Exploration System Mission Directorate and Constellation Program Support for Analogue Missions

Stephen J. Hoffman. Ph.D.
Science Applications International Corporation
Stephen A. Voels, Ph.D.
Science Applications International Corporation
Christopher E. Gerty
NASA Johnson Space Center

STAIF 2008
February14, 2008

Agenda

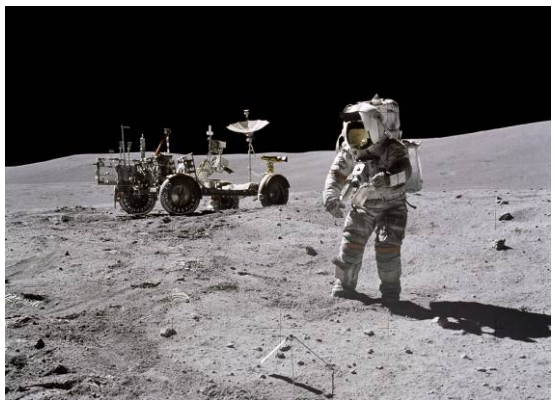
- Accomplishments in Fiscal Year 2007.
- Meetings and Conferences supported.
- Field activities supported.
- Analog web site status.
- Future work.

Accomplishments in FY2007

- Participated in five workshops and conferences dealing with analog activities.
- Supported four major field activities.
- Investigated one new (to this program) field site for possible use in testing and training.
- Web site focused on analog activities was opened for external use.

What is an “analog mission”?

- An ***analog*** is an activity performed in a representative environment that is similar to a feature of the target mission.



(NASA image; used with permission)

Feature mapping

Physical Environment
Concept of Operations
Flight systems and technologies
Science activities
Medical/Physiological/Psychological
Systems of systems interaction

(NASA image; used with permission)

- An ***analog mission*** is an analog activity that maps multiple features of the target mission in an integrated fashion to gain an understanding of system-level interactions.

Analog Missions Initiative: Proposal

Vision: To create a cross-cutting Earth-based program to minimize cost and risk while maximizing the productivity of planetary exploration missions, by supporting precursor system development and carrying out system integration, testing, training, and public engagement as an integral part of the Vision for Space Exploration.

Functions:

- Learn → **Gain a deeper understanding of system of systems interactions driving requirements definition, concept of operations, system development and the technology investment strategy.**
- Test → **Evaluate and validate requirements, concepts of operations, technologies and system interactions.**
- Train → **Train crew, ground teams, managers and technologists in modes and challenges of exploration.**
- Engage → **Excite and engage the public in the Exploration Vision through joint human/robotic analog missions and educate the next generation of explorers.**

The Best way to learn is through experience.

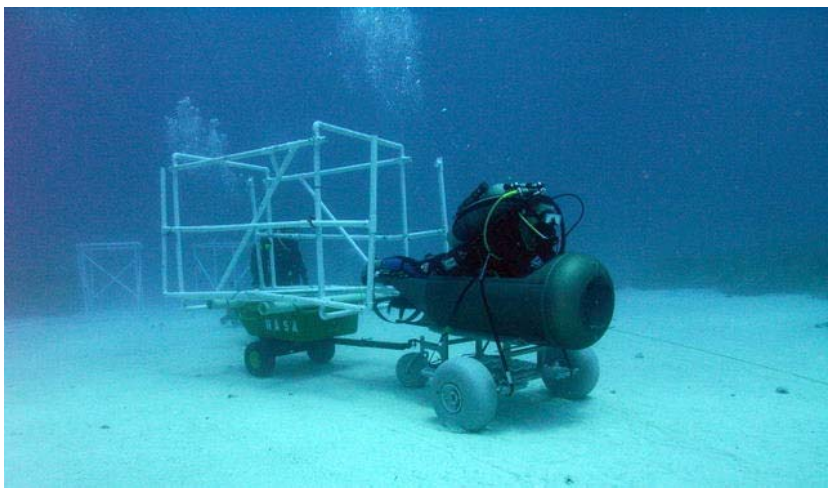
Meetings and Conferences Supported

- NASA supported five workshops or conferences with international participation to disseminate knowledge of these analog efforts to the interested community
  - Japan-U.S. Science, Technology, and Space Applications Program (JUSTSAP; Nov 2006).
  - STAIF (Feb 2007).
  - a NASA-sponsored workshop during LPSC (Mar 2007).
  - International Mars Exploration Working Group (IMEWG; May 2007).
  - 2nd International Workshop: Exploring Mars and its Earth Analogues (Jun 2007).

NASA Extreme Environment Mission Operations (NEEMO) - 13

- **Objective**:
  - To assess the acceptable center of gravity and stability limits for future space suit and portable life support system backpack designs.
  - To collect data on the "Work Efficiency Index (WEI)" for EVA.
  - To evaluate lunar geological exploration tasks relevant to the future lunar missions as identified by the NASA Lunar Architecture Team (LAT-2)

- **Location**: The Aquarius Habitat located at Longitude -80.45°, Latitude 24.95°, near Key Largo, Florida.



(NASA image; used with permission)

(NASA image; used with permission)

NEEMO 13 (cont.)

- Results:
  - For NEEMO 13, EPSP refined their investigation with 4 new PLSS CG locations (*N=8 at NEEMO/total*).
  - On the NEEMO 13 mission, EPSP evaluated a method to deploy a "Solar Power Unit (SPU)." This, and/or similar tasks, will be evaluated on NEEMO 14.
  - Performed geological tasks including soil, rake, and drive tube samples, and rock collection to evaluate lunar tool concepts. This evaluation included methods for single tool usage versus combining the tools into a single transportable package that could be deployed and utilized at a lunar worksite. This study will be continued on NEEMO 14.

- Ongoing studies from previous NEEMO Missions:
  - During the NEEMO 9-12 mission, EPSP collected data on six PLSS center of gravity (CG) locations and six suit weight configurations (*N=12 for CG at NEEMO; N=10 for Suit Weight at NEEMO; N=19 for CG total including NBL; N=17 for Suit Weight total including NBL*)
  - EPSP has collected WEI data on every NEEMO mission starting with NEEMO 8 and plans to continue to do so in future NEEMO missions.
  - Based on the data collected in these mission and other NASA based studies, NASA is in the process of refining their space suit and PLSS design to limit CG and stability affects.

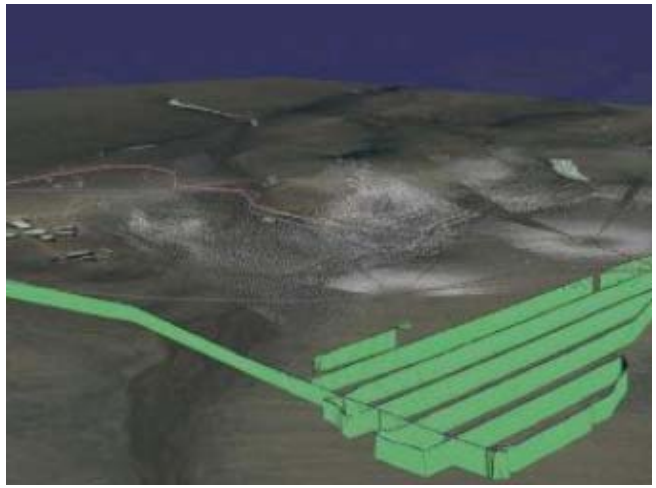
Haughton Mars Project

- **Objective**: Carry out two NASA-supported exploration activities:
  - The NASA ARC K-10 Rovers Experiment performing systematic surveys of several simulated lunar outpost sites.
  - The NASA JSC 10-K Lunar EVA Walkback Experiment to quantify the actual distance traversed versus straight line distance (10km), to compare VO_2 max for unsuited subjects in 1G with suited subjects in 1/6G, and quantify the metabolic cost (oxygen consumption) for test subjects in a “real world” setting (the analog site) compared to a treadmill setting.
- **Location**: The Haughton-Mars Project Research Station (HMP RS), located at 75° 25.95’ N, 089° 51.75’ W, on Devon Island (Nunavut).
- **Results**:
  - The K10 rovers were equipped with a JPL ground penetrating radar to map underground layers and an Optech 3D scanning laser to map topography. During the three-week test, the two K10's drove a total of 45 km, collected more than 25 GB of data, and operated for a combined total of 200 hours.

(NASA image; used with permission)

Haughton Mars Project (cont.)

- **K10 Rover Results (cont.)**
  - The robotics systems developed by this project will help NASA reduce the number and duration of EVA sorties required for site assessment during future lunar exploration missions.



(NASA image; used with permission)

(Grant Schaffner; used with permission)

- **Walkback Results**
  - The walkback experiment gathered data for three different test subjects each walking back to base camp over three different 10 km radials. This will provide dispersion data for laboratory testing. The VO_2 max experiment showed good correlation with $1/6^{th}$ gravity laboratory tests with suited subjects. The metabolic cost experiment showed good correlation but with a consistent 30-50 percent increased O_2 consumption in the “real world” compared to the treadmill setting.

Desert RATS 2007

- **Objective**: Carry out three primary and three secondary NASA-supported exploration activities
  - Demonstrate operational concepts for lunar outpost assembly to inform future Lunar Architecture Team studies:
    - Site reconnaissance survey for lunar outpost using SCOUT rover (JSC).
    - Deploy solar panel system with power cables assisted by SCOUT rover (GRC).
  - Acquire quantitative data on human-robot interaction that can be used to compare operational scenarios:
    - Measure task efficiency of robots, humans, and human-robot teams while performing representative operational tasks.
    - Measure effects of 5-10 seconds lunar time delay on selected telerobotic operations.
  - Demonstrate technologies for EVA and robotics operations:
    - Lithium-ion battery for spacesuit PLSS (GRC).
    - Coordination of robotic system activities (JSC/ARC).
  - Secondary Objectives"- EVA operations demonstrations
    - Dust mitigation techniques.
    - Rover ergonomic studies with modified commercial Global Electric Motorcars car (JSC).
    - EVA information system prototype (JSC/GRC).

(NASA image; used with permission)

Desert RATS 2007 (cont)

- **Location**: Cinder Lake, Longitude -111.52°, Latitude 35.32°, near Flagstaff, Arizona.
- **Results**: All tests successfully completed and results delivered to principal investigators. Detailed results presented at this conference in the presentation "Desert Research and Technology Studies (RATS) 2007 Field Campaign Objectives & Results" by J. Kosmo, and B. Romig (NASA Johnson Space Center).

(NASA image; used with permission)

(NASA image; used with permission)

Svalbard Reconnaissance

- **Objective**: To investigate the potential of conducting exploration analog activities within Svalbard, to include space suit testing similar to the operations run under the banner of Desert RATS each year, as well as geologic training of astronaut crews. Undertaken as part of the Artic Mars Analog Svalbard Expedition (AMASE) during the period 8-27 August 2007.

- **Location**: Svalbard, an archipelago of islands in the arctic located between ≈76°N and approximately 81°N and 10°E and 28°E.

- **Results**: The justification for suit testing should be based on whether we can test, in Svalbard, hardware and/or procedures that support the work of AMASE or NASA's Astrobiology Program and that cannot be done anywhere else.

(Dean Eppler; used with permission)

Svalbard Reconnaissance (cont.)

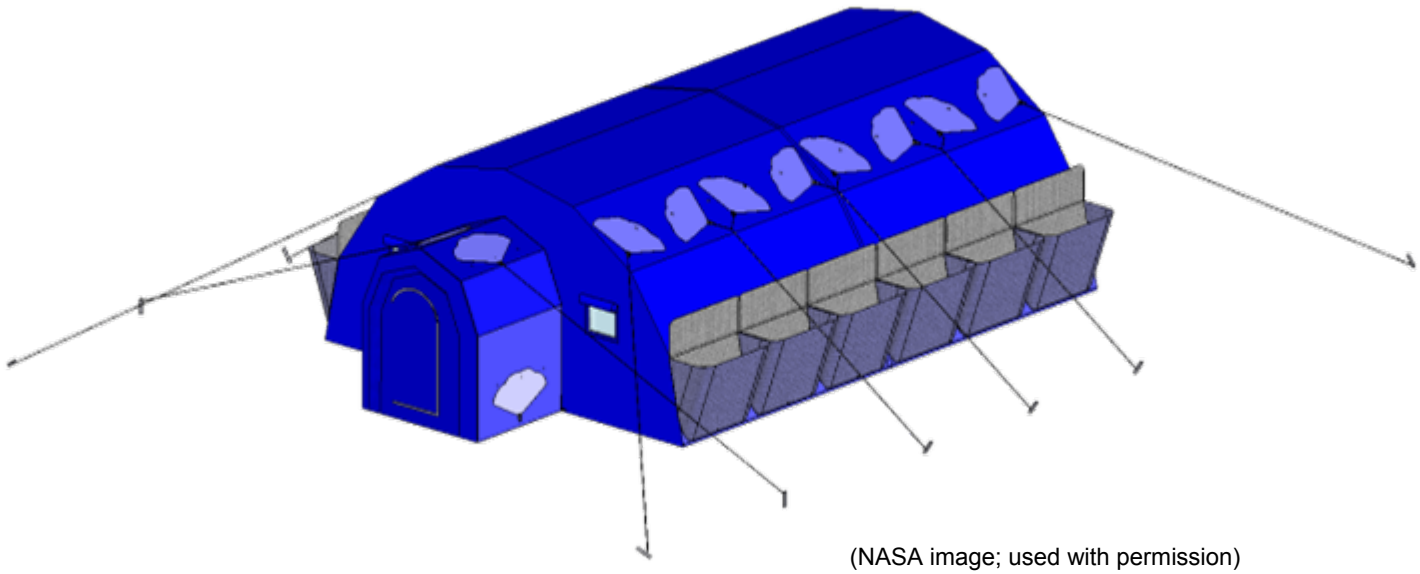
- **Results**:
  - Two areas that can be explored for potential suit activities:
    - AMASE-based hardware testing, to include the sterile bio-geochemical sampling of potential biological sources in the field and the operation of various field sensors that have been deployed on AMASE, such as the CHEMIN and SAM instruments.
    - Testing of planetary protection issues associated with human EVA, including characterization and management of biological “signal” leakage from suits.

(Dean Eppler; used with permission)

  - The geology of Svalbard is unique. Outcrop exposures are exceptional, allowing opportunities for crew training in basic geologic sciences, as well as the issues associated with exploration operations in harsh terrain. Further, many sites have a similar morphology to the Martian surface, and can provide a very real training and operations testing environment for future planetary missions.

Habitat Demonstration

- **Objective**: Design, construct, and test a proof of concept inflatable structure, focusing on its deployment characteristics and durability in a representative harsh environment – the Antarctic. The members of this joint project include NASA, the National Science Foundation, and ILC Dover.
- **Location**: McMurdo Station, Latitude: 77.88°S; Longitude: 166.73°E, Antarctica



(NASA image; used with permission)

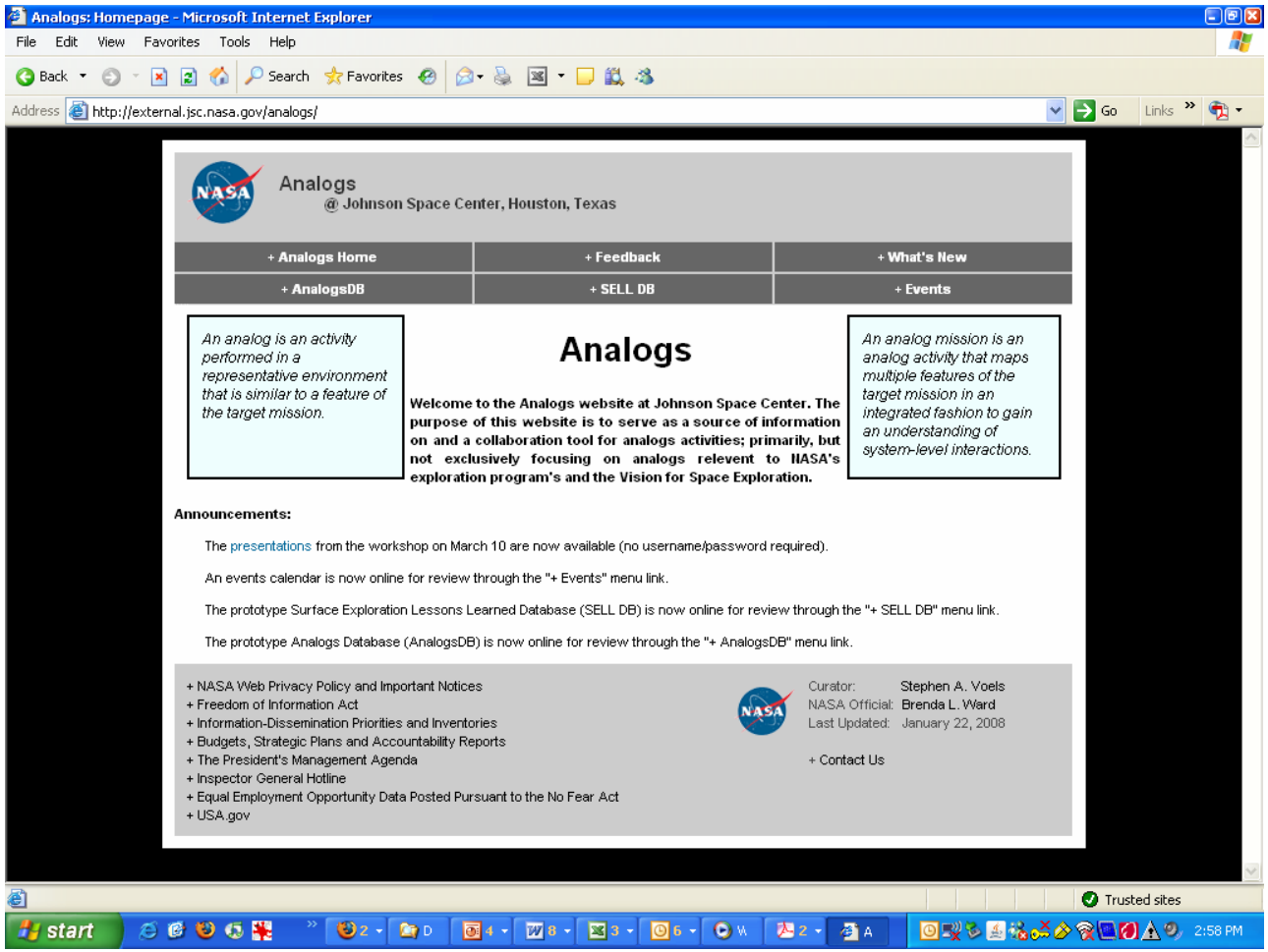
Habitat Demonstration (cont.)

- **Results**: The habitat has been designed, constructed, and successfully deployed at McMurdo Station. Testing will continue for the next 12 months.

(Dave Cadogan; used with permission)

(Sam Feola; used with permission)

Analogs Web Site



http://external.jsc.nasa.gov/analogs/

Summary of FY2007 Activities

- Participated in five workshops and conferences dealing with analog activities.
  - JUSTSAP (Nov 2006).
  - STAIF (Feb 2007).
  - a NASA-sponsored workshop during LPSC (Mar 2007).
  - IMEWG (May 2007).
  - 2nd International Workshop: Exploring Mars and its Earth Analogues (Jun 2007).
- Supported four major field activities.
  - NEEMO 13
  - 10K Walkback Experiment at HMP
  - Several EVA-related demonstrations at D-RATS
  - Inflatable Habitat demonstration
- Investigated one new (to this program) field site for possible use in testing and training: AMASE sites in Svalbard
- Web site focused on analog activities opened for external use.

Future Work

- Plans for FY 2008 are still being formulated but will include some or all of the following:
  - Support field activities, such as mobility testing for human crew transportation and ISRU demonstrations.
  - Populating data fields in the analogs web site.
- Expanded coordination between the Science Mission Directorate (SMD) and Exploration Systems Mission Directorate (ESMD) at NASA Headquarters.