NASA Advisory Council Lunar Workshop Planning

Science Subcommittees Meeting
July 6-7, 2006

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NAC Science Committee

Themes for Lunar Science Strategy

- **Consider Exploration Science, Lunar Science, and Lunar-Based Science for a Return to the Moon. (Science of.. on.. and from.. the Moon)**
- **Develop Science Objectives and Priorities as initial guidance for Return-to-the-Moon Program Planning, Spacecraft Design, Training, and Operations.**
  - Consider Decadal Survey and other Strategic planning inputs. <http://www.lpi.usra.edu/lunar_resources/documents.shtml>
  - Comparable to 1965 Woods Hole & Falmouth Conferences planning for Apollo's Lunar Exploration. <http://history.nasa.gov/SP-4214/ch3-6.html>

Workshop Objectives

- **Prioritize and justify what each subcommittee recommends that NASA plan as Science <u>objectives and priorities for the human and robotic lunar sortie missions</u> within the preliminary operational, hardware, and software constraints of those missions.**

- **Provide lunar exploration, lunar science, and lunar-based science objectives and priorities <u>specific enough to influence the design, planning, personnel training, and operation of lunar sortie systems</u>.**

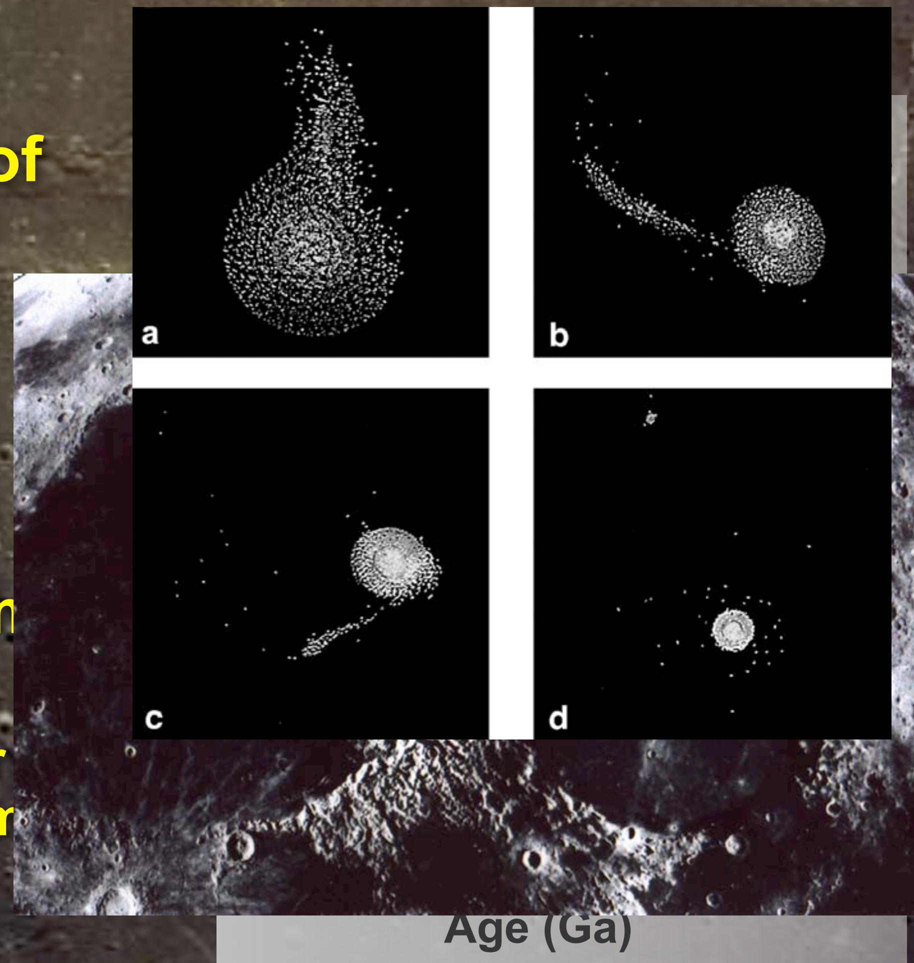
  - **Consider not just the science objectives, but also <u>how</u> they can be achieved.**

Workshop Objectives, cont

- **Ensure that NASA's exploration strategy, architecture, and hardware development enable the best and appropriately integrated science activities.**
  - Lunar Science Strategy influences Architecture.
  - Architecture sets requirements for systems design and development.
- **Identify needed Technology Developments.**
- **Identify needed Science Programs.**
  - Lunar Fundamental Research
  - Data Analysis (past, present, future mission data)
  - Other solicitations / e.g., concept studies for sortie / outpost science

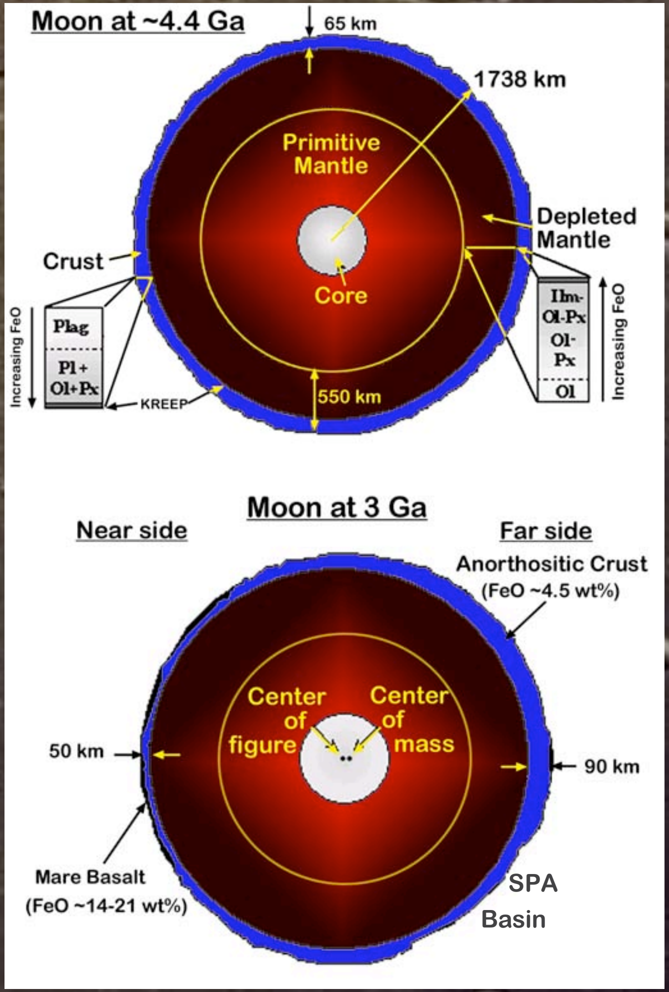
Lunar Science Key Issues

- Test Hypothesis of Origin of Moon by Giant Impact into early Earth
- Determine ages of Large Impact Basins
- Test the Impact “Cataclysm Hypothesis
  - Calibrate early Impact Histor Earth and Inner Solar System



Lunar Science Key Issues

- Global delineation of Internal Structure of the Moon; How did the early Moon differentiate?
  - Extent (depth) of early Magma Ocean
  - Distribution of different Igneous Rock Suites in the Moon's Crust
  - Original Distribution of Magma-Ocean Residual Melt (internal heat-producing material)
  - Structure / composition / variability of Upper Mantle (source of volcanic materials)
  - Lower-Mantle characteristics: composition, transitions
  - Core composition, size (implications for early magnetic field; lunar origin)



Lunar Science Key Issues, cont

- Timing of Lunar Core formation
- Nature and Cause of Moon's Global Asymmetry
- Global Sampling / Remote-sensing Correlations of major Geological and Geochemical Units
- Ages, Compositions, and Distribution of Lunar Volcanic Materials, including buried deposits
- Depositional History of Polar / Cometary Volatiles
- Determination of Resource Distribution & *In Situ* concentrations, including at the Poles; ISRU
- Lunar-Based Instrument Networks
  - Seismometers / Retro-reflectors / Heat Flow / Magnetometers

Lunar-Based Science

Heliophysics

- Lunar-Based Instrumentation
  - Sun
  - Solar Wind
  - Solar wind – Magnetosphere interaction
  - Solar wind – Lunar Surface interaction
- Regolith, Ejecta Blanket, & Basalt-flow Stratigraphy
  - Solar Wind Composition and Energy over Time
- Other?

Astrophysics

- Potential role of Moon as an Observatory Platform
  - Radio Astronomy; constant-view polar observations
- Information to evaluate designs of potential Lunar-based Observatories
  - Additional characterization of Lunar Environment
    - Dust Migration / Precipitation / Rejection
    - Geotechnical Parameters for Construction
    - Seismic Stability
  - Protection of Critical Systems
    - Dust (note Apollo Retro-reflector Stability)
    - Thermal Cycling
    - Vacuum environment
    - Radiation environment
- Galactic and Solar Radiation History
  - Regolith and Ejecta Blanket Stratigraphy
- Other ?

Earth Sciences

- Lunar-Based Instrumentation
  - Multispectral, multisensor Global observations
  - Magnetospheric Physics
  - Educational Initiatives
  - Other?

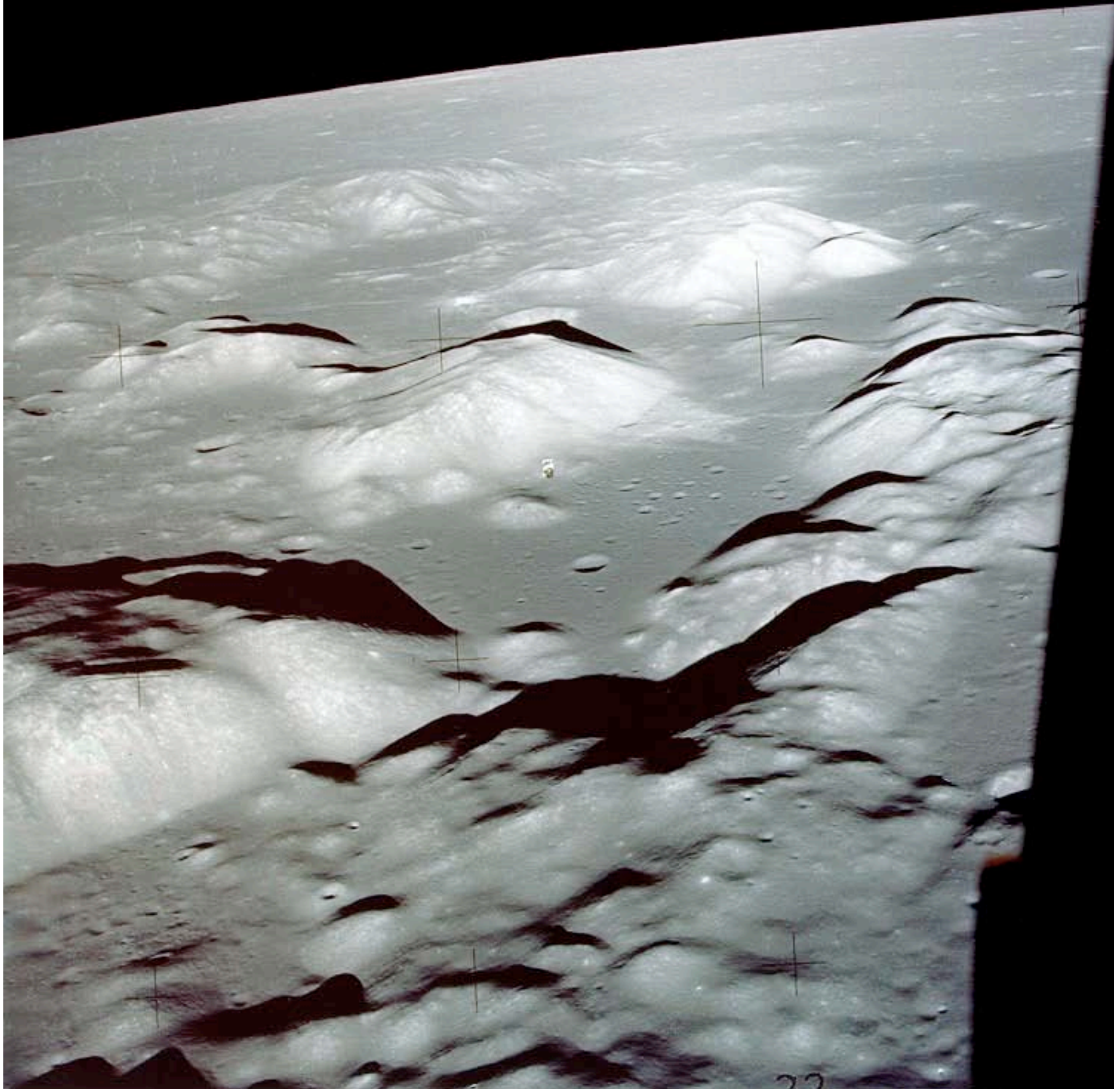
Planetary Protection

- Testing of Systems and Strategies in an Extreme Environment
  - Forward Contamination
  - Sample Container Sealing
  - Container Dust Management
  - Microbe & Organic Molecule Viability
  - Other?

Examples of Constraints from ESMD Lunar Architecture

- Site Selection
- Payload “Envelope”
- Exploration Enhancement
- Mobility Enhancement

Site Selection Considerations



Pinpoint Landing Capability

Future Location of Permanent Lunar Operations

Resources Exploration

Exploration Science

Lunar Science

Lunar-Based Science

Mars Simulations

Payload "Envelope"

Mass

Stowage

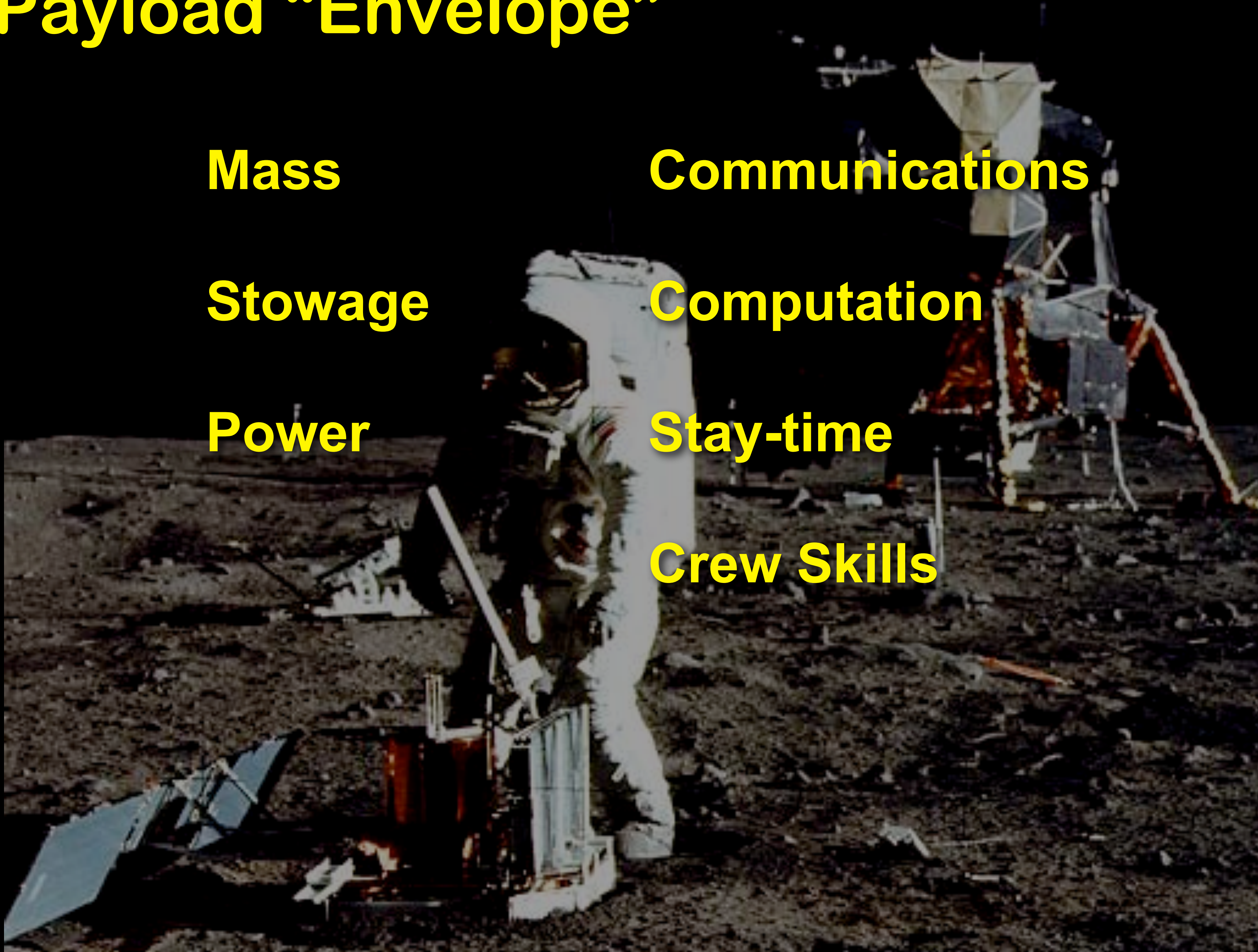
Power

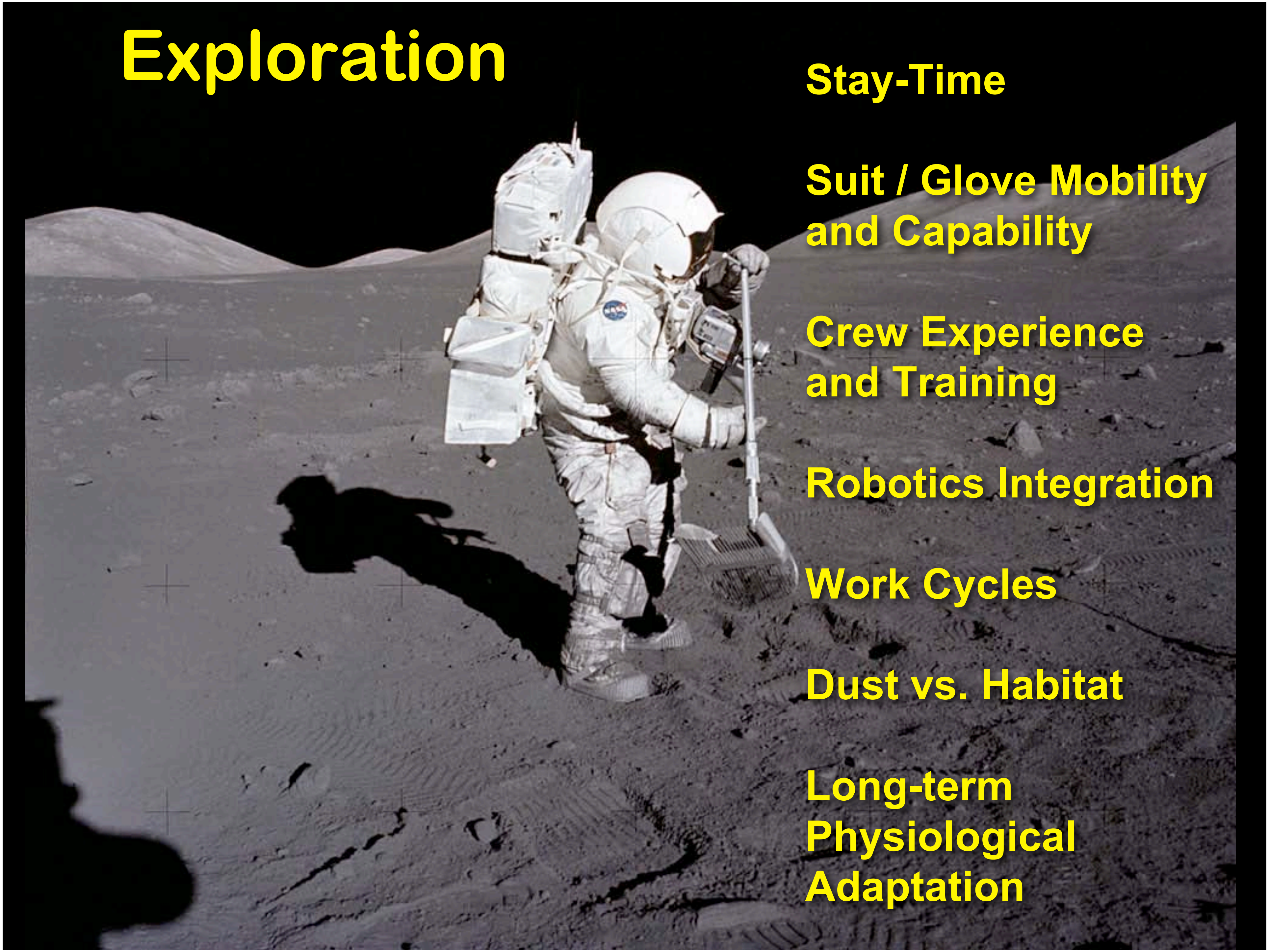
Communications

Computation

Stay-time

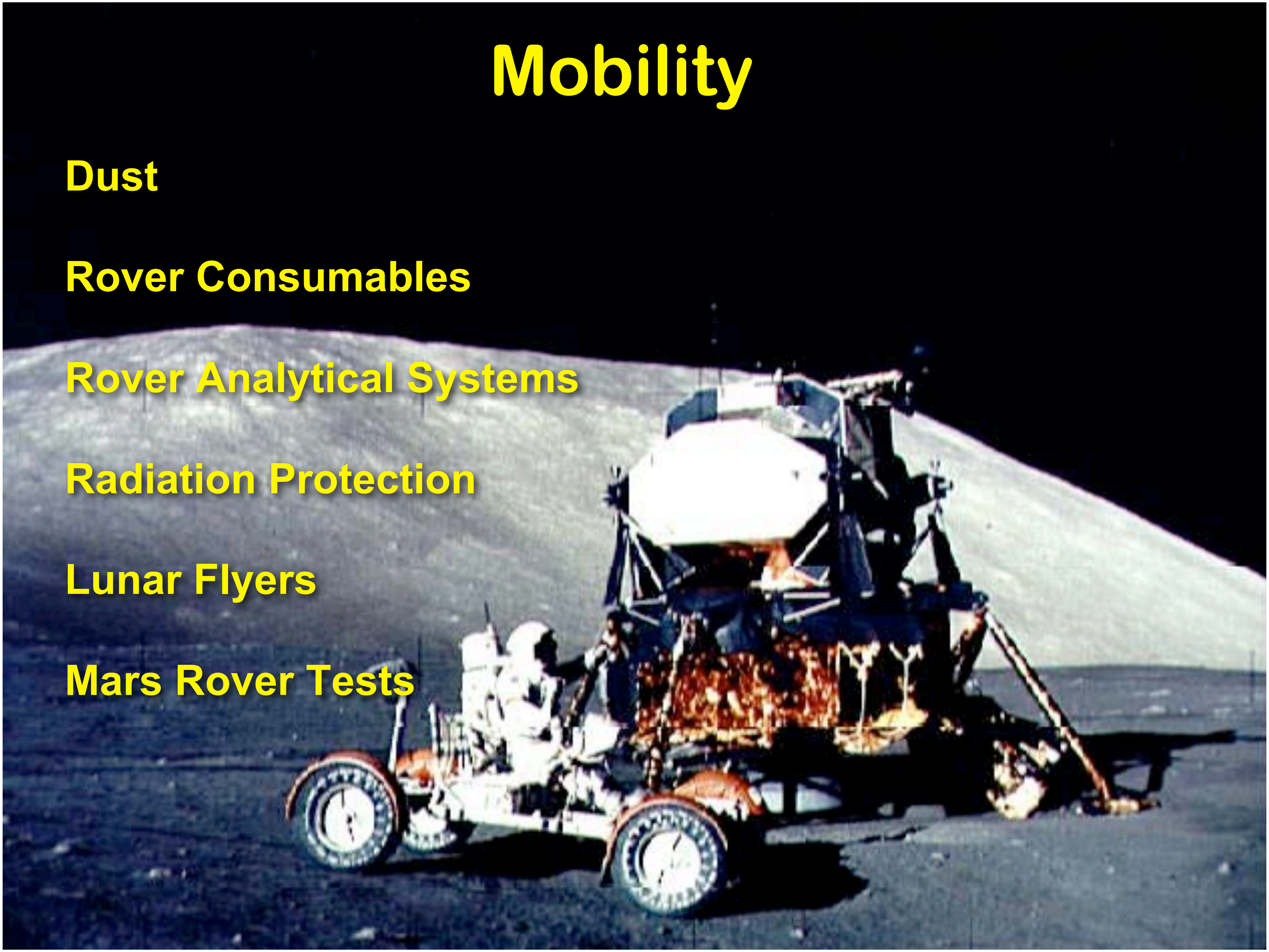
Crew Skills




Exploration
Stay-Time
Suit / Glove Mobility and Capability
Crew Experience and Training
Robotics Integration
Work Cycles
Dust vs. Habitat
Long-term Physiological Adaptation

Mobility

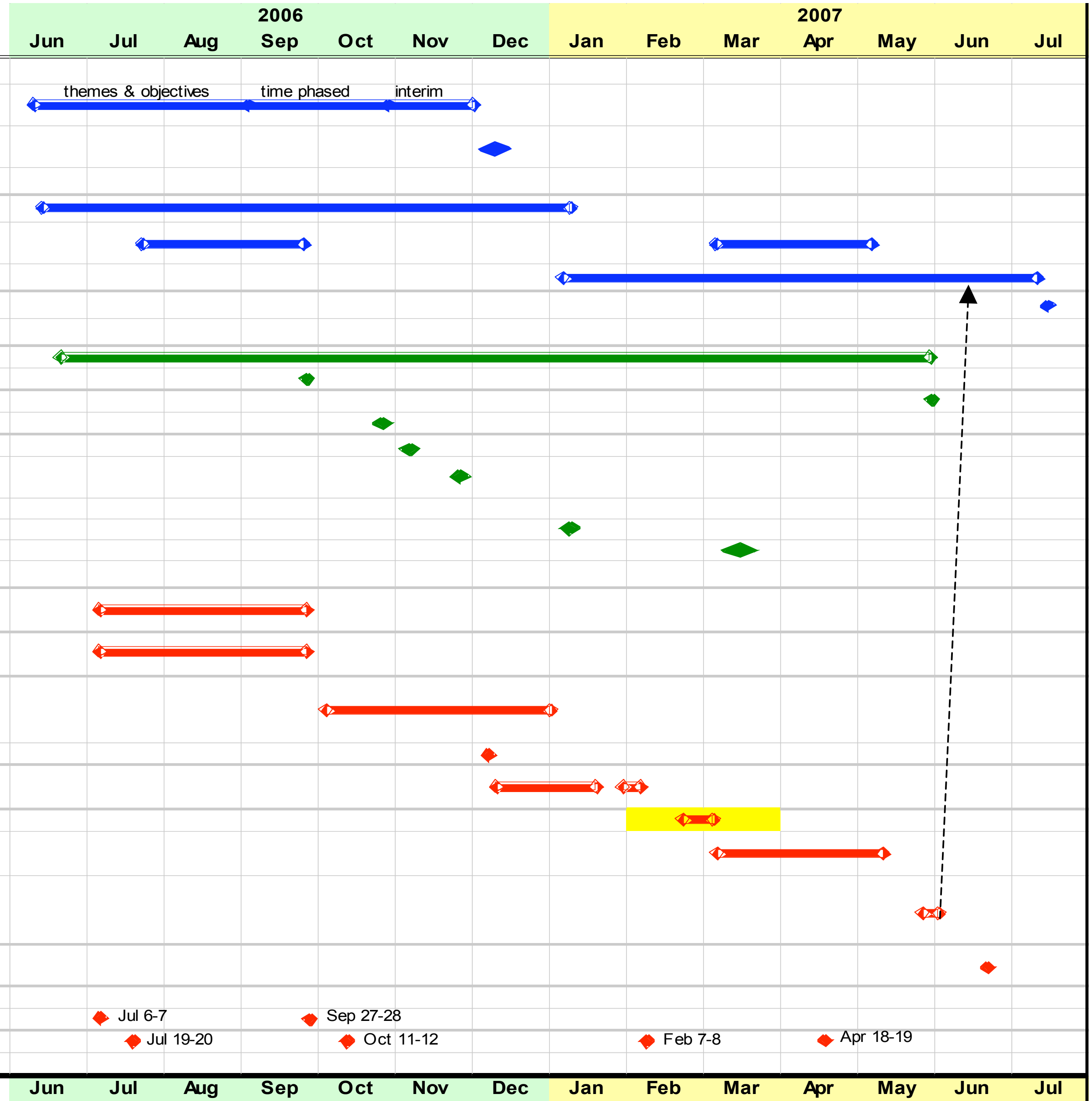
- Dust
- Rover Consumables
- Rover Analytical Systems
- Radiation Protection
- Lunar Flyers
- Mars Rover Tests



NAC Lunar Science Workshop Planning Timetable

Draft 7/6/06

Activity	Start Date	Finish Date
Stategy Development		
Global Exploration strategy development	Jun '06	Dec '06
Global Strategy Rollout/ Exploration Conf (Houston)	12/4/06	12/6/06
Architecture Development		
Baseline Architecture	6/12/06	1/10/07
Study Teams	7/24/06 3/5/07	9/26/06 5/11/07
Architecture Review & Revisions	1/15/07	7/16/07
Architecture Revisions Approved		7/16/07
External Activities		
NRC SSB Lunar Sci Study	6/20/06	5/30/07
Interim Results		9/26/06
Final Results		5/30/07
CAPTEM Meeting	10/26/06	10/27/06
OPAG Meeting	11/6/06	11/7/06
Astrophysics Enabled by Return to the Moon Workshop	11/27/06	
Other Community-based Wkshps		
MEPAG Meeting	1/10/07	1/11/07
Lunar Planet Sci Conf	3/12/06	3/17/07
NAC/Subcommittee Activities		
Review Themes/Objectives for Science Strategy	7/6/06	9/26/06
Formulate Initial Plans for Lunar Workshop	7/6/06	9/26/06
SCs & Analysis Gps review SSB interim Rpt, plan Workshop inputs	Oct '06	Jan '07
Exploration Conf (Sci Panel?)	12/5/06	
Review of ESMD draft operational constraints		1/16/2007 2/6/07
NAC Lunar Science Workshop	2/26/07	3/2/07
Synthesize Workshop Recommendations	Mar '07	May '07
Conceptual Design Review (CoDR) of Science Strategy in ESMD's draft lunar architecture	5/28/07	6/1/07
Final recommendations on Sci. Strategy to Administrator		6/22/07
Meetings		
Subcommittees		
NAC		



Workshop Strawman / Draft Outline/Agenda

- **Days 1, 2: Plenary presentations of goals and objectives by ESMD/SMD and as related to each subcommittee, including invited science presentations.**
  - Introduce all attendees to each other and to each others' interests and possible activities of interest on the Moon.
- **Days 2, 3: Separate subcommittee deliberation with each subcommittee producing a set of recommended goals and objectives to meet those goals.**
  - Subcommittees coordinate prior to Workshop (intra)
  - Establish presentation format for subcommittee product pre-Workshop
- **Day 3 evening, Day 4 morning: "Coordinating committee" integration of individual subcommittee recommendations into a strawman approach to lunar sortie mission science.**
- **Days 4, 5: Plenary discussion and editing of the strawman approach.**
- **Day 6: Coordinating Committee synthesis of Workshop results.**
  - This document, once approved by the Science Committee and the Council in April, could be given to ESMD/SMD for possible integration into the lunar architecture.

Why February 26 – March 2?

- **Lunar and Planetary Science Conference scheduled March 12-16, 2007**
  - Avoid being back-to-back with the LPSC.
  - LPSC will be attended by many of the same individuals needed for workshop deliberations.
- **Could consider March 26-30 for the workshop**
  - Avoid the additional delay if at all possible…
  - Would leave only three months to assimilate the results of the workshop in preparation for Council's late May review of ESMD draft of the first formal lunar architecture.*
    - * scheduled (per draft of 6/16/06) for publication July 16, 2007

Other Workshop Issues for Subcommittees

- **Subcommittee and Analysis Group attendance and roles**
- **Workshop Science Organizing Committee**
  - Each Subcommittee acts as a Workshop Science Organizing Committee for their discipline.
  - Each subcommittee should discuss the planning for appropriate Workshop breakout sessions, including proposed agenda topics, speakers, and products.
- **Suggestions for plenary agenda**
  - including speakers and additional group discussion topics.
  - The plenary Workshop agenda will be reviewed and approved by the NAC Science Committee.
- **Workshop Implementation and Logistics**
  - Determine constituencies & participants
  - Provide members for organizing committee
    - Subcommittee representation
    - Analysis Group representation
  - Recommend optimal dates, conference length, and location

Results of the Falmouth Conference

- **Final report summarized recommendations for the early landings, the "post-Apollo" (advanced) missions, and the more distant future when a lunar base could be contemplated.**
- **Highest priority on the early missions was:**
  1) **to return the greatest number and variety of samples possible,**
  2) **emplace long-lived surface instruments,**
  3) **geologic exploration of the landing area by the astronauts.**
- **Early missions could only sample isolated areas of the lunar surface.**
- **Later missions should survey the entire Moon and then study the equatorial belt in detail.**

Results of the Falmouth Conference, cont

- The advanced missions should be supported by an unmanned logistics system that would land additional consumable supplies and scientific equipment.
- Crews might stay up to 14 days and explore as far as 15 kilometers from the landing site.
  - Additional equipment should include analytical instruments for on-the-spot discriminatory tests on lunar material, so that astronauts could select a wider variety of samples.
- Surface transportation should be provided.
  - A wheeled vehicle with a range of 8 to 15 kilometers
  - A flying vehicle that could carry 135 kilograms of instruments from point to point over a 15-kilometer range
  - With the flying unit, astronauts could secure samples from otherwise inaccessible locations, such as a crater wall.

Workshop Motivation

Falmouth provided the best scientific advice NASA could get at the time, and its recommendations formed the basis for the earliest mission planning.

It was the first of several iterations of scientific planning that would take place during the rest of the Apollo program. NASA would make every effort to carry out as much of the program as could be done within a changing context of available resources.

Progress often seemed intolerably slow to some scientists, but in the end a gratifying proportion of the Falmouth recommendations would appear in mission plans.

http://history.nasa.gov/SP-4214/ch3-6.html

Questions, Suggestions