measuring the differences between the satellites, determining the distribution of mass in an asteroid.
- CubeSats can be distributed around the surface of Mars to operate like small weather stations distributed over a range of elevation over the surface of the planet.
- With the help of remote operated cameras, propulsion and communications, CubeSats can work outside of a manned vehicle. For example, they can examine the exterior of a manned spacecraft on an Orion mission to Mars or to the Moon by sending out a few of these nanosatellites to take exterior photos of the spacecraft in order to do integrity assessment of the capsule.
- By sending a number of CubeSats in orbit on the Moon or Mars, they can serve as data relays so that if you have a rover on one place of the Martian surface and a mother ship that's orbiting it, an array of CubeSats in orbit can work as a data communication relay.

C. Aligning CC and CQC with Strategic Plan

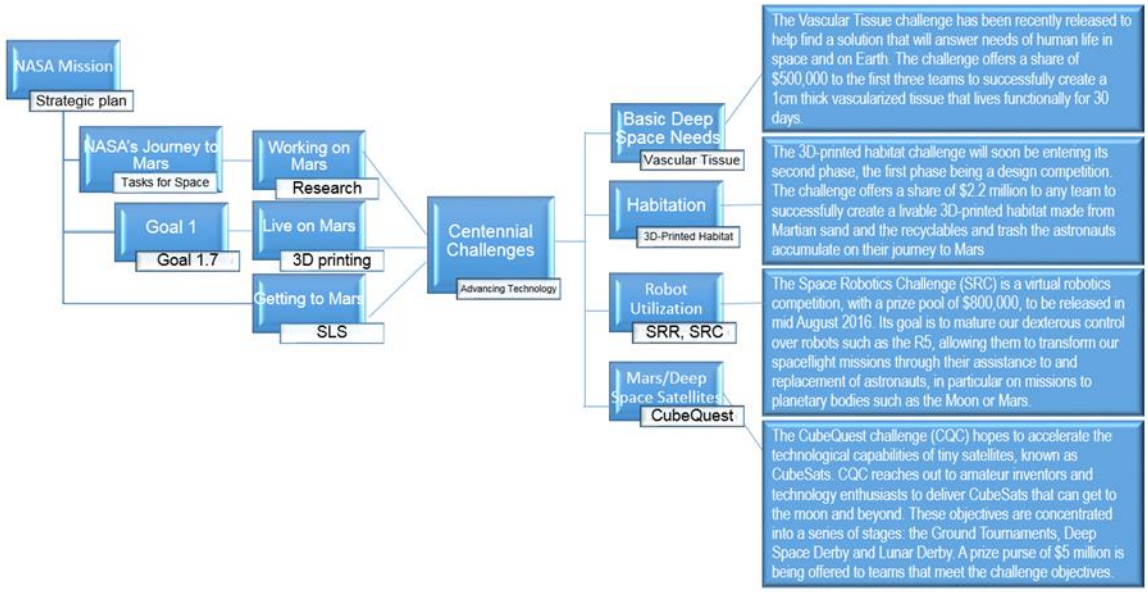
NASA's Centennial Challenges Program aligns with Goal 1, Objective 1.7, of NASA's Strategic Plan, to expand the frontiers of knowledge, capability and opportunity in space, and transforming NASA missions and advancing the nation's capabilities by maturing crosscutting and innovative space technologies.

The way this program carries out this objective is by developing challenges that target technology needs in different areas as described by NASA's technology roadmaps, and allocating prize pursues to each of these challenges as an attractive incentive for people from diverse sources to participate and come up with innovative strategies that may solve these technological barriers with the take-home of becoming glorious winners of a NASA competition. In addition, by providing prize purses, winners can have the funds to push their projects further, developing them into technologies NASA and the private sector can use.

Additionally, CubeQuest adheres to this objective by offering prizes for CubeSat technologies that satisfactorily complete a series of objectives. These objectives are concentrated into a series of stages such as the Ground Tournaments, Deep Space Derby and Lunar Derby. The purpose of these objectives is to stress on and serve as an

incentive to possibly solve current technological deficiencies that CubeSats face. These current challenges revolve around areas such as communication, propulsion, power management, navigation, thermal management, command and control. The hopeful end goal of implementing these objectives is to prevent these deficiencies from continuing to hinder CubeSats from opening the doors toward deep space exploration that will be faster, cheaper, and better than conventional satellites.

Below is the strategic plan roadmap to visualize the alignment of Centennial Challenges to the NASA mission.



D. Website Improvements + New Documents

- Create a slideshow of the content of CQC's web page: This approach makes the information in the webpage more accessible and easier to see for interested viewers. The slideshow will give a brief description of what each tab consists of, but more detail can be found by clicking on that specific tab of interest.
- Create uniform structure for the challenge's website:
  - Overview – Detailed and synthesized description of the technology that will be developed or created upon successful completion of the corresponding challenge, the phases/levels/stages that make up the challenge, the prize awards involved, and the ultimate opportunity to compete for a secondary payload spot on the first mission of NASA's Orion spacecraft, which will launch atop the agency's Space Launch System (SLS) rocket.
  - Welcome Packet / "Challenge for Newbies" Packet – This packet will be of most benefit for future competitors as the packet talks about the program, what the operations and awards of the challenge consist

of, how to register for the challenge, and as a final note, contact information for any questions or concerns related to the challenge or the program as a whole.

- Schedule – A tab that not only contains the schedule of the challenge, but also updates every time each phase/level/stage gets completed by erasing that phase/level/stage and providing future dates.
- "After the Challenge" Packet – An informative packet which will provide any success stories that past winners of the challenge may have regarding any businesses the competitors might have opened, application of their technology in new ongoing research, or any scholarships offered for graduate studies. In addition, the packet will provide past winner's overall experience in the challenge and any feedback/recommendations.

- Create the script for a 30 second video trailer: This product, made in collaboration with NASA 360, will give a synthesized explanation of how CQC and future CubeSat missions aligns with the strategic plan and NASA mission.
- Construct a strategic plan roadmap: This will provide a visual representation of the alignment of Centennial Challenges to the NASA mission.

E. Exhibits

- Develop plans to create new exhibits: Exhibits, including a 3D-printed CubeSat, the SLS Adapter Stage for Secondary Payloads and informative, collectable cards of past CQC winners.

IV. Conclusion

In order to make a project flourish, the researcher(s) must be able to effectively communicate to any intended audience the benefits involved with the project and how the public can benefit directly from it. Thus, completing tasks such as the ones described in this document lend themselves toward public engagement and funds, which are two of the fundamental elements that help projects/researches proceed at max throttle.

Acknowledgments

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