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Dr. Jaydeep Mukherjee, FSGC Director
Mail Code : FSGC, Building M6-306, Room 7010,
Kennedy Space Center, Florida 32899

August 17, 2009

Subject: Final Report

Dear Dr. Mukherjee,

Please accept this document as the official final report for the grant titled “Education & Outreach with Florida Students Through Direct Interaction with the Crew of a Simulated Mars Mission,” which is receiving funding from the Florida Space Grant Consortium.

In July of 2009, the 4Frontiers Corporation, in coordination with the Mars Society, conducted a month-long Mars simulation. Joseph Palaia and Vernon Kramer of 4Frontiers were selected as members of a crew of six who resided in the Flashline Mars Arctic Research Station (FMARS), a simulated Mars base located on Devon Island in the Canadian arctic. There, they conducted a sustained program of field exploration while operating under Mars mission constraints. The simulation provided the opportunity to conduct a range of research projects focused on understanding the technical and human factors which may be faced by the first human Mars explorers. The grant provided by the Florida Space Grant Consortium helped to offset some of the operating costs of conducting this expedition, and resulted in Florida students interacting with the crew during the expedition, providing these students with direct exposure to this exciting research.



Caption: FMARS crew member pose with FSGC flag in front of the habitat.



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The expedition summary below provides an overview of mission accomplishments, with the sections of this report following the summary covering specifics related to the scope of work performed per the original Florida Space Grant Consortium grant request.

Expedition Summary

The 2009 FMARS crew returned on July 31st from the stark arctic wilderness of Devon Island, having completed their one month rotation at the Flashline Mars Arctic Research Station (FMARS). Having overcome hardships imposed by the harsh arctic weather, extreme isolation, limited supplies and equipment and the self-imposed restrictions of the formal Mars simulation, the crew achieved all major mission objectives.

Over the course of the formal Mars simulation, the crew completed sixteen extra vehicular activities (EVAs) in 43.5 hrs, traveling a distance of 128 km. This translates into a cumulative in simulation (in-sim) crew time of 106 man-hours and a distance of 323 km. The crew's efforts included a number of firsts for simulated Mars explorers in a Mars analog environment, including the testing of new technologies and equipment for use in aerial surveying, in situ resource utilization (ISRU), geophysical measurement, medical laser treatment, image geotagging, path planning and analysis, and public communications.

Using hardware provided through a sponsorship by Prioria Robotics, the crew flew the Maveric unmanned aerial vehicle (UAV) six times over Devon Island. Four of these flights were conducted in-sim for the first time ever, supporting the idea that human Mars explorers could launch, operate and recover a UAV while encumbered by a spacesuit. This capability expanded the crew's field of view and the rate at which they could survey surrounding terrain. The Maveric UAV was deployed at the sites of several hydrothermal pipes, where aerial footage of these features with correlated GPS track information was captured for analysis, aiding later site sampling by crew geologists.

Several GPS units including a Trimble GeoXM, provided by Del Mar College and Edward B. Stott, helped the crew navigate on a long-distance EVA to Gemini Hills, an extensive deposit of hydrothermal breccia created by the Haughton meteor impact. The primary objective was to locate and sample a gypsum deposit at this site. Gypsum is a hydrated calcium sulfate mineral which is 20% water and is found in abundance on Earth and at many locations on Mars. Used to make plaster of Paris, sheetrock, cement, and other building materials, this white mineral will be an important resource for Mars industry. The crew returned to the Hab with samples from the gypsum deposit, crushed and heated them, and recovered nearly all of the possible liquid water and plaster of Paris. This ISRU demonstration was a first for a Mars simulation!



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Seven of the sixteen FMARS EVAs were devoted to two geophysical experiments. One project was to install Devon Island's first seismometer, a Trillium Compact provided by Nanometrics. The crew scouted deployment locations and installed the equipment while fully in-sim, a first for Mars analog research. Seismic stations similar to this will provide important understanding of the interior of planets including Mars, particularly the deep crust, mantle, and core. The second geophysical project tested how effectively human explorers in space suits could deploy low frequency electromagnetic survey equipment, a TEM47-PROTEM provided by Geonics Limited, to search for groundwater beneath Haynes Ridge near the Hab location. Future human Mars explorers may conduct similar surveys in their search for life and resources to support human settlement.

The crew conducted and were subjects in a research study using a Class IV High Power Laser therapy device provided by Lighthouse Technical Innovation, Inc. Crew members received treatment on focused areas before and after each EVA. The laser therapy is effective due to the penetration of coherent laser light into the tissues causing deep heating and local vasodilation. The additional blood supply provided by the dilated vessels can serve many functions, most notably preparation of the muscles for physical exertion and accelerated healing of muscle soreness, strain, or pain from past injuries. The laser therapy at the FMARS Hab was effective in relieving symptoms caused by physical exertion and was concurrent with the quick healing of minor injuries, recovery from an illness, and the complete lack of muscle pulls or extended soreness. The crew could be seen waiting in line for the warm laser treatment, as the treatment itself also provided relaxation.

The Omega Envoy Project, a team vying for the Google Lunar X PRIZE, provided a prototype lunar rover for testing during the FMARS 2009 mission. The rover was assembled and tested prior to the mission by 4Frontiers Corporation interns, in coordination with the Florida Space Grant Consortium and NASA's Exploration Systems Mission Directorate. Outfitted with a communications and video package designed in collaboration with the University of Central Florida DARPA team, the rover was continuously operated via the internet from the team's headquarters in Orlando, Florida. This demonstration proved key technologies and provided essential teleoperational experience related to communicating with and controlling the rover from a remote location. It provided a deeper understanding of the complexities to be encountered in lunar rover operation.

For all FMARS 2009 EVAs, the crew wore a Garmin Forerunner combined GPS and heart rate monitor system to gather concurrent geographic and physiological data. Crew members also captured geotagged photos and videos using Coolpix P6000 GPS-enabled cameras, donated by Nikon. These technologies allowed them to easily combine ground and UAV GPS tracks, heart rate data, and photo information within the geographic context of Google Earth to produce visuals for display on the FMARS website. The crew also gathered data



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useful for the evolution of MIT's Mission Planner Software, which may be used by future astronauts to generate safe and efficient EVA traverses.

Social media outlets like Twitter, Facebook, YouTube, and Picasa Web Albums also helped the FMARS crew share its activities with the interested public. Some crew members also maintained blogs that garnered substantial followings. As of this writing at least 25 stories featuring FMARS 2009 have been published, showing media interest in the expedition.

Thanks in large part to The Mars Society volunteers serving on the Mission Support team (in Colorado, Florida, Texas, Washington, and Australia), the FMARS website received a major overhaul this year, helping the crew to organize, manage, and release to the interested public the volumes of generated information. Mission Support posted crew reports, photos and video files to the website, and also assisted in troubleshooting technical problems as they arose. The crew also benefited from the expertise of an international team of physicians who provided telemedicine support.

In coordination with Southern Methodist University (SMU), Florida Space Grant Consortium (FSGC) and the Georgia Space Grant Consortium (GSGC), FMARS crew members conducted four live video webcasts with students groups. These sessions included the SMU Talented & Gifted Program, NASA Kennedy Space Center Interns, NASA Digital Learning Network via Georgia Tech, and Gardendale Magnet Elementary School in Florida. Students, educators and interns in attendance gave the FMARS crew high praise for providing this glimpse of life in a simulated Mars habitat.

Crew members spent the remainder of their time performing a variety of Hab maintenance and improvement tasks. These efforts have helped to insure that future crews will arrive to find a station in good working order, ready to rapidly begin the next Mars simulation. The 2009 crew hopes that their efforts have contributed to the body of knowledge pertaining to Mars mission simulations and analog research. A series of publications and public presentations will be produced by the crew members to ensure maximum leverage of this investment to further the goals of The Mars Society and to aid humanity's drive to place the first people on the surface of the Red Planet.

More information about the FMARS 2009 mission is also available at <http://www.fmars.org>.



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Tasks Performed Under This Grant

4Frontiers conducted two interactive video conference sessions with student groups within the state of Florida during the course of the FMARS expedition. These sessions were coordinated within Florida by FSGC staff. They made use of the satellite internet connection at FMARS, a webcam, and the internet service Skype (this setup seemed to provide adequate bandwidth to perform the sessions). The sessions consisted of approximately one hour total of live video presentation by each of the FMARS crew members, followed by an interactive question and answer session with the Florida participants. During the presentation portion of the sessions, each crew member discussed their role in the expedition, including a description of their individual research projects. Crew members then took turns answering audience questions, based upon the content of the question and the crew member's individual areas of specialty.

The first session was conducted on July 20, 2009 (the 40th anniversary of the Apollo 11 moon landing) with a group of interns at the Kennedy Space Center. The session began with a face-to-face presentation to the audience by Jason Dunn. Jason is a director of the Omega Envoy Google Lunar Xprize team, who discussed their prototype lunar rover which was being tested on Devon Island at FMARS as part of this same expedition. Following Jason and a presentation by KSC intern Alex Miller (who discussed UAVs for use at Kennedy Space Center), the crew conducted their video presentations, followed by the question and answer period. The session went well, with positive feedback from both FSGC staff and the interns in attendance.



Captions: Left: Crew member Brian Shiro installs the FMARS satellite dish for internet connectivity. Right: Crew member and 4Frontiers VP Joseph Palaia conducts the Q&A session on July 20th with KSC interns.



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It should be noted that immediately following the July 20th video session, the FMARS crew conducted their most ambitious EVA. This was a trek to the Gemini Hills, a deposit of breccias. Here they collected samples of the mineral gypsum, a hydrated mineral found on Mars which could be mined by future Martian astronauts in order to provide a source of water.



Captions: Left: Crew members on EVA enroute to the Gemini Hills. Right: A crew member takes in a stunning vista looking out across the breccia deposits at the Gemini Hills.

The second session was conducted on July 24, 2009 with a group of approximately 60 students from the Gardendale Magnet Elementary School on Merritt Island, Florida. For this session, the crew began directly with their video presentations, and this was followed by an extensive question and answer period. The crew was impressed by the depth of the questions asked by these students, who seemed to get a lot out of the presentation! Immediately following the session, crew member Joseph Palaia posed in one of the simulated space suits on the screen while several group photographs with the students were taken.

Project Impact to the Space Program

The space program depends upon congressional support in order to maintain its budgets and operations. This congressional support is in turn derived from the support of the American public. Outreach events such as those conducted through this FSGC grant provide immediate, tangible access for the public to space exploration research and activities. The questions asked by students and interns who attended these sessions show both interest and excitement. Engagement of young people in this manner, especially those within the state of Florida, may yield increased public support for space exploration and result in an increase in the number of students pursuing STEM (science, technology, engineering and mathematics) careers.



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Personal Quotes

The feedback received from individuals who took part in and attended the video sessions was overwhelmingly positive. A few select quotes are listed below:

“The crew had a very successful videoconference with more than 60 students with Gardendale Elementary Magnet School in Florida. The Skype audio and video portions went very well with only two short “drops”. The students also responded by asking a lot of pertinent questions and were really excited about space and Mars after the conference (according to reply emails). I must say that these outreach programs have a real impact to the recipients and helps boost the morale of the crew.”

-- Vernon Kramer (from the FMARS Commander’s Report on July 20, 2009)

“WOW! Saying Thank You does not seem enough to show the appreciation I feel for the time and effort you expended on behalf of the Math and Science students here at Gardendale. They really enjoyed listening to all of you and left the Lab talking excitedly about becoming space scientists! It was truly an amazing opportunity for them to see scientists at work, and you were all so patient with their questions. This is something they will remember and talk about for a long time. I truly appreciate all of the preparations that went into the transmission and am grateful to you for providing such an awesome opportunity for the students. Thank you so very much.”

-- Julie A. Gilbert, Math and Science Lab, Gardendale Elementary Magnet School

Future Work

The FMARS program will continue in 2010, and 4Frontiers intends to play an active roll in the planning and execution of that mission. This will include seeking opportunity to expand upon the successful outreach events held during the 2009 mission. We look forward continuing our collaboration with the Florida Space Grant Consortium and to providing new opportunities for Florida students.

This concludes this final report.

Sincerely,

Joseph E. Palaia, IV
Principal Investigator