**SPACEWARD BOUND: FIELD TRAINING FOR THE NEXT GENERATION OF SPACE EXPLORERS.**

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**Introduction:** Spaceward Bound (SB) is an educational program developed at NASA Ames. The mission of SB is to train the next generation of space explorers by having students and teachers participate in the exploration of scientifically interesting but remote and extreme environments on Earth as analogs for human exploration of the Moon and Mars. Through our field expeditions and Mars simulations, we inspire, engage and educate members of the STEM education pipeline, and prepare individuals for employment in disciplines needed to achieve NASA's mission and strategic goals.

Though SB is described as an educational program, of tantamount importance to the P.I. and program leaders is that the program is beneficial to both science and education. All program elements are built around established science research activities and contribute to the fulfillment of specific research goals.

**Why Education:** Geology and Astrobiology field science will be an important component of early missions to return to the Moon and explore Mars. The astronauts that will crew these missions are currently in middle school. The senior managers and scientists that will plan and organize them are now in college. In order to succeed with these missions, we must inspire and train these students in field exploration. SB training consists of both STEM education, as well as education that leads to the understanding of exploration concepts and skills. Teachers, specifically, must be trained not only in exploration science content and skills, but also pedagogy and pedagogical content knowledge. Hence, SB is working toward a science-driven pedagogy of exploration for K-14 that utilizes participatory learning to bring teachers and students closer to science and scientists. In addition, the SB program targets traditionally underserved and under-represented communities by recruiting teacher participants from partner educational organizations that that serve these same populations. (see: http://quest.nasa.gov/projects/spacewardbound).

**Program Description:** During SB field expeditions, K-12 teachers become field assistants on established science expeditions to environments analogous to the Moon and Mars. While learning STEM content, concepts and skills they become immersed in the conduct of scientific research and experience first-hand the intrigue, excitement, collegiality, and challenges of terrestrial analog field research. A growing body of evidence indicates that these experiences are unique and exceptional in their ability to inspire and motivate participants into dual roles of scientist and teacher.

SB Mars simulations feature two-week student training and research missions to the Mars Desert Research Station (MDRS) in Utah. Crew members are expected to plan all aspects of the expedition, including learning how to get along "off the grid." They are involved in all aspects of mission planning from logistics, to research, to Advanced Extravehicular Activities training. Students perform actual research on local geology, crewmember physiology, and microbiology as well as field-testing on new EVA hardware, rigging data loggers, and performing work-study task and procedure analysis. A significant portion of the work is done prior to the expedition, working out the logistics of what equipment will be necessary during a two-week stay in a Mars analogue environment. Crews typically work 12-15 hour days and are expected to conduct themselves as leaders.

**Teacher Field Expeditions:** A fundamental component of the SB program is the establishment of partnerships with science and education organizations both in the U.S. and internationally. The first SB field expedition was held in June 2006 in partnership with the University of Antofagasta, Chile. Seven middle school teachers from around the U.S. teamed with seven teachers from Antofagasta to work alongside scientists in exploration of the Mars-like soils in the Atacama.

Subsequent expeditions have been held in the Mojave Desert (2007, 2008, 2009) in partnership with California State University and the Desert Research Institute; Arctic 80°N (2008) with CSA; Australia (2008, 2009) with the Mars Society Australia; Pavilion Lake (2008, 2009) with CSA; North Dakota (2008, 2009) with ND Space Grant. An expedition to the Gobabeb Desert in Namibia is planned for Spring 2010. We are in the development stage of an expedition to Hawaii and Idaho as well as returns to Australia and the Atacama.

All expeditions are comprised of three components: 1) Education, 2) Science, 3) Technology. The overarching theme that unites the three components is exploration. Scientific activities are approached from the perspective of how similar activities would be performed on the Moon or Mars, how research here on Earth could assist the analysis of research results from the Moon/Mars, and what infrastructure and technol-

ogy is needed to support the research which will, in turn, need to be provided on the Moon/Mars surface.

**Figure 1.** View of the University of Antofagasta Desert Field Station at Yungay Chile in the hyperarid core of the Atacama Desert.

Education activities are guided by the motivation to train teachers to inspire students to be the next generation of explorers. While exploration is often presented in classrooms as a motivational supplement to existing curriculum and components of exploration are taught, no pedagogy of exploration itself exists.

A true pedagogy of exploration will provide unparalleled experience in affective and cognitive motivations such as curiosity, discovery, bravery, disappointment, tenacity, flexibility, etc. It also requires a synthesis of currently segregated academic disciplines, i.e. “hard” science, “soft” science, and non-science. Modern curriculum and pedagogy are ill-equipped to embrace this synthesis - much less able to develop the content, concepts, and skills to teach it.

In the broad sense, the contribution of these expeditions to the education community (including educational research) and to the science community is the development of a program that enables the amalgamation of the expertise and experience of master teachers with the knowledge, practice, and experience of today's explorers to begin the conceptualization and development of this pedagogy.

Analysis of the teacher's final reports (see web site) reveals how this new pedagogy may look It also provides clear evidence of the intrinsic power of authentic exploration to motivate, engage, frustrate, and thrill.

**Mission Simulations at MDRS:** The focus of SB Mars simulations is to enable students at the upper undergraduate and graduate level to participate as crew members in two-week long immersive full-scale simulations of living and working on the Moon and Mars at MDRS, established and operated by The Mars Society. SB crew rotations began in November 2006 and have continued since then.

**Figure 2.** The Mars Society Desert Research Station in the desert near Hanksville, Utah.

Students in each crew came from a variety of schools and backgrounds. At the start of each simulation, a meeting is held to discuss the structure, approach and goals of the expedition. The students, in fact, define and enact their own training program through their simulations. Interactions with these students in the field has been shown to be just as inspiring and educational for the science PI, as well as the students.

SB student crews have developed three products which are utilized and enhanced by successive crews:

1. The Habitat User Guide and Operations Manual.
2. Spaceward Bound Training Curriculum which covers a range of skills that are essential for field astronauts working on Mars or in Mars-analog field environments on Earth. These include working in bulky suits, mechanical skills, equipment repair, biology and geology skills, greenhouse operations, electronics, navigation, field documentation, ATV operation, etc. This curriculum is utilized as the basis for the course that trains every SB student in these basic skills.
3. "The Lovely Planet" Guide to Science and Field sites at MDRS. This is a series of mini-reviews and locations of sites of specific interest as well as a description of the relevant topic of research at MDRS. The Guide is written at the Scientific American-level with images, detailed maps, etc.

**Spaceward Bound 2.0:** A new program component brings new interactive tools and web 2.0 approaches to the SB expeditions to reach more teachers and students, and enable more science. This effort will provide detailed visual data sets of expedition sites, data archiving for science use, remote virtual participation in field trips, high data rate interaction from the field, connection to virtual worlds (e.g. Second Life), teleoperation of field robots, teleoperation of field loggers and experiments, and development and testing of field instruments.