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A Space-STEM Education Model for Developing a Global Space Settlement Workforce

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Abstract

Inspiring the next generation of space explorers is an essential aspect of space settlement development. A Lunar Caves Analog Test Sites (LCATS) space-STEM education model is applied to inspire students to engage in space settlement by attaching project-based space-STEM learning experiences to actual technology, engineering and science investigation challenges associated with various site development growth phases of a specific space settlement initiative. The model framework aligns the student learning experience with mission priorities for planetary surface systems engineering and mission operations, science experiments and science instrumentation, and allows students to freely advance ideas for technology concept investigations. A proposed global collaboration component of the model between participating international space communities using international student exchange programs can be implemented through national space agency policy directives in support of the education element of the space settlement initiative. The formation of a global network of space-STEM education communities concurrently engaged in a unifying mission objective of advancing space settlement research and technologies enables a pathway for a global space settlement workforce. In turn, public benefits are seen in the advancement of Science, Technology, Engineering, and Mathematics (STEM) education leading to job creation, industry expansion to include secondary space sector support industries, and the evolution of the space based market. This can facilitate potential government incentives for private funding of space settlements, and spill overs in global economic health through international collaboration. Through project-based space-STEM learning experiences a robust, multi-generational, international space settlement workforce for the future can emerge.

Overview

The "Lunar Caves Analog Test Sites (LCATS) for Space-STEM Learning Performance" program is being developed by the non-profit WEX Foundation of San Antonio, Texas [1]. LCATS provides real-world context for students to assist aerospace professionals with solving actual space exploration technology development challenges using project-based curricula. The benefit of project-based educational programs is quite established [2] [3]. Project-based learning, a teaching methodology that utilizes student-centered projects to facilitate student learning, is touted as superior to traditional teaching methods in improving problem solving and thinking skills, and engaging students in their learning [4] [5]

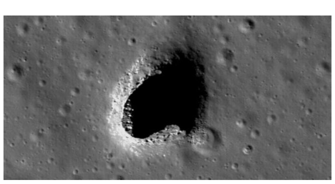

Figure 1. NASA image M128202846LE

Student projects and curricula of the LCATS program are attached to actual technology, engineering and science investigation challenges associated with the growth phases of human settlement at a specific lunar location. The Marius Hills Skylight located in the Marius Hills region of Oceanus Procellarum at 14.2°N, 303.3°E is believed to be the opening to a lunar lava tube cave useful for eventual human habitation[6]. The site is being investigated by the Lunar Ecosystem and Architectural Prototype (LEAP2) international consortium of aerospace industry organizations developing technologies for lunar settlement at the site [7]. The LEAP2 commercial lunar site development program provides a framework for LCATS project-based curricula development to be aligned with the goals of the commercial venture for actual development of the lunar site [8].

The differentiator with the LCATS/LEAP2 education initiative is the specificity of its technology research and development projects. For project-based learning, all consortium sponsored curricula initiatives are focused on their application to advancing the body of knowledge for site development of planetary pits and lava tubes, in particular, development of the Marius Hills Skylight as a commercial prototype for understanding how to use these planetary features to the benefit of human settlement on distant planets.

Figure 2. LCATS is a NASA funded, science-based academic enrichment program

The various LEAP2 site development growth phases aligns the student learning experience with mission priorities for planetary surface systems engineering and mission operations, science experiments and science instrumentation, and allows students to freely advance ideas for technology concept investigations. Local Texas caves in the area and region are utilized as analog environments for fielding student experiments and technology challenges through simulated missions.

Using the LEAP2 framework, our nascent LCATS education program has successfully completed its second year project phase with an initial student cohort investigating a critical LEAP2 technology for lunar dust characterization. The sequence of COTS (commercial-off-the-shelf) to prototype development and proposed lunar surface flight test of this technology using a mentor chain of professional scientists/engineers with graduate/undergraduate students guiding a student cohort of middle and entry level high schoolers demonstrates our contention that technology projects of the STEM program can be in the critical path for technology demonstrations of the commercial LEAP2 venture. Figure 3 outlines the Technology Readiness Level (TRL) path the instrument is undergoing in preparation for a proposed commercial lunar flight technology demonstration mission in 2021 [9].

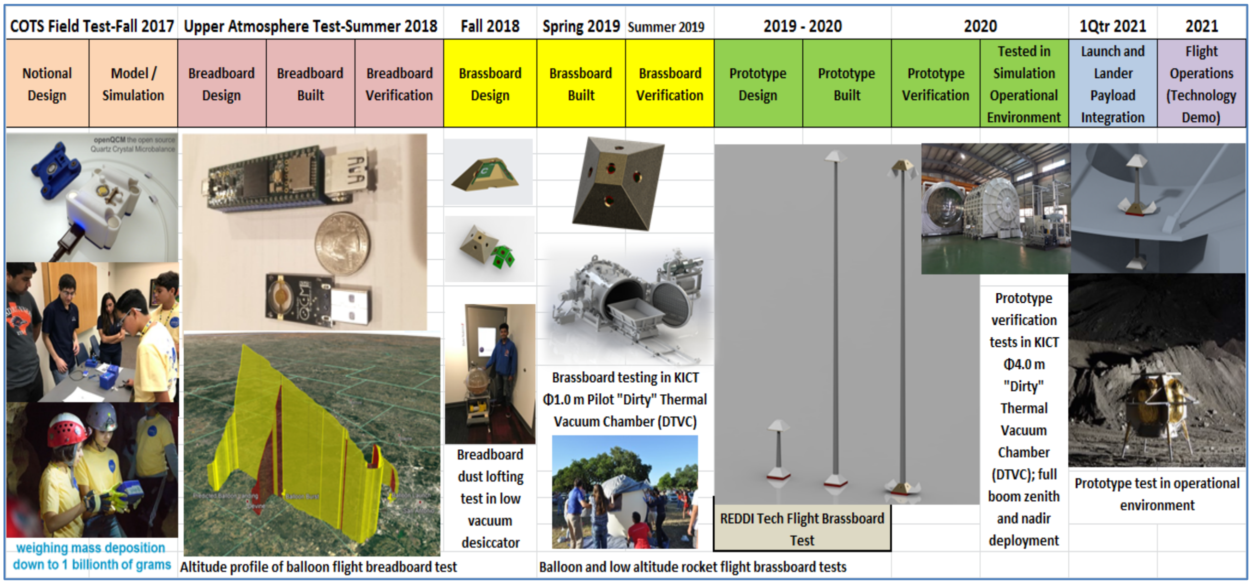

Figure 3. TRL progression timeline for the LCATS lunar dust measurement instrument

Global Model

The LCATS program works with host schools in lower-income and high-needs communities to recruit math and science students to change their education and career trajectories. A particular focus is placed on improving Space-STEM teaching and student comprehension for students who have been traditionally underserved and underrepresented in institutions of higher education. LCATS goals include preparing and encouraging underrepresented minorities, female and economically disadvantaged students to pursue higher education and careers in human space exploration.

On an economic level, the purpose of our LCATS ***evidence-based*** project is to demonstrate how any community can have its own space program and use that program to drive a pipeline for nurturing an entrepreneurial and STEM workforce for the community. Our overarching aim is to show how a community space program can act as a catalyst when used as an informal educational framework for STEM workforce development and economic growth.

This process begins by partnering with the community education system to develop curricula at multiple levels and internship programs that focus on the courses needed to gain the STEM knowledge applicable to a very specific community vision, which gets students excited about learning and being part of something that is a grand adventure. Actually being a participant in the community's efforts to explore space can entice a new generation of students into the STEM fields. With a local space program, e.g., a community goal to go to the moon (or even go into low earth orbit by developing its own satellite, or its own space station module) the community can enable and inspire students who in turn become scientists and engineers, as well as the entrepreneurs who start companies, facilitating local job growth. In the case of LEAP2, we are essentially using a commercial lunar base development program to demonstrate how such a program could impact economic development for the regional community. This community engagement can extend to an international level of networked communities all focused on a global formal declaration of communities committed to the LEAP2 program [10]. Each community contributes their own specialized expertise relevant to the expertise needed for the various LEAP2 system architecture component development, i.e., cluster expertise in mining and energy generation; food and waste processing; water production for fuels; vehicles and equipment systems, and logistics, to name a few.

This global space workforce education model of networked communities focused on space settlement technology development is applicable to any space settlement genre, given that there is specificity of the type and location of the habitation settlement, e.g., a permanent orbiting space colony at xyz orbital location (Figure 4). Such a focus induces an amalgamation of the critical technologies necessary for realization of the project through the global community network. Critical and long lead-time technologies for an orbital settlement would differ from a Moon or Mars settlement that relate specifically to large-scale habitats, including life support, farming, power, architecture and construction methods, and effect of gravity, i.e., artificial gravity for rotating in-space habitats vs. 1/6 or 1/3 gravity for planetary settlements.

Figure 4. Re-vision of a Gerard K. O'Neill space colony. Credit: Rachel Silverman for Blue Origin

Cross-disciplinary international collaboration in space exploration is very well recognized as a mechanism for risk mitigation by distributing resource and hardware contributions across the mission architecture. Inspiring the next generation of space explorers with the value of international collaboration is an important aspect of the educational outreach component of the space-STEM program. Establishment of an inclusive local community sponsored space program for STEM education, community workforce development, and entrepreneurship should include collaboration between communities with international student exchange programs. Formalizing international student exchange within the space settlement program can change students' lives by opening their eyes to different methods of achieving their goals, and that the friendships students make abroad promote the cause of international cooperation and world peace. By example, our proposed LCATS international student exchange program is shown in Figure 5.

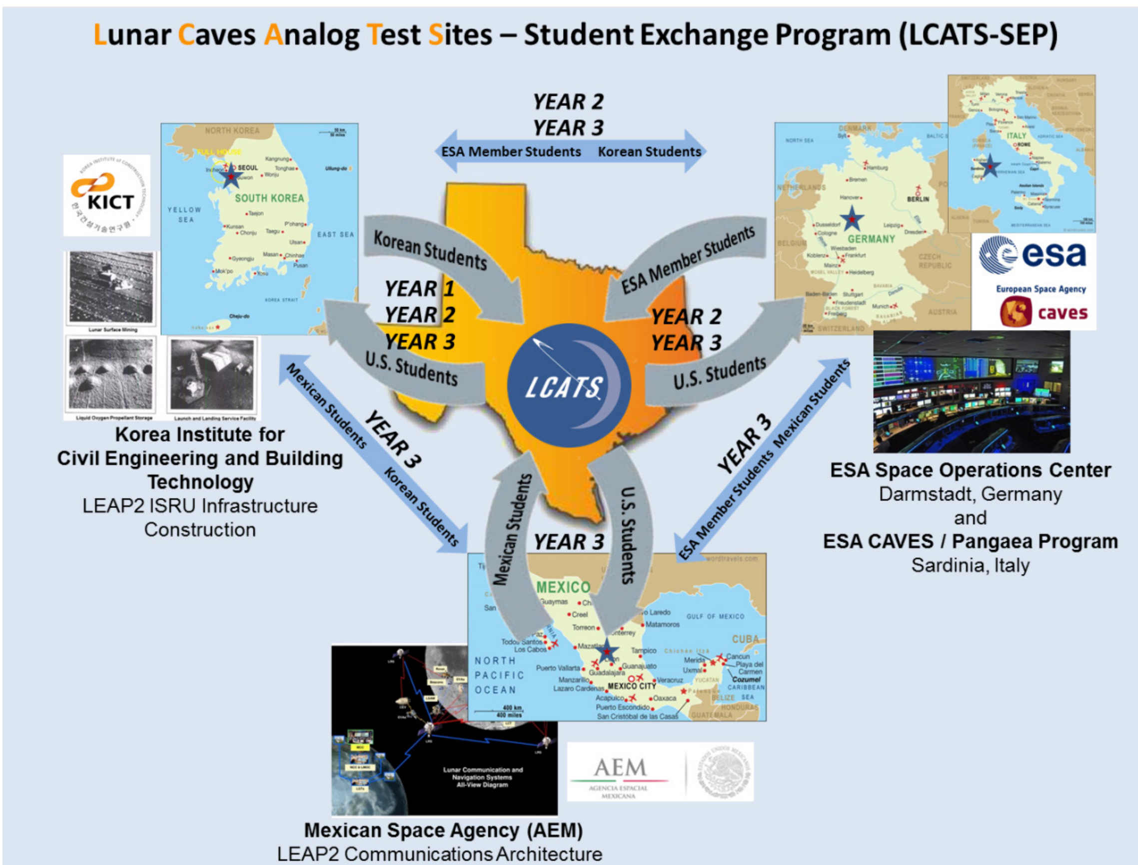

Figure 5. Phased Growth Model of the LCATS-Student Exchange Pilot Program

Conclusion

Any formal declaration of national or international commitment to space settlement will eventually necessitate creating government offices, positions and advisory boards. A coordinated, multiagency effort to support space settlement development with legislative action should include an education and workforce development component created by these implementation bodies.

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