



**Lunar Environmental Management:
Science Input Needed for Guiding the Development of
Lunar Exploration and Use Policies**

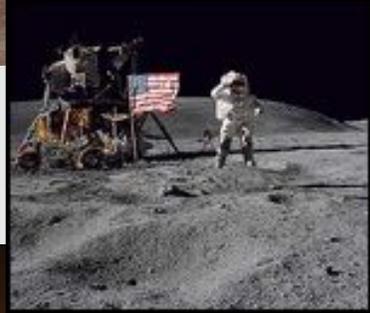
M.S.Race, C.P. McKay, J.D. Rummel



*Lunar Science for Landed Missions Workshop
SSERVI-LEAG Jan 10-12 , 2018 NASA ARC*

SSERVI-LEAG Workshop Objectives

- Produce a set of priority targets for near-term landed missions on the Moon
 - *Primarily, but not exclusively, from commercial exploration firms interested in pursuing ventures on the Moon (Partnerships?)*
 - *Target areas on the Moon for near-term in-situ science, network science, and sample return missions.*
- Intended to **stimulate discussion about specific targets**
- Initial community **consensus of priority landed targets**, with the potential of future solicitations *for science-focused payloads at such target sites.*



Overview:

The Long View:

- Exploration *and* Use of Lunar Environments
- Context: Outer Space Treaty & Other Guides
- *Sustainable, Balanced Plans, Precautionary*
- *Work Together & Recognize the Gaps-*
- ***Think Ahead – Sustainability***

in Space and On Earth (especially for the Moon)



Starting Framework: Lunar Exploration Roadmap

Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Priorities (2016)

Cross Cutting Themes

- Live & Work on Other Worlds
- Expand Earth's Economic Sphere to Encompass the Moon
- Pursue Activities to Benefit Life on Earth
- Strengthen & Create Global Partnerships
- Engage, Inspire, Educate the Public

SCIENCE EXPLORATION

Advance Understanding of:

- Formation Evolution & State of Moon
 - Volcanic & Impact Processes, Stratigraphy/Geology; Weathering, Earth-Moon System; Human Impacts etc
- Witness Plate for SS evolution etc.
- Platform for Observing Studies to Earth & Elsewhere
- Lunar Environment as 'Research Tool'
 - Human, Microbial, Technology; other; Real Time Studies

FEED FORWARD to Mars & Elsewhere

- Test Technologies, Life Support, Mobility, Resources, Power, Infrastructure; Communication, etc.
- Risk Reduction
- Prepare for Future Missions to Other Bodies

SUSTAINABILITY

- Maximize Commercial Activity
- Enable/Support Collaborative Expansion of Science & Exploration
- Enhance Security Peace & Safety



Others Also Thinking Ahead:



U.N. Outer Space Treaty (1967) *(Applies to Governments & Non-Government Entities)*

- **COSPAR** Planetary Protection.
 - Moon = Category II (No operational constraints on *in situ* activities or sample return)
 - Documentation/Categorization Letter.; Describe Mission Profile/End of Mission; Organics > 1 kg
- **COSPAR** Planetary Exploration PEX- 2010 ...New Framework Needed to
"...protect outer space environments and (*provide*) consistent & predictable legal landscape for commercial space endeavors...." [3 WORKSHOPS, stepping stone approach 2010-2013]
- **IAA**: Protecting the Environment of Celestial Bodies (2010)
- **IISL** (2009) - "On Claims to Lunar Property Rights"
- **NASA** GLXP (2011) Protect Human Heritage Sites (Scientific & Historic Value of US Government Artifacts)
- **UN COPUOS** (2010 on) – Working Group on Long Term Sustainability of Space (Voluntary Norms; Mainly LEO/GEO)
- **UN COPUOS** (2016) **Hague Space Research Governance Working Group** (legal Subcommittee)

Identification and formulation of building blocks for the governance of space resource activities as a basis for negotiations on an international agreement or non-legally binding instrument

Recommendations on the implementation strategy and forum for negotiations on an international agreement or non-legally binding instrument.

Today:
Rapidly Changing Space Activities & Issues-
Many NEW Gaps (Scientific & Otherwise)

Outer Space Treaty...

...Peaceful Exploration & Use for Benefit of Mankind...

Potential Conflicts, Societal Concerns & Policy Gap

What/ How contribute to next round of policy?

- **Exploration (Science) and 'Use' (all other activities)**
- **OST Mute on Resource Utilization & Environ. Mgmt.**
- **No Code of Conduct or EIS/Review Process**
- **International Areas- No Sovereignty**
- **No Oversight or Enforcement**
- **Soft Law Approach**
- **What is 'Sustainability' or Stewardship?**

(Also consider indirect Impacts on Earth?)





Outer Space Treaty of 1967

*50 Years of Guidance & Regulations
but Duality in Implementation*

LEO & GEO

Multiple Stakeholders
Many Legal Issues

Liability
Harmful Interference
Ownership of Assets
Rescue / Mutual Aid
Access to Communic. Freqs.
Access to Orbital Assets Satellites
Remote Sensing
Space Debris
Launch Licenses
Jurisdiction over national entities

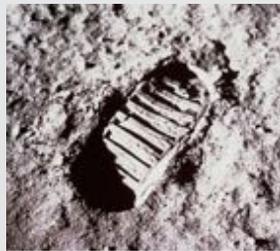
** No Planetary Protection **

Moon & Celestial Bodies

Scientists & Governments
Single Legal Issue

Planetary Protection

Nothing Yet on:
*Environmental Use
Environmental Mgmt.
Claims/Rights
Multiple Stakeholders
Time Frames?
etc.*



What's Ahead?



- **'Use' & 'Development' Also Addressed in Treaty**
 - Not just government & science activities- (For Benefit *and Use* by All Mankind)
- **Many Other 'Plans' Ahead** (Can Proceed Quickly – e.g. Apollo program)
 - Google Lunar X Prize
 - “Lun-Ex” Commercial Payload Delivery (Spacecraft Bus with airline-type cost sharing)
 - Bases & Infrastructure (incl. Waste Disposal and Power Supply)
 - Space Ports
 - Mineral and Resource Use (strip mining; In Situ Resource Utilization ISRU; rare minerals)
 - Water Ice Uses?
 - Astroburials ? Advertisements, etc.
 - Tourism and Astro-adventurism (individuals)
 - Far Side Telescopes?
 - Communications Infrastructure
 - Terraforming and Large Scale Changes
 - “Rights” to resources-- US Space Legislation; Luxembourg (asteroids)



APPEAL to Workshop Participants

- **As Think About Landing Sites & Science Priorities, ALSO CONSIDER:**
 - Mixed Use Guidelines for Exploration... what goes into it?
 - Multidisciplinary– Future long range?
 - 'Strawman' Framework for Non-Habitable Bodies? (like the Moon)
 - What Criteria (not Bio-Geo-Chemical Sustainability like on Earth)
 - Issues, Timelines, Environments of concerns?
- **Consider Scientific Criteria for Env. Protection & Sustainability & Uses**
 - Ex. Off Limits? Blended Uses? No Restrictions?
 - Science Protection/ Environmental Concerns ?
 - Resource Management (not 'habitable' environment under PP policies)
 - Balance Stakeholders? Now? Intermediate? Long Term?
 - Approaches Like Antarctica and Other Unusual Habitats?
(Extremes - Undersea, Sub-Surface? Deserts? Volcanoes? etc.)

Looking Ahead

Think Outside the Box... While Thinking About Landing Sites & Science
Consider **KEY INFO** Needed for in Policy Areas for Moon
Science & Other Criteria? Locations?

Think Outside the Agenda... An Invitation
Informal Discuss/Debate Strawman Guidelines?

Over Refreshments ?
Thursday evening (5:00 pm or ?)

Plan Ahead and Share: *Two Feed Forward Opportunities:*

- **COSPAR** July 2018 Pasadena for PEX Session?
- **UNISPACE +50** Vienna June 2018 *Fifty years since the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (1968 - 2018):*
 - Gather & consider the future course of global space cooperation for the benefit of humankind.
 - Build a comprehensive Space2030 agenda for the contribution of space activities to the achievement of the Sustainable Development Goals

