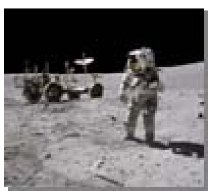
CONSTELLATION

NASA/ESMD Analogue Mission Plans





2nd INTERNATIONAL WORKSHOP
Exploring Mars and its Earth Analogues

June 2007

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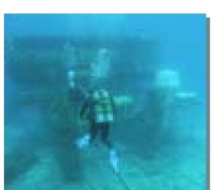
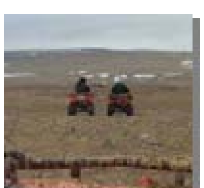
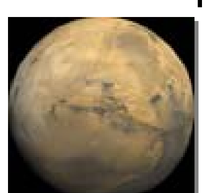



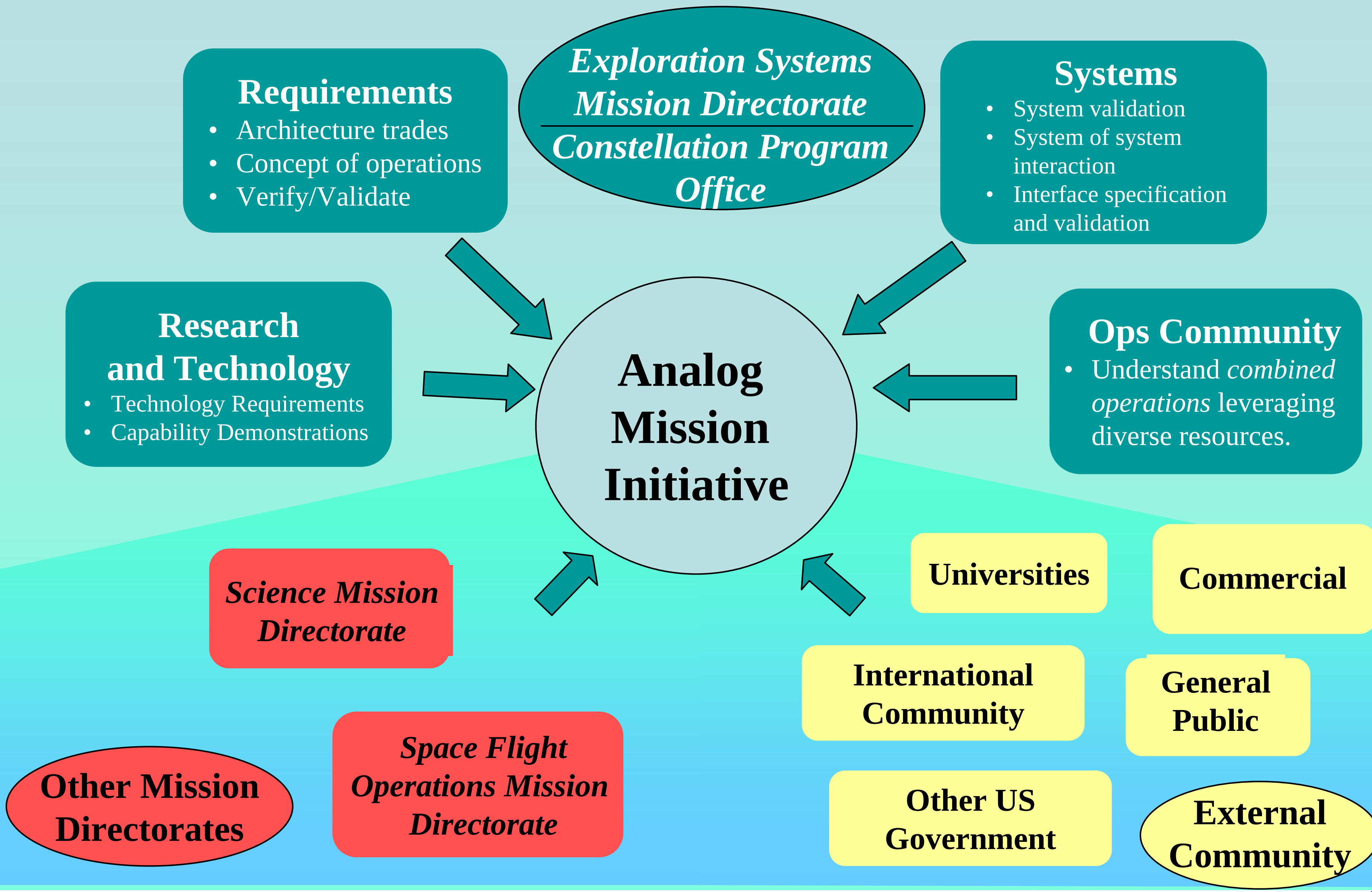


CONSTELLATION

ESMD Goals for the Use of Earth Analogues

- Learn
  - Reduce risk to crews for human surface missions to the Moon and Mars
    - Identify hazards (and develop mitigations) on Earth long before they arise in flight
  - Learn what works and what doesn't work for surface exploration missions
- Test
  - Validate surface mission designs
    - Long duration presence
    - Outpost buildup
    - Human & robotic roles
  - Demonstrate integrated use of products from multiple CxP projects
    - Validate hardware/software performance under realistic conditions, as commanded by crews and/or mission control
    - Identify performance shortfalls in systems and support iterative testing
  - Validate mission operations designs
    - Mission Operations (Mission Control) functions for these missions
  - Influence engineering and payload system designs via early use in realistic situations
  - Enable surface science by demonstrating integration of science activities and payloads into surface exploration mission activities
- Train
  - Reduce risk to crews and to mission objectives
    - Improve crew and Mission Control team readiness for surface activities
    - Increase mission efficiency and effectiveness by evaluating competing approaches early
- Engage
  - Help sustain the excitement of exploration for the public well before missions become reality

Stakeholders Summary

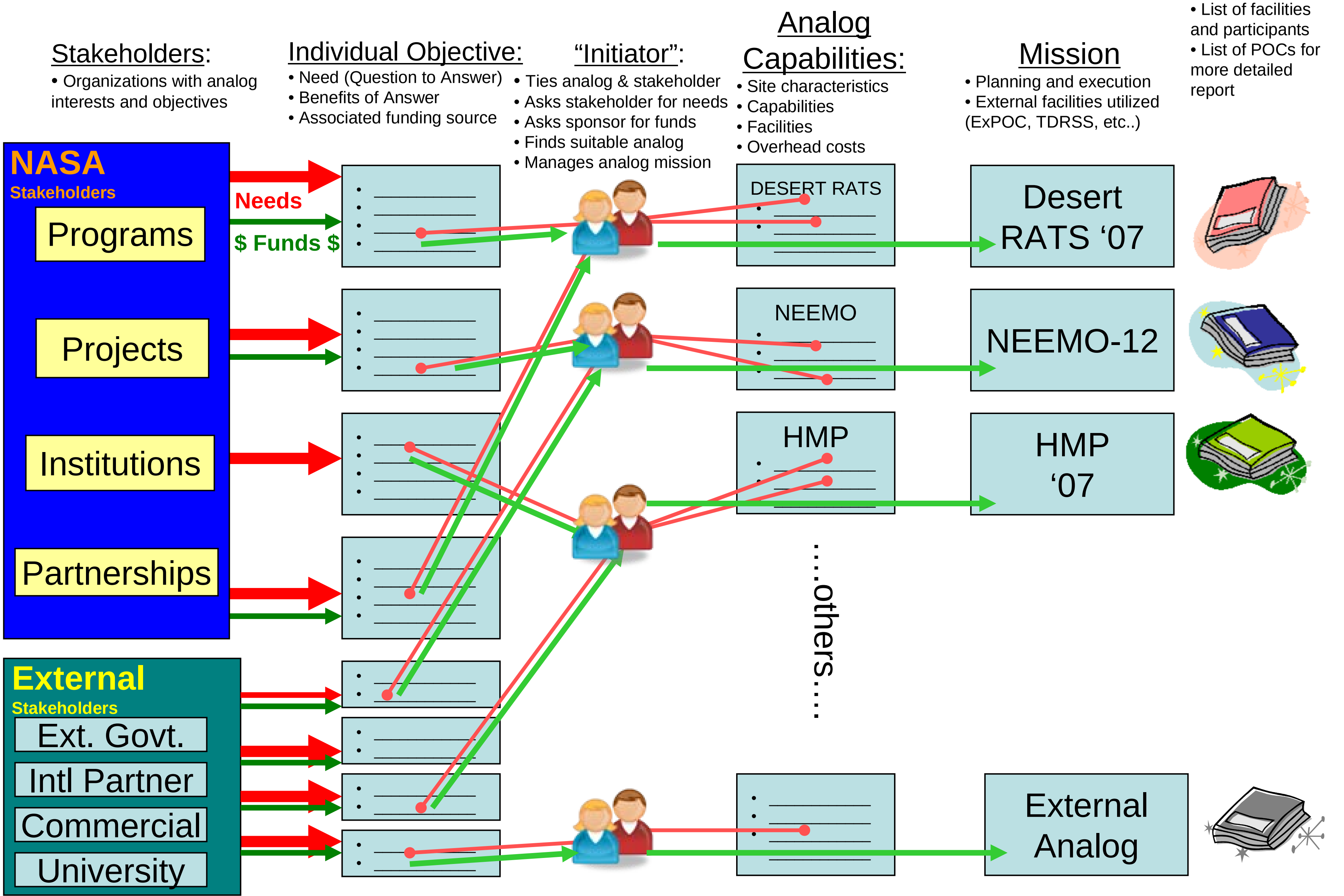


Issues with Current Analogue Situation

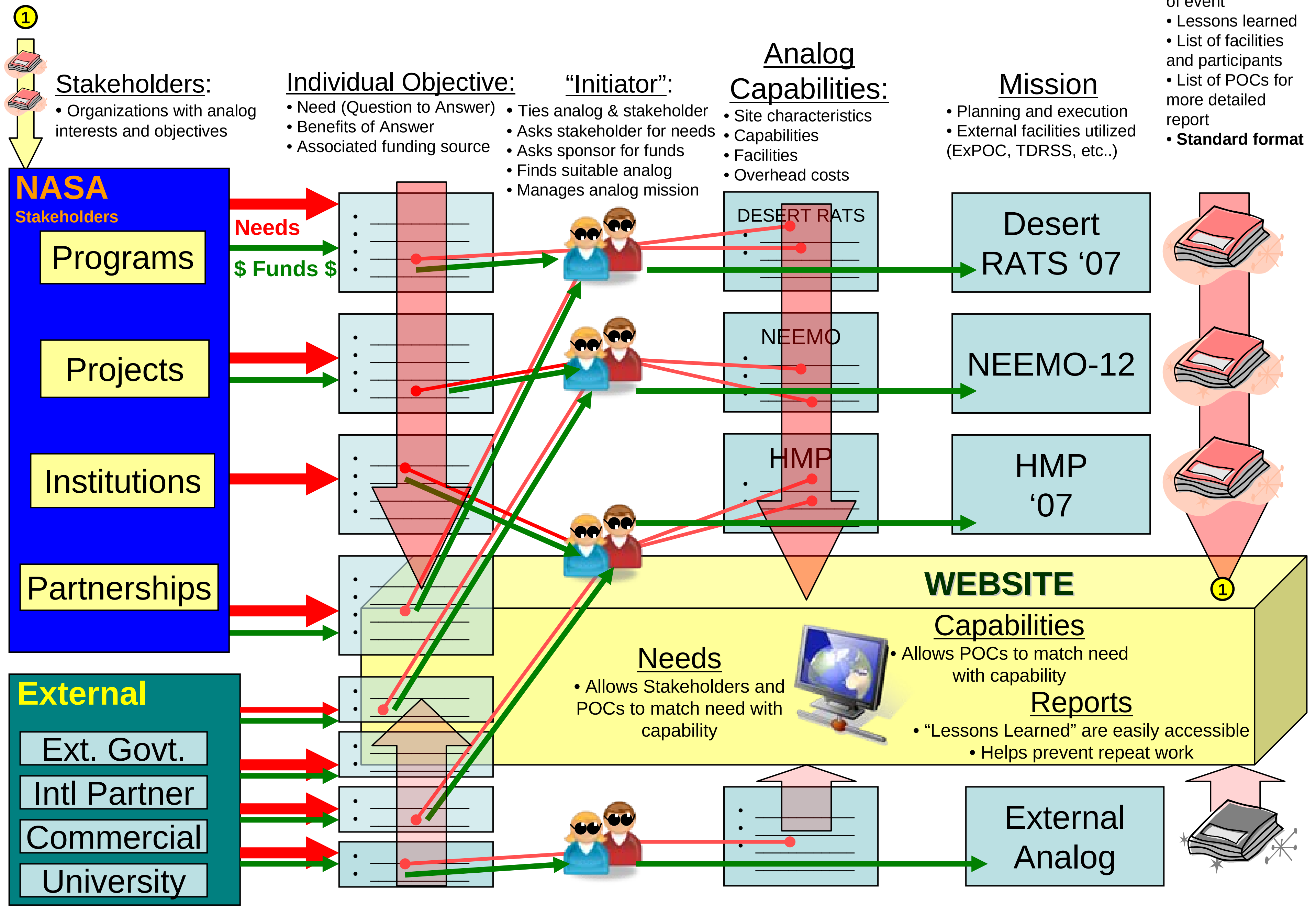
- <u>Too much is being managed individually</u>
  - Analog missions have been happening on their own for past years
    - Utilizing “down-time” and excess funding
  - Greater need for analogs dictates a new process which can handle more activities
- <u>Budget issues create an uncertain future for analog missions</u>
  - “Extra” funding is no longer available or is not reliable
  - Analogs may not be able to maintain infrastructure if future missions are not justified
    - “Beg/Borrow/Steal” approach is not effective in keeping the focus on <u>relevant results</u>
- <u>Corporate knowledge is not being captured well and/or disseminated:</u>
  - Analogs dating back to the 1960’s have already produced answers to questions that are being asked again in the 2000’s
  - Many answers may retire with the “third generation” of space explorers
  - Analogs trying to answer the same question could benefit from collaboration
    - Don’t want to perform same objectives twice
    - Important objectives could use two separate perspectives

- <u>Common Thread</u>: **Lack of communication and exposure**

Current state of Analogues



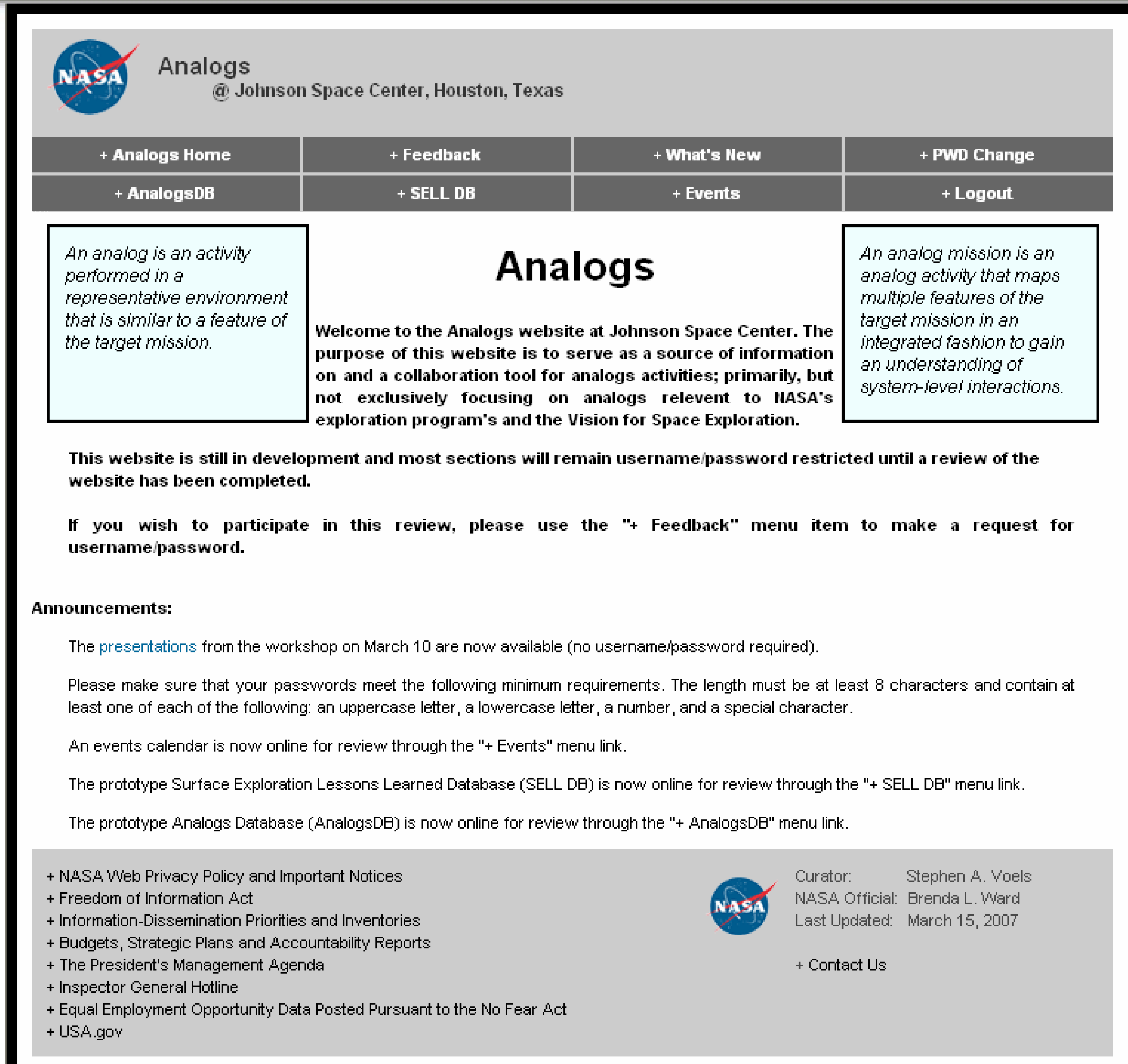
Implementation Plan (Second Step)



Recent Progress in Utilizing Analogues

- Analogues Database and Web Portal updated and moved to a “green” server
  - Web Portal is currently ID and Password protected
  - Ready to add Apollo-era training sites
  - Ready to incorporate EVA lessons-learned database compiled by NASA Astronaut Office
- Community briefings regarding plans and status
  - Space Technology and Applications International Forum (STAIF) - Feb 2007
    - Primarily technology users and developers
  - Invited Meeting at JSC (“First Analogs Workshop”) – Mar 2007
    - Timed to coincide with Lunar and Planetary Sciences Conference (LPSC), so primarily science user community but NASA analogue users also represented
  - Initial “supplier” community meeting – Mar 2007
    - Largely JSC-based long-standing analogues programs: Desert Research And Technology Studies (Desert RATS), Haughton-Mars Program (HMP), and NASA Extreme Environment Mission Operations (NEEMO)
  - Architecture to Requirements Development Integration Group (ARDIG) established as focal point for Constellation Program Office analogues activities
    - Launched “analogs initiative”
    - Begin coordination activity among JSC-based analogues groups: Desert RATS, HMP, and NEEMO

Website Layout Example – Home Page



Analogs
@ Johnson Space Center, Houston, Texas

+ Analogs Home	+ Feedback	+ What's New	+ PWD Change
+ AnalogsDB	+ SELL DB	+ Events	+ Logout

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

Analogs

Welcome to the Analogs website at Johnson Space Center. The purpose of this website is to serve as a source of information on and a collaboration tool for analogs activities; primarily, but not exclusively focusing on analogs relevent to NASA's exploration program's and the Vision for Space Exploration.

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.

This website is still in development and most sections will remain username/password restricted until a review of the website has been completed.

If you wish to participate in this review, please use the "+ Feedback" menu item to make a request for username/password.

Announcements:

The presentations from the workshop on March 10 are now available (no username/password required).

Please make sure that your passwords meet the following minimum requirements. The length must be at least 8 characters and contain at least one of each of the following: an uppercase letter, a lowercase letter, a number, and a special character.

An events calendar is now online for review through the "+ Events" menu link.

The prototype Surface Exploration Lessons Learned Database (SELL DB) is now online for review through the "+ SELL DB" menu link.

The prototype Analogs Database (AnalogsDB) is now online for review through the "+ AnalogsDB" menu link.

+ NASA Web Privacy Policy and Important Notices
+ Freedom of Information Act
+ Information-Dissemination Priorities and Inventories
+ Budgets, Strategic Plans and Accountability Reports
+ The President's Management Agenda
+ Inspector General Hotline
+ Equal Employment Opportunity Data Posted Pursuant to the No Fear Act
+ USA.gov

Curator: Stephen A. Voels
NASA Official: Brenda L. Ward
Last Updated: March 15, 2007

+ Contact Us

Website Layout Example - Analogue Site

Analogs Database
@ Johnson Space Center, Houston, Texas

Text Search the Database
+ Advanced Search

+ Analogs Home | + Analogs DB | + Submit Entry | + Feedback | + What's New | + Logout
+ Projects | + Missions | + Sites | + Facilities | + Equipment | + Contacts

Site Details

Name

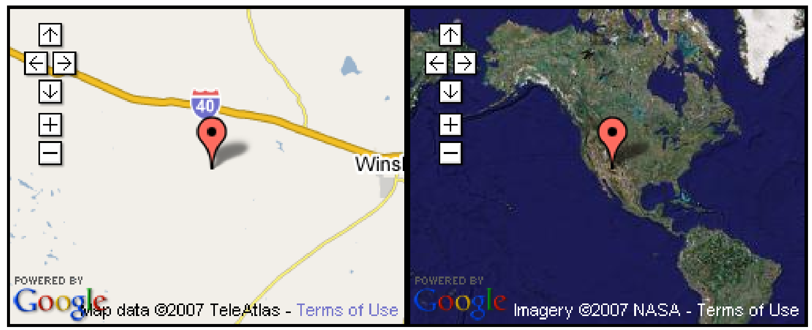
Meteor Crater

Location KML

Longitude, Latitude (datum)
Altitude
Description

-111.02778°, 35.02158° (WGS84)
1700 meters
North America, USA, Arizona, Flagstaff

Nearest Location with Climate Data (Link)



Sponsor or owner

Meteor Crater Enterprises Inc

Lead Person

No information in the database.

Contact Person

No information in the database.

Description

Test site is located on the rim of a mid-late Quaternary impact crater which formed when an iron-nickel bolide impacted into Mesozoic sediments, primarily the Moenkopi Shale, Kaibab Limestone and Coconino Sandstone. The test site is located within the ejecta blanket, with flat to hummocky terrain created by emplacement of impact fragmented and shocked Kaibab limestone. Boulders up to 2-3 m in size are found, although the majority of the surface consists of smaller, <0.25 m cobbles of primarily Kaibab Limestone in a matrix of shocked and comminuted limestone and sandstone.

Staging Information

No information in the database.

Special Access Information

Need to get permission from the commerical operator of the Meteor Creater tourist attraction.

Website Layout Example - Analogue Mission

Analogs Database
@ Johnson Space Center, Houston, Texas

Text Search the Database
+ Advanced Search

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Mission Details

Name

Advanced Space Suit Field Test 2000

Dates

September 2, 2000 to September 15, 2000

Orgainizational lead or sponsor

NASA JSC

Lead Person

Joseph J. Kosmo

Contact Person

Amy Ross

Description

Until the ASRO project, little was known about the investigation strategies necessary for determining and coordinating the interaction between humans and robotic rover vehicle systems towards achieving effective planetary surface exploration. As a result of this test experience and based on the preliminary findings and recommendations, as reported in CTSD-ADV-360 document, a series of representative planetary surface EVA deployment task were conducted as part of a joint project between elements of NASA-JSC to continue further investigation regarding synergism and interaction between humans and a robotic assistant vehicle for potential future planetary surface exploration application.

Objectives

The objectives of this series of test activities was to develop an interdisciplinary level of "lessons learned" by conducting preliminary engineering assessments and human factor evaluations of various representative space suited EVA / robotic assistant vehicle planetary surface deployment task while in Lunar / mars analogy remote field site locations. In addition, the test activities were valuable in demonstrating to various levels of NASA management, the scope of technology needs that will be required to successfully accomplish future human and robotic assisted rover vehicle exploration of planetary surfaces. Other benefits include public education-outreach opportunities and Public Affairs Office (PAO) coverage for new releases.

Results

No information in the database.

Lessons Learned

Objectives of ARDIG Analog Initiatives

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.

- Increased visibility of analog capabilities
  - If organizations are familiar with what analogs exist, it is easier for “initiators” to establish objectives
- Advertisement of Constellation Program needs
  - Analogs wish to make their mission realistic
    - Answering current NASA and Vision for Space Exploration questions
    - Validates their existence
  - Turns into “free data” for active NASA programs
    - If more fidelity is desired, NASA organization can sponsor next mission, or initiate an Announcement of Opportunity (AO) to allow several analogs to compete for seed funding
- Record of past mission findings in a common, searchable format
  - Summary of event, lessons learned, and a link to more information

Future Plans

- Open Analogs Database and Web Portal to larger user community
  - A completely open Web Portal will be subject to NASA internal review and approval
  - Provide an on-line repository for analogues community (not just NASA) to store results of field deployments and research past deployments and associated lessons learned
- Coordinate analogue testing activities among ESMD-supported teams
- Coordinate with international analogue testing activities as appropriate
- Expand the database of usable analogue sites, missions, and lessons learned
  - Provide an assessment and characterization of usable analogue sites
- Please contact Gib Kirkham (NASA OER) for additional information

Backup Material

Example: Cold-Trap Sample Return

Question: What is the relative productivity of various methods for acquiring, handling, and storing, with minimal heat-induced alteration, samples from "cold traps" located at the lunar poles?

Source	Requirements
HSR&T	Spacesuit-based Command and Control, Communications
	Sample handling equipment and procedures
ESR&T	Wireless Networks for Surface Ops (ASTP/CCEI)
	Multimodal Human-Automation Interface (ASTP/SISM)
	Surface Transport Rover for cold (40 K) ops (TMP/LPSO)
	Alternative sample collection devices for cold (40 K) ops
Constellation	Surface Habitat Infrastructure Deployment ConOps

Proposed Analogue Mission Components:

Location: Analogue Terrain Site (e.g. small craters located at Cinder Lakes or larger such as Meteor Crater)

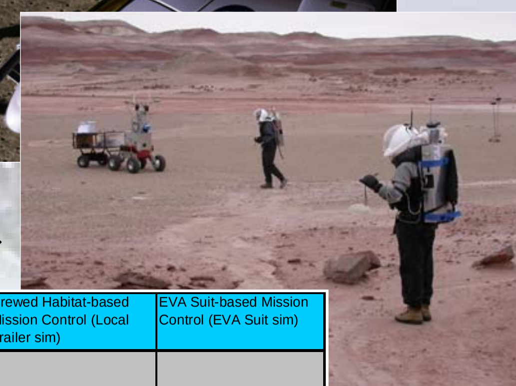
Control Option 1: Earth-base Mission Control (JSC/ExPOC)
- High-bandwidth Communications with 3 second time-delay
- Multiple operators available

Control Option 2: Crewed Habitat-based Mission Control (Local Trailer)
- High-bandwidth communications with 0.1 second time-delay
- Single operator

Control Option 3: EVA Suit-based Mission Control (EVA Suit)
- High-bandwidth communications with no time-delay
- Single operator using voice input for commands and HUD for display

Teleoperated rover
- Locomotion system capable of descending and ascending representative lunar crater slopes (angle and roughness)
- Interface capable of supporting alternative sample acquisition devices
- Video and sensor relay and monitoring
- Heat management components
- Capable of remote driving control

Deployed alternative (to rover) sample acquisition
- Constraints on terrain placement
- (e.g. requires craters of representative size and slopes)
- Heat management components



Mission Time vs. Mission Control Options	Earth-base Mission Control (JSC sim)	Crewed Habitat-based Mission Control (Local Trailer sim)	EVA Suit-based Mission Control (EVA Suit sim)
EVA crew time			
Total crew time (EVA plus Habitat)			
Total operator time (EVA plus Habitat plus Earth Operators)			
Total deployment time			

Analogue Mission Outcome:

Recommendation for extremely cold sample acquisition and handling designs and requirements

Example Site Characterization Matrix

SITE CHARACTERISTICS

FUNCTIONS	Terrrain									Climate						Science								
	Terrain Type	Slope / Grade	Rock Size Distribution	Soil Properties: Gradation	Soil Properties: Grain Morphology	Soil Properties: Ice Content	Soil Properties: Moisture Content	Soil Properties: Composition	Soil Properties: Mechanical Properties	Temperature (variation - hi/lo)	Rel Humidity	Precipitation	Insolation	Wind (vel/dir)	Dust	Layered Sediments	Impact Features	Variety (multiple geologic environs)	Micropaleontology / fossils	Surface ice	Volcanics	Geothermal Activity	Isolation	Hostility
Human Factors	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MED	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	HI	HI
EMU Testing	HI	HI	HI	MED	MED	MED	HI	MED	HI	HI	HI	MED	MED	MED	HI	MED	MED	MED	MED	MED	MED	MED	LOW	LOW
Ancillary EVA Systems Testing	HI	HI	HI	MED	MED	MED	MED	MED	HI	HI	LOW	LOW	LOW	MED	HI	MED	MED	MED	MED	MED	MED	MED	LOW	LOW
Robotics/Rover Testing	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI	MED	MED	MED	MED	HI	MED	MED	MED	MED	MED	MED	MED	LOW	LOW
Operations	MED	MED	MED	LOW	LOW	LOW	LOW	LOW	MED	HI	LOW	HI	HI	MED	HI	MED	MED	MED	MED	MED	MED	MED	HI	HI
System/Science Equip Deployment	HI	HI	HI	MED	MED	MED	HI	MED	HI	HI	LOW	HI	HI	MED	HI	HI	HI	HI	HI	HI	HI	HI	LOW	LOW
Geology Field Training	HI	HI	HI	LOW	LOW	LOW	HI	LOW	MED	LOW	LOW	MED	LOW	LOW	HI	HI	HI	HI	HI	HI	HI	HI	LOW	LOW
Simulated Traverses	HI	HI	HI	LOW	LOW	LOW	HI	LOW	HI	MED	LOW	MED	LOW	LOW	MED	MED	MED	MED	MED	MED	MED	MED	HI	HI

IMPORTANCE

HI (green) MED (yellow) LOW (red)

HI - high degree of similarity is critical to effective analogy
MED - similarity enhances analogy but is not critical
LOW - similarity not important to effective analogy

Integrated Analogue Studies - Prerequisites for Human Exploration

Haughton-Mars 1

H. Remote Science 2

Desert RATS 3

Mars Desert R. S. 4

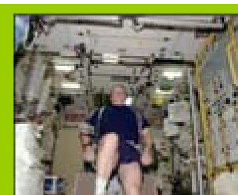
Flashline Arctic R.S. 5

○ low ● high

Elements	Analogue Field Studies 1	2	3	4	5	6	7	8	9	10
Science Value	●	◐	◐	◐	●	◐	○	◐	◐	●
Science Operations	●	●	●	●	●	●	◐	◐	◐	◐
Tech. Development	●	●	●	◐	●	◐	●	◐	●	●
Tech. Integration	◐	●	●	◐	◐	◐	●	◐	●	◐
Mission Operations	◐	◐	●	◐	◐	●	●	●	◐	◐
Crew Training/Bio	◐	◐	●	●	●	●	●	●	◐	◐
Human Factors	●	◐	◐	●	●	●	●	●	◐	●
Cost effectiveness	●	●	●	●	◐	●	◐	○	●	●
Outreach/Education	●	●	●	●	●	●	●	●	●	●
Overall Integration	●	●	◐	●	●	◐	●	◐	◐	●

NEEMO 6

Integrity 7



Intl. Space Station 8

Mars Yard/Chamber 9

Antarctic/desert 10

Rating Scale Definitions

	○	◔	◑	●
Science Value	None/Not appropriate	Simulated science tasks or science tasks not relevant to planetary science. Little/no publishable results.	Valid scientific objectives/tasks relevant to future planetary exploration. No intent to publish science results or publishible science results not directly relevant to planetary science.	Planetary science tasks lead to publishable (peer-reviewed) science results.
Science Operations	Science operations not relevant to future missions.	Low fidelity relevant science operations, but not focused on operations lessons learned.	Medium fidelity to actual projected science procedures for planetary surface missions. Qualitative lessons learned.	High fidelity of science planning, procedures, communications, and reporting to planetary surface missions. Quantitative metrics.
Technology Development	Little/no technology development	Relevant technology used but not developed. Primarily application of existing technology.	Relevant technology developed but not dependent on analog environment.	New technology tested by taking full advantage of analog environment.
Technology Integration	None/Not appropriate	Different systems used simultaneously but not integrated.	Only a small number of applicable technologies used in an integrated fashion.	Multiple technologies used in an integrated fashion as proposed for actual mission.
Mission Operations	Mission operations not relevant to future missions.	Low fidelity relevant mission operations, but not focused on operations lessons learned.	Medium fidelity to actual projected mission operations for planetary surface missions. Qualitative lessons learned.	High fidelity of mission planning, procedures, communications, and reporting to planetary surface missions. Quantitative metrics.
Crew/Team Training	None/Not appropriate	Tasks developed to meet immediate needs of test. Some applicability to flight or ground crew training.	Tasks are representative of space mission. Alternative procedures are tested and compared.	Tasks are directly applicable to mission preparation for flight or ground crews, e.g. motion flight simulators.
Human Factors	None/Not appropriate	Human crews involved, but low fidelity to planetary habitats or surface activities.	Medium fidelity habitat or surface simulation.	High fidelity habitat or surface simulation.
Medicine/Physiology	None/Not appropriate	Some studies relevant to future long-term human missions	Studies relevant to maintaining crew medical and health for orbital, transit, and/or surface human missions	Direct medical and physiological experiments on humans in long-duration space flight conditions
Outreach/Education	None/Not appropriate	Low level of activity. Low visual content/difficult to explain. Not directly relevant to mission.	Moderate level of activity. Moderate visual content/relatively easy to explain. Partially relevant to mission	High level of activity. High visual content/easy to explain. Directly relevant to mission.
Overall Integration	None/Not appropriate	Low level of overall coordination among analog element (science value, science operations, etc.)	Moderate level of overall coordination among analog element (science value, science operations, etc.)	High level of overall coordination among analog elements (science value, science operations, etc.)