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NASA's eXploration Systems and Habitation (X-Hab) Academic Innovation Challenge

Jason Crusan[a], Carol Galica[b,*], Tracy Gill[c,**]

[a] Advanced Exploration Systems Division, National Aeronautics and Space Administration, 300 E Street SW, Washington, DC, 20546-0001, USA
[b] Advanced Exploration Systems Division, National Aeronautics and Space Administration / Stellar Solutions Inc., 300 E Street SW, Washington, DC, 20546-0001, USA
[c] Research and Technology Management Office, National Aeronautics and Space Administration, Kennedy Space Center, FL, 32899-0001, USA

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ABSTRACT

Future exploration missions in the space between the Earth and the Moon or beyond will require complex operational activities to ensure that crew, cargo, and exploration systems safely reach their destination. Through the eXploration Systems and Habitation (X-Hab) Academic Innovation Challenge, NASA develops strategic partnerships and collaborations with universities to increase knowledge in technologies, capabilities, and operational approaches related to future human spaceflight missions. X-Hab activities help NASA bridge strategic knowledge gaps, better understand technology risk reduction, and combine the innovative approaches and diverse insights of university teams with unique agency expertise.

The X-Hab Academic Innovation competition links with senior- and graduate-level design curricula that emphasize hands-on development of functional prototypes for deep space exploration missions. Research topics are identified and funded annually by NASA technology projects in collaboration with the National Space Grant Foundation. University teams submit proposals based on their interests and capabilities, and multiple small awards are made for the design and creation of studies or products that align with NASA strategic objectives. The selected project teams implement the design course during the fall and spring semesters using a systems engineering approach that requires formal reviews with NASA for requirements and system definition, preliminary design, and critical design. The challenges allow students to follow genuine hardware and systems engineering development processes and gain valuable experience that will extend to their professional careers.

Since 2011, NASA has selected 49 X-Hab student concepts to address space habitation systems including advanced fabrication concepts, plant growth, atmosphere management, waste handling, and recycling. This paper provides a status and overview of submissions received, selected projects, success stories, and lessons learned. It also details methods employed by NASA to manage and promote the X-Hab competition, summative information on participating organizations, and next steps for the activity. The X-Hab project assists NASA in optimizing technology investments, fosters innovation and facilitates technology infusions that address specific, real-world challenges being faced by NASA as the agency works to send humans further into space than ever before.

1. Introduction

With the forward progress of NASA's new Space Launch System and emphasis on future deep space missions, the breadth of technology required to complete such long duration flights is inadequate. The challenges that exist – from producing food on the journey to effectively recycling breathable air to utilizing every last resource available – create opportunities for groundbreaking innovation (see Tables 1 and 2, Figs. 1–8).

In 2011, NASA introduced the X-Hab Challenge as a head-to-head university-level competition to design, demonstrate and attach an expandable habitat "Loft" concept onto an existing NASA built operational hard-shell prototype. The objectives of this challenge were to engage and inspire the next generation of innovative engineers and the successful design, manufacturing, and demonstration of an expandable habitat. The projects were selected through a competitive process in collaboration with the National Space Grant Foundation. The three selected university teams were Oklahoma State University, the University of Wisconsin-Madison and the University of Maryland. The teams were given a year to design and build their prototype for final

* Corresponding author.
** Corresponding author.
E-mail addresses: Jason.Crusan@nasa.gov (J. Crusan), Carol.A.Galica@nasa.gov (C. Galica), Tracy.R.Gill@nasa.gov (T. Gill).

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Table 1
Proposal phase timeline.

February	Release of Request For Proposals (RFP)
April	Questions for Technical Interchange due
April	Responses to submitted questions published
April	Proposal due
May	Award announcements

Table 2
Award phase timeline.

Summer	Design Phase
September	Kickoff meetings
October	System Definition Review (SDR)
November	Preliminary Design Review (PDR)
January	Critical Design Review (CDR)
March	Progress Checkpoint Review
May	Project Completion and NASA Evaluation

testing of their designs at NASA's Johnson Space Flight Center. Oklahoma State University was the winning team and their "loft" design was used to provide astronauts with a means of habitation during the 2011 NASA Desert Research and Technology Studies (RATS) analog field testing mission in the arid climate, harsh winds and rocky desert terrain of Arizona. This initial challenge showed great potential and opportunity for NASA and universities to mutually benefit from this type of collaboration. The success has resulted in the expansion of scope from habitation to other areas of exploration systems.

Since then, NASA in collaboration with the National Space Grant Foundation has released an annual call for proposals, selecting 49 projects from 19 unique organizations in 15 states as of the date of this paper.

2. Approach

NASA invests in the future by advancing the capabilities and technologies that drive human pursuit of innovation, challenging destinations, and profound questions. X-Hab develops strategic collaborations with universities to help bridge strategic knowledge gaps and increase knowledge in capabilities and technology risk reduction related to NASA's vision and missions. Besides its overarching focus on public-private partnerships and finding new ways to conduct business, NASA's Strategic Plan outlines the following goals and objectives that are appropriate areas for contribution by X-Hab projects:

Strategic Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.

- *Objective 1.7*: Transform NASA missions and advance the Nation's capabilities by maturing crosscutting innovative space technologies.

Strategic Goal 2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.

- *Objective 2.3*: Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.
- *Objective 2.4*: Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets [1].

NASA's Advanced Exploration Systems (AES) division, the sponsor of the X-Hab Challenge, pioneers new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond low-Earth orbit. AES activities are uniquely related to crew safety and mission operations in deep space, and are strongly coupled to future vehicle development. AES has five objectives for the X-Hab Challenge:

Fig. 1. Deep Space Habitat Demonstration Unit with the 2011 Oklahoma State University X-Hab loft on top.