

# Outpost Science and Exploration Working Group (OSEWG)

Presented to  
LEAG 2007 Annual Meeting

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NASA Headquarters*

*October 1, 2007*





# OSEWG Organization

- Chartered jointly by ESMD and SMD in FY2007 to coordinate and guide outpost-related science and exploration planning
- Terms of Reference signed 3/07 by ESMD (Cooke and Yoder) and SMD (Hartman and Hertz)
- Working group reports to ESMD and SMD Deputy AAs
- Group co-chaired by ESMD Manager for the Lunar Architecture Team (Yoder) and SMD Lunar Program Scientist (Morgan/Snook)
- Core membership drawn from HQ and Constellation (Cx) and to include SOMD, ARMD, ESMD, and other organizational members as appropriate
- Jointly funded by respective Mission Directorates





# Lunar Architecture Team Science Capability Focus Element Work Flow

181 Objectives from Global Strategy Team



ALL Science Objectives (45 "SMD" Science objectives + some others...)



Each Objective Deconstructed to Define Needed Capabilities and Mapped to Architecture



PRIORITIES from Tempe Workshop



Top Objectives



Grouped into key reference payloads



Mapped to Architecture options





# LAT 2 Science Focus Element Team Accomplishments

- Worked extensively with science community at NAC Tempe Lunar Science Workshop to develop science priorities and science needs
- Using output of the Tempe workshop, developed a list of “Top Objectives” and Key Reference Payload Elements
- Pulled together basic parameters (mass, etc.) for Key Reference Payload Elements
- For 2 Reference Payload Elements, performed detailed assessments and preliminary engineering designs to further refine mass, power estimates and other issues
  - Lunar Environmental Monitoring Station
  - Lunar Telescope
- With OSEWG, held Workshop on Architecture Issues Associated with Sampling to work with Science community to assess needs for surface sample handling
- Worked with CAPTEM to assess requirements for returned sample mass, traceable to science objectives. Inserted risk into Cx system to investigate increase of sample mass return.
- Produced preliminary manifests for science in the Architecture Options
- With the Integration Team, developed Science Figures of Merit
- Supported the Integration Team in assessing sortie sties for science



# PSS findings

## Highest Ranking by PSS/LEAG:

- INTERNAL STRUCTURE and DYNAMICS - Geophysical/heat flow network - requires multiple sites, widely spaced ("global access")
- COMPOSITION/EVOLUTION of LUNAR CRUST - requires extensive sampling at both local and diverse sites
- IMPACT FLUX - requires access to impact basins and sample return for age dating
- SOLAR EMISSIONS/GCR/INTERSTELLAR - requires drilling, regolith and core sample integrity, careful documentation
- CURATORIAL FACILITIES - development of sample documentation, environmental, and orientation controls needed
- SAMPLE ANALYSIS INSTRUMENTS AND PROTOCOLS - infrastructure for pristine sample collection, storage, documentation, and transport needed

Table of Objective Assessments and Rankings

Objective Number	Objective Description	LEAG/PSS Ranking (1-5) 42: Highest priority	MEAG Low-high Near best to Worst	Implementation Considerations	Ranking for prior output	Comments
mQSD-1	Determine the general structure and dynamics of the Moon to constrain the origin, composition, and structure of the Moon and other planetary bodies	50	high	long-term power supply; cooling site; safety	1	This objective cannot be achieved from a single site. However, a reference station (geophysical station) should be set up at an outcrop site because it would provide precise information about the interior and, near regularly, it would represent a start toward establishing a long-duration global seismogeophysical network
mQSD-2	Determine the composition and evolution of the lunar crust and mantle to constrain the original evolution of the Moon and other planetary bodies	60	medium	targeted sample return; multiple lookovers	2	Significant progress can be made by intensive study of one site and documentation and return of core and regolith samples throughout the region surrounding the outcrop. How much progress can be made depends on the geological setting of the specific site chosen; proximity to a diversity of geologic settings is particularly important
mQSD-3	Characterize the lunar geophysical environment to constrain the origin, composition, and structure of the Moon and other planetary bodies	6	medium	long-range surface mobility; multiple lookovers; sample return; coordination remote sensing	3	Little progress can be made on this objective from a single site, and the acquisition of a heat flow measurement. The utility of a single heat flow measurement depends on the geological and physical setting of the site
mQSD-4	Determine the origin and distribution of endogenous lunar volatiles as one aspect of understanding the origin, composition, and structure of the Moon and other planetary bodies	7	low	long-range surface mobility; targeted sample return; various site	4	Achieving this objective requires landing sites with the best chance of yielding significant information about lunar endogenous volatiles, such as physicochemical deposits, near volcanic vents, or evidence of possible recent outgassing
mQSD-5	Characterize the crustal geology of the Moon via the regolith to identify the range of geological materials present	8	low	multiple, widely separated sample locations	5	This is less effective than going to diverse locations on the Moon to sample the crust, but significant progress can be made from one site. South polar location is a previously unexplored terrain. Regolith samples and rock fragments in the regolith component may collect from large rock samples. Regolith sampling can be done remotely
mQSD-6	Characterize the impact process, especially for large basins, on the Moon and other planetary bodies to understand the terrestrial environment	8	high	local to regional surface mobility for astronauts; sample return	2	Significant progress can be made at a single site by studying one or more basins in detail. Regulate orbital and sample data, and geologic and geophysical field studies
mQSD-7	Characterize impact flux over the Moon's geologic history, to understand early solar system history	40	high	sample return for age dating; long-range surface mobility and/or access to multiple lookovers	3	If the outcrop were within a large basin not previously sampled, significant progress could be made. For example, if the site were inside South Pole-Aitken basin, it would be possible to sample the melt sheet (which is able to date the event) and trace the associated crater basins. Access to South Pole-Aitken basin requires a far-sited, southern hemisphere site
mQSD-8	Investigate meteorite impacts on the Moon to understand early Earth history and origin of life	7	low	surface mobility; extensive site field; geologic investigation; sample return for dating & geochemistry	4	Requires access to multiple impact craters and regolith samples. If an outcrop of a single impact site where numerous craters can be observed and large amounts of regolith can be processed and analyzed, progress is possible for key indicators, mineralogy, or chemical compositions
mQSD-9	Study the lunar regolith to understand the nature and history of solar emissions, galactic cosmic rays, and the local interstellar medium	8	high	return of regolith; extensive powder age record	3	Extreme regolith excavation at a single site could address this objective by identifying layers deposited by specific impact events. Extreme ISM processing could aid the search
mQSD-10	Determine lunar regolith properties to understand the surface geology and environment of the Moon and other airless bodies	7	low	intensive study of regolith, including excavation, sampling, & geophysical studies	4	This objective can be achieved well at an outcrop site. Investigation would go far beyond what is known from Apollo cores and other regolith measurements, and could include in situ measurements of many geotechnical and other regolith properties. Planning for excavation
mQSD-11	Characterize the lunar regolith to understand the space weathering process in different orbital environments	7	low	local surface mobility; frequent, sample documentation; collection; orientation to Earth	4	Can be done well at a single site with detailed investigation of regolith at different locations and with different degrees of surface exposure
mQSD-12	Characterize lunar volatiles and their sources to determine their origin and to reveal the nature of impacts on the Moon	8	medium	in-situ analysis of volatile deposits; specimen in vacuum; low temperature	4	Analysis of volatiles in the lunar atmosphere and at least near polar cold traps are well enabled by a polar outcrop location. Needs to be done early in the human exploration program
mQSD-13	Characterize transport of impact volatiles to understand the processes of post-impact deposit origin and evolution	7	low	global access (range of latitudes & locations) desired	4	Much of this objective can be achieved at a polar outcrop site through access to permanently shadowed craters and regolith near to and at a range of distances from the pole
mQSD-14	Characterize volatiles and other materials to understand their potential for lunar resource utilization	7	high	needed to ISRU; extraction enabling; needs to be allowed early; access to specific, widely separated, widely separated	4	Ground truthfully characterization of deposits located from orbital data are used to accurately targeted locations on the Moon should be done during the robotic precursor phase to identify the best outcrop location. Doing this from a polar outcrop location instead of during the precursor phase will characterize the deposits at the site, but this is too late to influence optimal outcrop location, that started a "4"
mQSD-15	Provide curatorial facilities and technologies to ensure contamination control for lunar samples	9	low	development of facilities; documentation, collection, environmental and orientation controls needed	5	Objective can be well achieved at an outcrop location; potential site selection depends on precise hardware case for laboratory, permanently shadowed sample documentation, collection, transfer, and processing
mQSD-16	Provide sample analysis instruments and protocols on the Moon to analyze lunar samples before returning them to Earth	8	medium	none	5	Objective can be well achieved at an outcrop location



# OSEWG/LEAG Workshop on Architecture Issues Associated with Sampling

- Held June 25-26, 2007 in Houston
- ~80 participants - approximately half scientists, half engineers/managers
- Workshop Objectives:
  - to explore the problem of joint human and robotic sample return from other planetary surfaces
  - to identify key areas in which further study is needed
  - to begin dialogue between science and engineering communities on sample triage and the architecture issues associated with high-grading and curating samples
- Half day of presentations from LEAG, CAPTEM, MEPAG, OSEWG, Constellation, Apollo astronauts Jack Schmitt and John Young, Apollo Backroom scientists, curators, and sample scientists. Show and tell, Apollo sampling tools
- Remaining time in breakout and plenary discussions





# OSEWG/LEAG Workshop Topics

Discussion breakouts - 7 groups went through identical discussion questions in the context of different lunar or Mars exploration scenarios (four lunar, three Mars scenarios) on end-to-end problem of sampling:

- TRAVERSE PLANNING** - Navigation, data requirements, field crew vs. ground team planning, crew time optimization, hab workspace requirements, teleoperations and robotic assistance
- SAMPLE AND DATA ACQUISITION** - Navigation, sampling strategies, sample preservation, in-situ measurements vs. sample collection, mass, power, and volume estimates.
- DOCUMENTATION** - Sample documenting automation - RF tagging or barcoding, Video/camera and audio requirements, real-time versus post documentation, time-stamping, real-time GIS capabilities in suit and/or rover
- SAMPLE HIGH-GRADING** - Concepts for optimizing mass returned, space and crew time requirements, robotic assistance, data requirements, rock garden/sample shed concepts, optimizing crew/ground interactions. Autonomous high-grading of samples in situ
- LABORATORY ANALYSIS** - Minimum and dream lab requirements (volume, functionality, sample preservation, glove box limitations, etc.), capabilities vs. mission duration, lab science vs. EVA science - optimizing crew presence
- SAMPLE RETURN** - Preserving sample integrity, mass/power/volume of returned sample masses (reports from recent studies)
- CURATION** - Surface sample handling, documentation, transport, storage





# OSEWG/LEAG Workshop Results

- Ten outstanding questions to be refined and assigned to appropriate study groups (or incorporated into studies already planned)
- Key areas needing study:
  - Optimizing the **human-robotic partnership** for maximum exploration science return, minimum risk
  - Preserving **sample integrity** - special vs. traditional samples
  - Criteria for sample **triage**, high-grading, and subsampling - better definition of SHeD reqt's
  - **Navigation** and communication requirements for sample collection, documentation, subsampling, and curation
  - *In situ* field measurements and **surface lab** analysis vs. returned sample mass trade space
  - Using **analog**s and past mission lessons learned to address sampling issues and inform surface system design





## OSEWG/LEAG Workshop Results (cont.)

- Workshop surprises / preliminary findings:
  - Controversy and healthy debate/disagreement over basic scientific and curatorial requirements
  - Strong opinion that returned samples should not come into contact with humans or habitat after collection in field
  - Strong support (and some trepidation) for tele-robotic capabilities for sample handling and surface curation with humans in hab or on Earth - telerobotics as human-extension tools rather than robot assistants





# OSWEG Near Term Interests - Examples

- Field requirements resolution
  - Field capture sample location – data collected and documentation
  - Locating sample area
- Sample mass return (100kg)
  - What can we do with 100kg?
  - What if we had an additional 50kg, etc?
- Lab requirements in hab
- Core tools
- Power requirements for return samples
- Power requirements for hab
- Power requirements for rover
- Communications requirements between astronaut and hab
- Communications between astronaut and rover
- Min science requirement for first missions
  - Handling systems etc
- Automation requirements





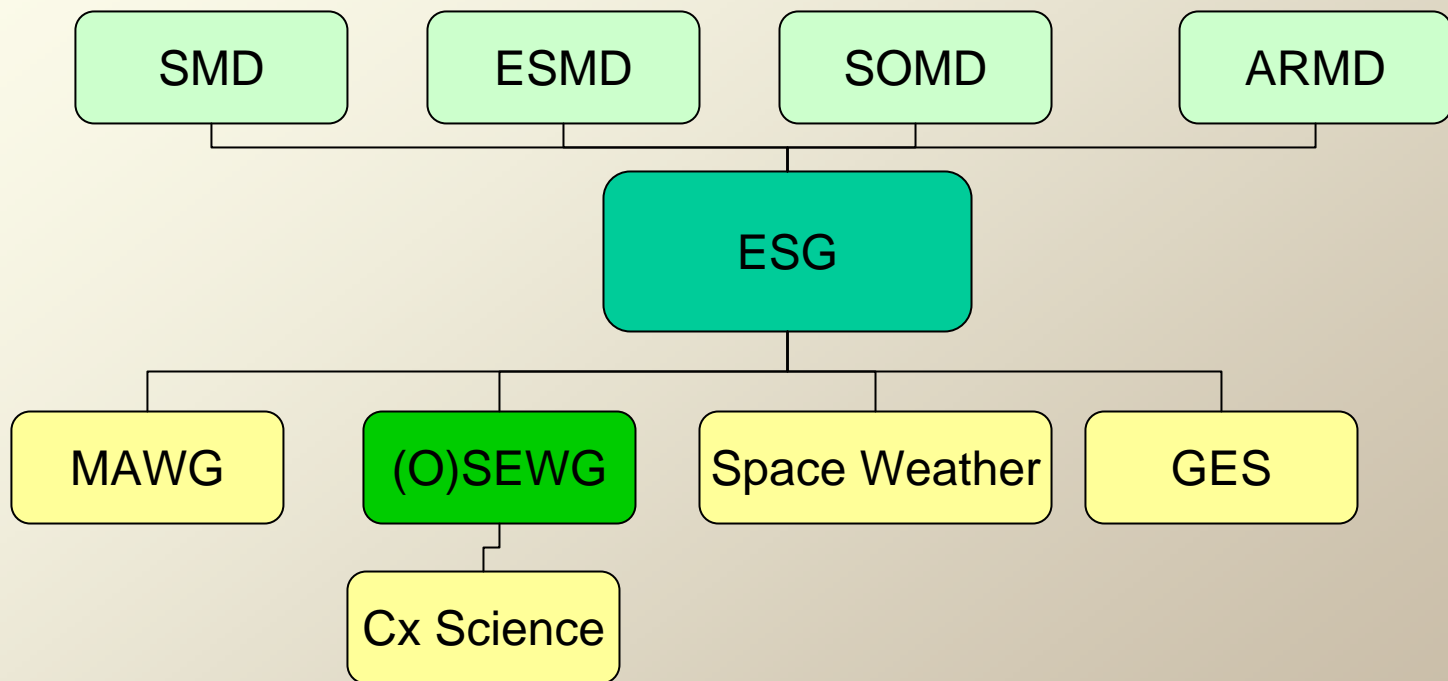
# OSEWG Kick-off and Terms of Reference

- OSEWG Kick-off meeting held at NASA HQ Sept. 26-27
  - Three TORs identified as starting points
  - Goal is to start with manageable tasks – validate the system process
1. Develop OSEWG roadmap for the next 5 years (high resolution for this year)
  2. Analog Missions Coordination – included entry points, reviews, expected outcomes, etc.
  3. Lunar Data Synthesis and Integration – ensures we are looking across the Lunar mapping resources i.e. LRO, Selene, MMM, etc.



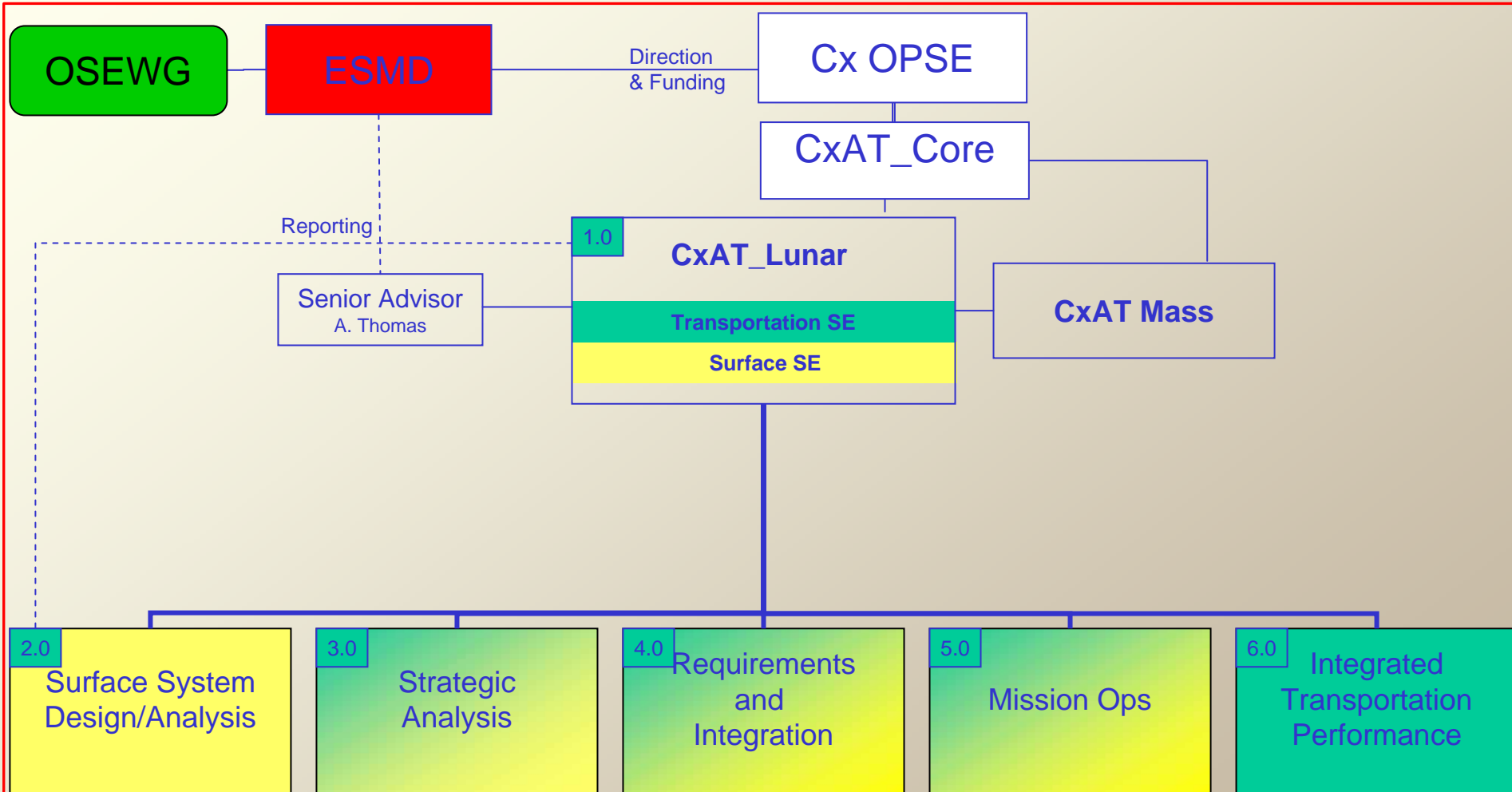


# OSEWGW Organization (cont.)



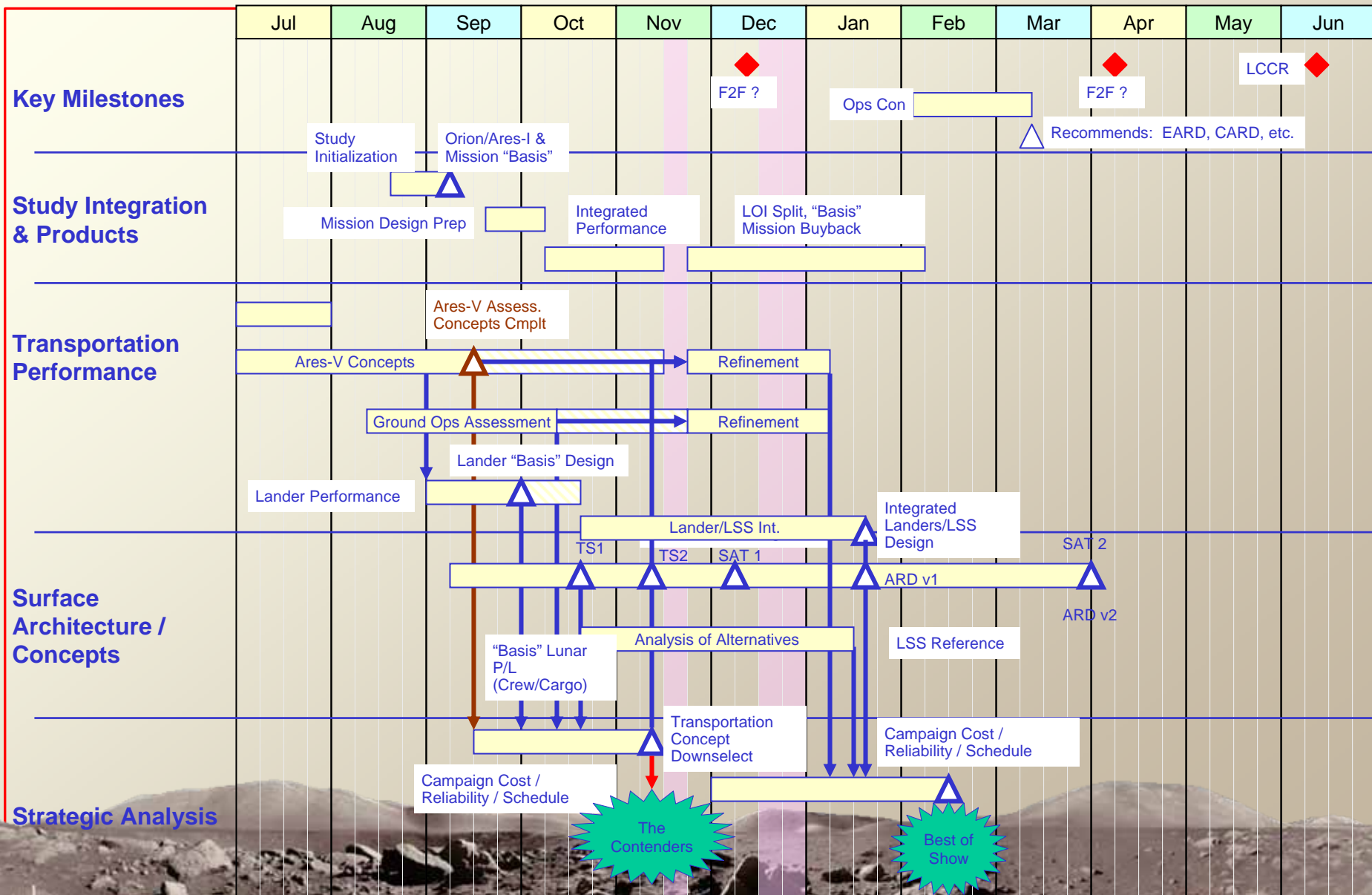


# CxAT\_Lunar Organization





# Draft Schedule sensitive to Cx milestones





# OSEWGW Tasks and Responsibilities

- Analyze and develop outpost Design Reference Science Investigations (DRSIs) using a case approach
- Focus on evolving, time-phased outpost activities with maximum synergy - scientific return, and exploration benefit
- Inform ongoing calls for joint SMD/ESMD research programs (e.g. LASER)
- Flesh out outstanding unknowns related to science operations – payload and sample masses, EVA requirements, mobility, work-space and laboratory equipment, crew time, human/robotic optimization, etc.
- Identify new technology needs (Primarily Science related)
- Address exploration requirements as contained in Exploration Architecture Requirements Document (EARD)





# Relationship of OSEWG to other groups

- CxAT Lunar – Supportive role for verifying and fleshing out outpost-related elements
- MAWG – Supportive role, particularly useful for ensuring good feed-forward and feed back to/from Mars architecture surface elements
- LEAG/MEPAG/CAPTEM/FEAT – Close working relationship – LEAG, MEPAG, CAPTEM, FEAT etc. can be tasked for studies requiring input from broad community base and expert groups





# Analog Missions Coordination: Functions and Benefits

- **Learn**

- Reduce risk to crews for human surface missions to the Moon and Mars
- Learn what works and what doesn't work for surface science operations and exploration missions
- Enable scientific advances in planetary and Earth studies

- **Test**

- Validate surface mission designs: Long duration presence, Outpost buildup, Human & robotic roles, etc.
- 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 and functions for planetary 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
- Demonstrate accomplishment of key milestones to decision-makers





# OSEWEG Analogs Coordination

- Facilitate and document SMD/ESMD/SOMD/ARMD jointly-coordinated analog activities
- Provide analogs community with prioritized set of needs, requirements, outstanding problems needing investigation, and other points of feed-in to NASA mission planning processes
- Expand the database of usable analog sites, missions, and lessons learned by opening it 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
  - Provide an assessment and characterization of usable analog sites
- Support and provide a forum for continued focused analog testing activities by ESMD, SMD, SOMD, or externally supported teams
- Coordinate with international analog science and engineering activities as appropriate






# Analogs - Continuing Past Work

- Analogs “Tasker” begun within ESMD in 2005
- Analogs Database and Web Portal created and put on 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
- Space Technology and Applications International Forum (STAIF) - Feb 2007
  - Primarily technology users and developers
- Invited Meeting at JSC (“First Analogs Workshop”)
  - 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
  - Largely JSC-based long-standing analogues programs: Desert RATS, Haughton-Mars Program (HMP), and NASA Extreme Environment Mission Operations (NEEMO)
- ARDIG established as focal point for Constellation Program Office analogues activities
  - Launched “analogs initiative”
  - Begin coordination activity among JSC-based analogues groups: DRATS, HMP, and NEEMO





# Website Layout Example – Home Page


Analogs  
 @ Johnson Space Center, Houston, Texas

+ <a href="#">Analog Home</a>	+ <a href="#">Feedback</a>	+ <a href="#">What's New</a>	+ <a href="#">PWD Change</a>
+ <a href="#">AnalogDB</a>	+ <a href="#">SELL DB</a>	+ <a href="#">Events</a>	+ <a href="#">Logout</a>

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

## Analog

**Welcome to the Analog 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 relevant to IASA'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 Analog Database (AnalogDB) is now online for review through the "+ AnalogDB" menu link.

<ul style="list-style-type: none"> <li>+ <a href="#">NASA Web Privacy Policy and Important Notices</a></li> <li>+ <a href="#">Freedom of Information Act</a></li> <li>+ <a href="#">Information-Dissemination Priorities and Inventories</a></li> <li>+ <a href="#">Budgets, Strategic Plans and Accountability Reports</a></li> <li>+ <a href="#">The President's Management Agenda</a></li> <li>+ <a href="#">Inspector General Hotline</a></li> <li>+ <a href="#">Equal Employment Opportunity Data Posted Pursuant to the No Fear Act</a></li> <li>+ <a href="#">USA.gov</a></li> </ul>		<p>Curator: Stephen A. Voels            NASA Official: Brenda L. Ward            Last Updated: March 15, 2007</p> <p style="text-align: center;">+ <a href="#">Contact Us</a></p>
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# Website Layout Example - Analog Site

**Analog Database**  
@ Johnson Space Center, Houston, Texas

**Text Search the Database**  
  
[+ Advanced Search](#)

<a href="#">+ Analogs Home</a>	<a href="#">+ Analogs DB</a>	<a href="#">+ Submit Entry</a>	<a href="#">+ Feedback</a>	<a href="#">+ What's New</a>	<a href="#">+ Logout</a>
<a href="#">+ Projects</a>	<a href="#">+ Missions</a>	<a href="#">+ Sites</a>	<a href="#">+ Facilities</a>	<a href="#">+ Equipment</a>	<a href="#">+ Contacts</a>

### 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 commercial operator of the Meteor Crater tourist attraction.





# Website Layout Example - Analog Mission

**Analog Database**  
@ Johnson Space Center, Houston, Texas

**Text Search the Database**

+ Advanced Search

+ <a href="#">Analog Home</a>	+ <a href="#">Analog DB</a>	+ <a href="#">Submit Entry</a>	+ <a href="#">Feedback</a>	+ <a href="#">What's New</a>	+ <a href="#">Logout</a>
+ <a href="#">Projects</a>	+ <a href="#">Missions</a>	+ <a href="#">Sites</a>	+ <a href="#">Facilities</a>	+ <a href="#">Equipment</a>	+ <a href="#">Contacts</a>

### Mission Details

**Name**  
Advanced Space Suit Field Test 2000

**Dates**  
September 2, 2000 to September 15, 2000

**Organizational 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**



# Integrated Analogue Studies - Prerequisites for Human Exploration



Houghton-Mars

1



H. Remote Science

2



Desert RATS

3



Mars Desert R. S.

4



Flashline Arctic R.S.

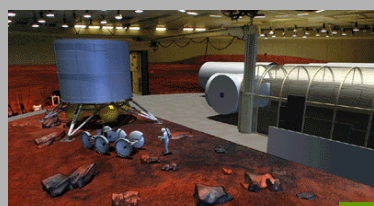
5

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





# OSEWGW Lunar Data Synthesis and Integration

- Lunar Reconnaissance Orbiter will provide data that are necessary to develop the maps needed for our return to the moon
  - Launch October 28, 2008
  - Data return will begin soon after start of nominal mission
  - Data will reside in the Planetary Data System, a repository for science data
  - Data in PDS format is not likely to be the most useful form for the users in Exploration Systems
- We need to identify the primary users and their needs
  - Who are the users?
  - What lunar mapping information do they need?
  - What form does the information need to take?
  - When is the information needed?





# Lunar Mapping Workshops

- First workshop dealt with the Why and the What - early activity focused on LRO
- The How is a subject being dealt with in parallel: the lunar mapping architecture
- Who - primary users
  - Constellation
  - LSAM
  - Habitat
  - Mobility
  - Power
  - Surface Ops
  - Site Selection
  - Comm
  - Mobility
  - Lunar Model Dev
- Who - Secondary (for now) users
  - Science
  - Education
  - Public Outreach
  - Public Affairs





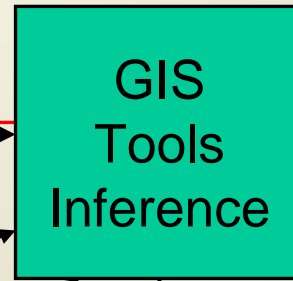
# Lunar Data Synthesis - Guiding Principles

- Requirements driven
  - Identify users
  - Discriminate between requirements and desirements
- Standards based
- Identify and leverage existing capabilities
- Extensibility
- Robustness

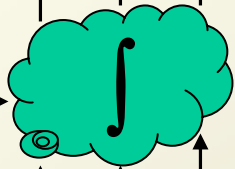
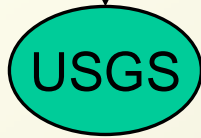




Data (metadata)



- Standards
- Extensibility
- Robustness
- Leverage



Q



Information

Quantitative

Mission Designers  
 Mission Planners  
 Mission Operations  
 Analysis Teams

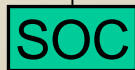
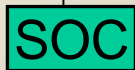
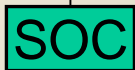
Reqs

Japan  
 India  
 ESA  
 Italy  
 China

Education  
 Public  
 Press

Qualitative

Query by Browsing









# Backup





# 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 publishable 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.)



# OSEWGW Participants

- **Craig, Douglas A. (HQ-BJ000)**
- **Durda, Daniel D. (HQ-DA000)**
- **Fogel, Robert A. (HQ-DG000)**
- **Gates, Michele M. (HQ-CI000)**
- **Giles, Barbara (HQ-DJ000)**
- **Gordon (HQ-DA000)**
- **Kakar, Ramesh (HQ-DK000)**
- **Leshin, Laurie A. (GSFC-600.0)**
- **Mendell, Wendell W. (JSC-KA)**
- **Snook, Kelly (HQ-DA000)**
- **Thomas, Andrew S. (JSC-CB)**
- **Wargo, Michael (HQ-BL000)**
- **Yoder, Geoffrey L. (HQ-BJ000)**

