International Space Exploration Coordination Group Science White Paper

Space Studies Board 2015 Fall Meeting

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About ISECG

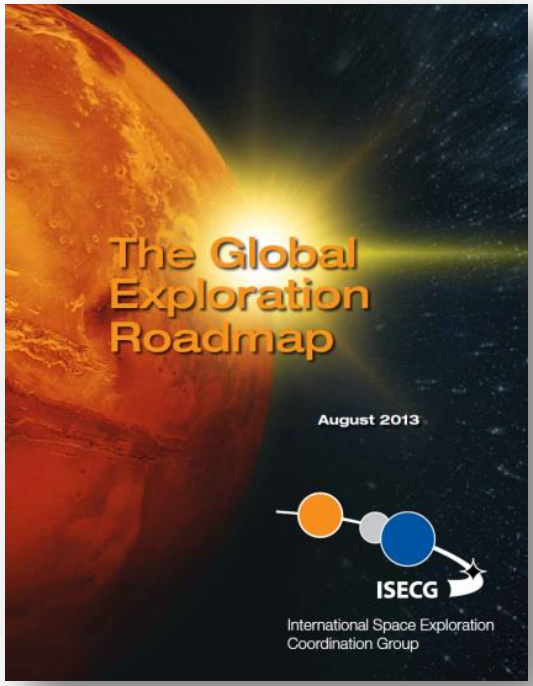
- **ISECG is a non-political agency coordination forum of 14 space agencies**
  - Website: www.globalspaceexploration.org

- **Work collectively in a non-binding, consensus-driven manner towards advancing the Global Exploration Strategy**
  - Provide a forum for discussion of interests, objectives and plans
  - Provide a forum for development of conceptual products
  - Enable the multilateral or bilateral partnerships necessary to accomplish complex exploration missions
  - Promote interest and engagement in space exploration among citizens and society

- **ISECG operating principles**
  - Open and inclusive
  - Flexible and evolutionary
  - Effective
  - Mutual interest

About the Global Exploration Roadmap

- **The GER is a human space exploration roadmap, recognizing the criticality of increasing synergies with robotic missions while demonstrating the unique and important role humans play in realizing societal benefits**
- **The non-binding document reflects a framework for agency exploration discussions on:**
  - Common goals and objectives
  - Long-range mission scenarios and architectures
  - Opportunities for near-term coordination and cooperation on preparatory activities
- **Since release of updated GER in August 2013, participating agencies have continued discussions and joint work in several areas which are of mutual interest**
  - Increase understanding of design reference missions for early mission themes
- **Highlighting opportunities for the science community with a dedicated Science White Paper and within the GER itself is a priority**



The Global Exploration Roadmap

ISECG

2013 2020 2030

International Space Station

General Research and Exploration Preparatory Activities

Note: ISS partner agencies have agreed to use the ISS until at least 2020.

Commercial or Government Low-Earth Orbit Platforms and Missions

Robotic Missions to Discover and Prepare

LADEE
Luna-25
Chandrayaan-2
Luna-26
Luna 27
RESOLVE
SELENE-2
Luna 28/29
SELENE-3
Rosetta
Hayabusa2
OSIRIS-REx
Apophis
MAVEN
ISRO Mars
ExoMars
InSight
ExoMars
Mars 2020
JAXA Mars Precursor

Mars Sample Return and Precursor Opportunities

Human Missions Beyond Low-Earth Orbit

Explore Near-Earth Asteroid

Multiple Locations in the Lunar Vicinity

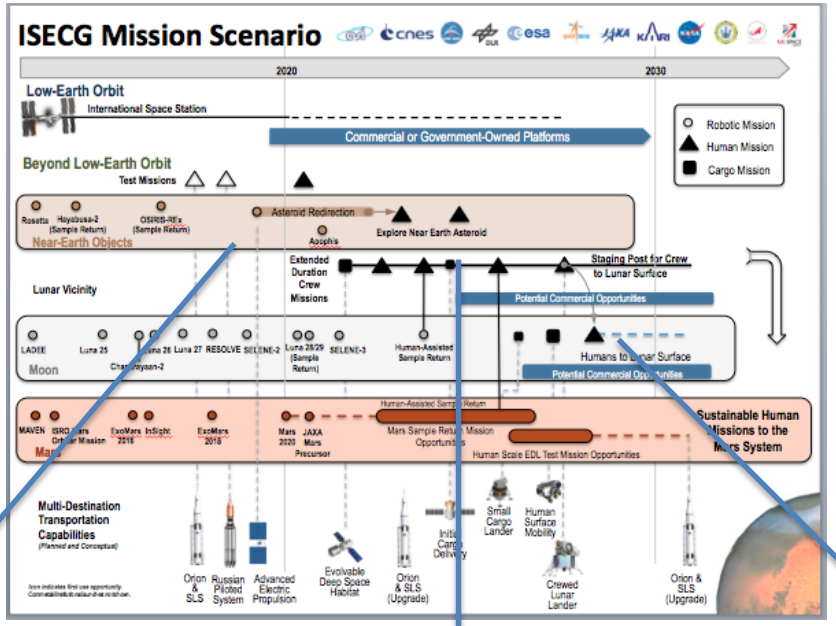
Extended Duration Crew Missions

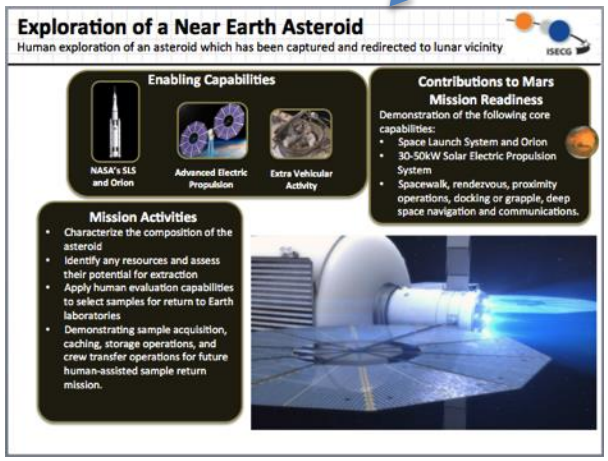
Humans to Lunar Surface

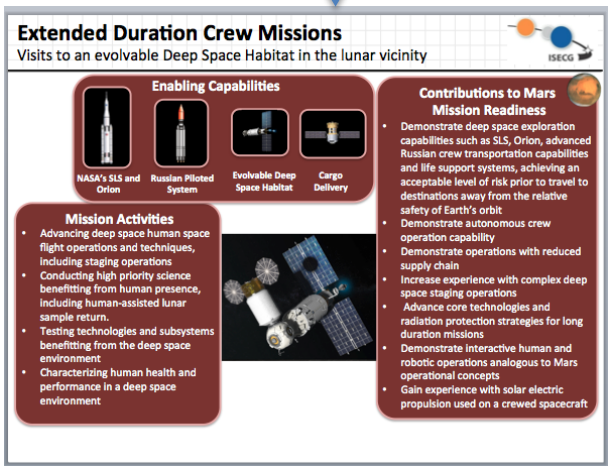
Missions to Deep Space and Mars System

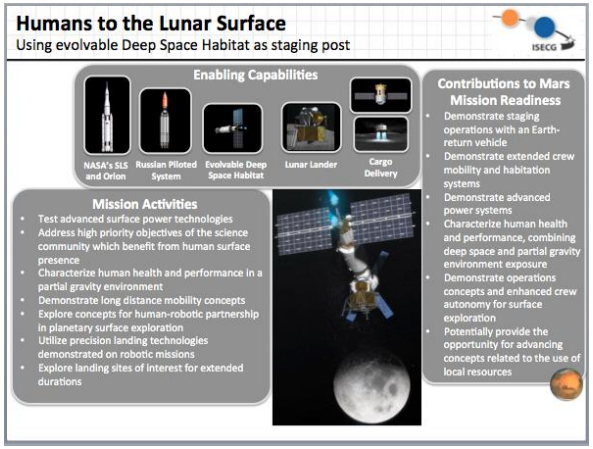
Sustainable Human Missions to Mars Surface

GER Mission Themes









GER Destination Themes Reference Missions

Cislunar Deep Space Habitat

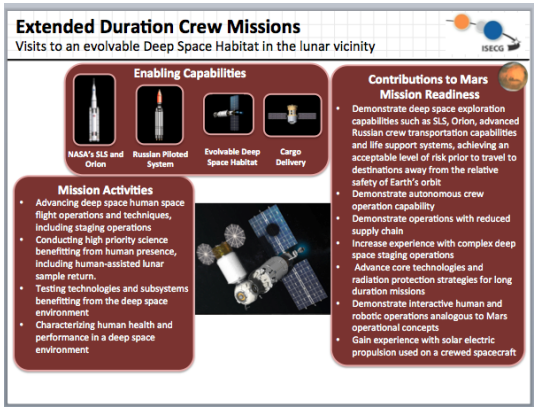
- Crew of four
- Initially annual missions lasting 30 days
- Increase both duration & frequency later in the decade.

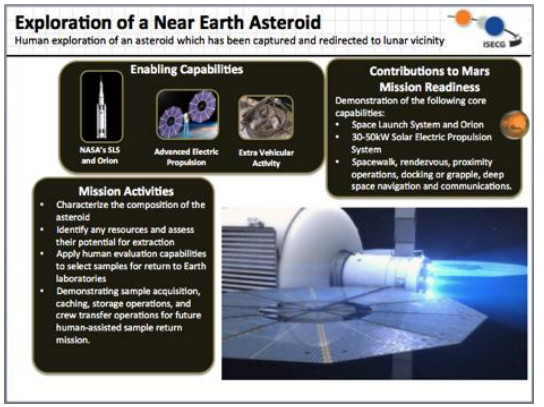
Near Earth Asteroid in Cislunar space

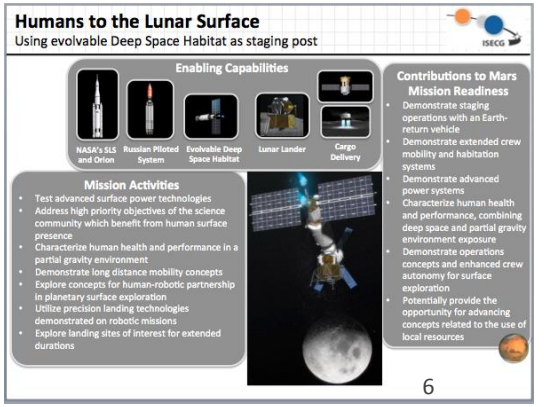
- Boulder collected using SEP-based s/c
- Crew of two visits asteroid boulder in lunar DRO

Lunar Surface

- Five 28-day missions with a crew of four
- One mission per year
- Reuse pressurized rover for each mission
- Rover is moved to next landing site in between crewed visits







ISECG Interaction with Scientific Communities

- **ISECG agencies acknowledge science communities as major stakeholders and scientific knowledge gain as important benefit of exploration activities.**
  - Scientists in general support GER and want to engage in the discussion.

- **Several agencies agreed in winter 2014/15 to facilitate interaction**
  - ASI, **CNES**, CNSA, CSA, **DLR**, ESA, JAXA, NASA, SSAU, UKSA (+ESF, SSERVI)

- **Objectives**
  - Coordinate **interaction with the science communities** on exploration planning and activities as required for the generation of ISECG products
  - Advance the development of a **Science White Paper** for the articulation of science opportunities in the GER in conjunction with the science communities

Science White Paper – Concept & Scope

- **Describe an international view of the science that could be enabled by human missions in the GER**
  - Engage the scientific communities in identifying these opportunities
  - Target the same stakeholder community as the GER
  - Focus on human missions and human/robotic concepts
  - Incorporate activities that have feed-forward benefits to Mars exploration

- **Incorporate interdisciplinary scientific topics that**
  - Encompass all relevant science communities and disciplines: planetary science, space science, life sciences, astrobiology, astronomy, physical sciences, etc.
  - Span all destinations (LEO, cis-lunar space, Moon, asteroids, Mars)
  - Incorporate input from the international science communities

Science Advisory Group Membership

- **Co-chairs:**
  1. Ben Bussey (NASA, USA) david.b.bussey@nasa.gov
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- **Members**
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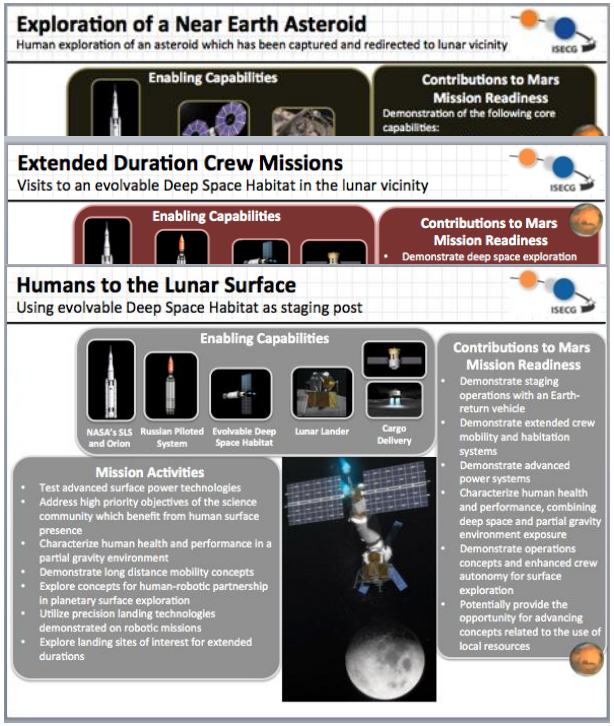
- **Executive Secretary**
  - Greg Schmidt (SSERVI, USA) gregory.schmidt@nasa.gov

Science White Paper – Development Process

- **Apply a transparent, interactive process that stimulates discussion on science opportunities in preparation of GER3**

GER Mission Themes



SWP Concept & Scope — Oct. 2014 — ISECG agencies

Overarching Science Topics

Science Opportunities

Editing & Review

Authors from science communities (led/guided by international Science Advisory Group)

SWP Publication — Fall 2016 — ISECG agencies

SWP Structure

Table of Contents (as of 10/2015) – total ~20 pages

- **Scope & Purpose**
  - Broad interaction between science communities and ISECG agencies
- **Exec. Summary (2)**
- **1. Linkage to GER (2)**
  - GER approach
    - Connect to Goals & Objectives
    - Long-term horizon goal (Mars)
    - Near-term destination focus
  - Human-robotic partnership / Value of human presence
- **2. Science Topics (2)**
  - Introduce topics
  - Spans all destinations
  - Incl. many scientific disciplines
- **3. Cislunar Deep Space Habitat (4)**
- **4. NEA in Cislunar Space (4)**
- **5. Lunar Surface (4)**
  - Each chapter 3-5 to highlight
    - Short summary of the mission theme including DRMs
    - Scientific opportunities structured by science topics
    - Science findings
- **Conclusion (1)**
- **References (1)**
  - E.g. GER2, COSPAR PEX, Decadal Surveys, MEPAG report, ILEWG, others, …

SAG-SWP Process

- **Each destination chapter has 2 SAG co-leads**
  - Science Opportunities of a Cislunar Deep Space Habitat
    - » Co-Leads: Giles Clement & Gordon Osinski
  - Science Opportunities at a NEA in Cislunar space
    - » Co-Leads: Masaki Fujimoto & Tim McCoy
  - Science Opportunities on the Lunar Surface
    - » Co-Leads: Ian Crawford & Clive Neal
  - Other SAG members may choose to support one or more chapters

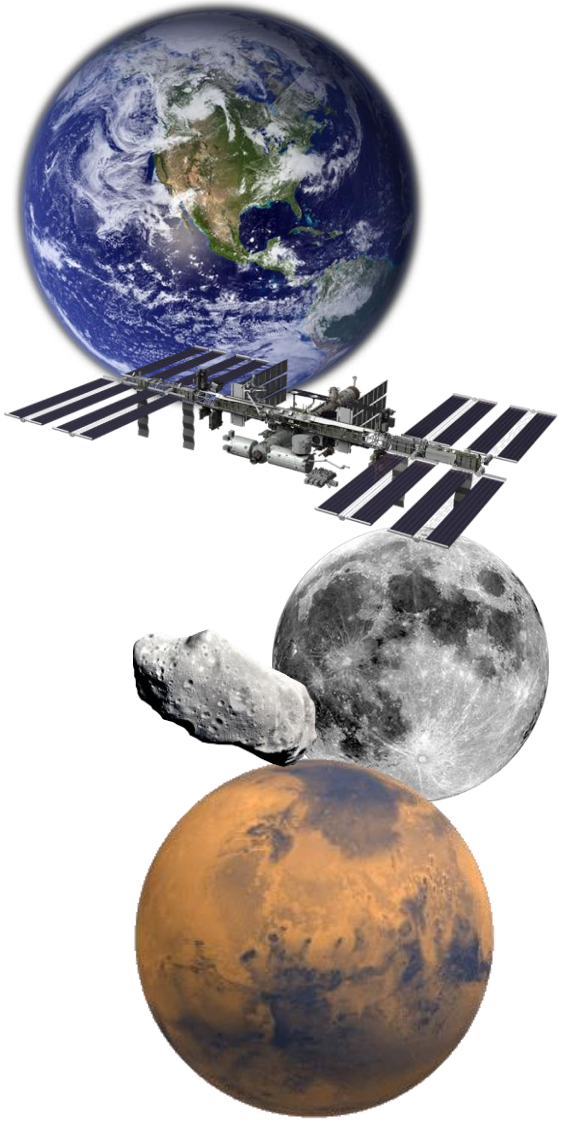
- **Chapter co-leads solicit input from subject experts in the community**

- **Additional community 2-way interaction and feedback by presenting initial science ideas at major meetings**
  - European Lunar Symposium, Small Bodies Assessment Group (SBAG), Lunar Exploration Analysis Group (LEAG), ESA Moon 2020-2030 Workshop, Exploration Science Forum
  - SWP COSPAR/SWG workshop planned for February 2015 in Paris

SWP Science Topics

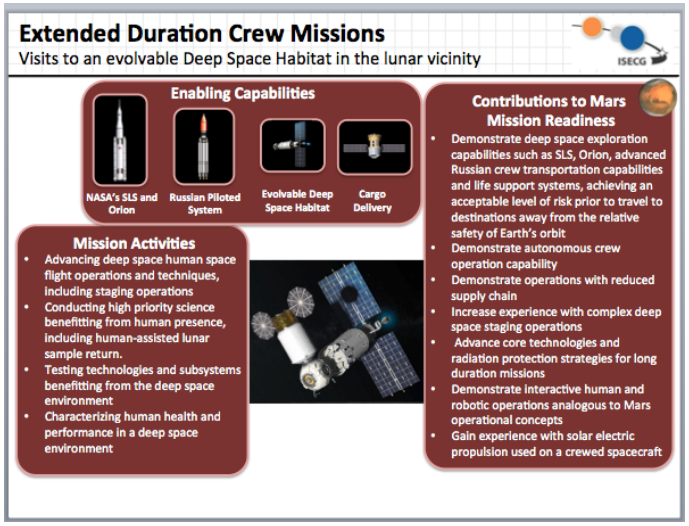
- **Living and working in space**
  - Overarching questions:
    - How do we become a spacefaring species?
    - How do we sustain life outside Earth?
  - Disciplines involved, e.g.
    - Human physiology, life sciences and life support
    - Prospecting and utilising local resources

- **Our place in the universe**
  - Overarching question:
    - How do terrestrial planets form and evolve?
    - How does life evolve in the planetary environment?
  - Disciplines involved, e.g.
    - Astronomy
    - Planetary geology
    - Solar physics, space physics
    - Astrobiology (understanding the building blocks of life)



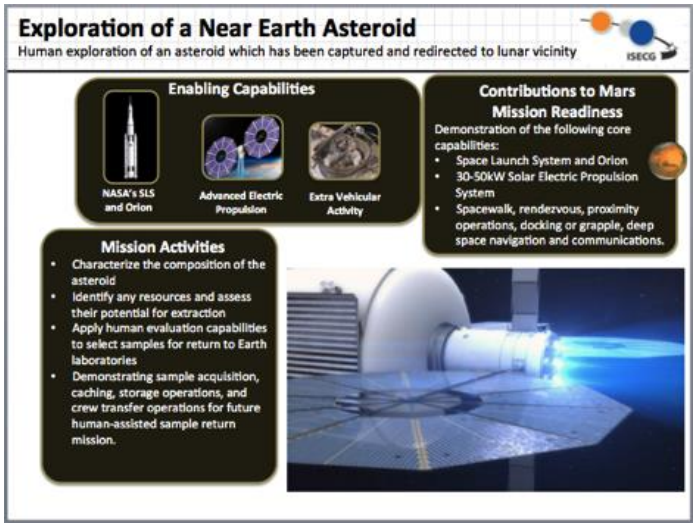
Science Enabled by Humans to a Cislunar Habitat

- **Human-assisted lunar sample return**
  - Increased return through more and improved selection of lunar samples
- **Construct and/or service large space telescopes**
- **Understand combined effects of radiation/reduced-gravity/isolation on humans**
- **Monitor Earth's climate to help design exoplanet observing instrument**
- **Facilitate access to challenging regions by low-latency telerobotics (e.g. permanently shadowed crater floors)**
  - Telerobotics experience useful for Mars exploration



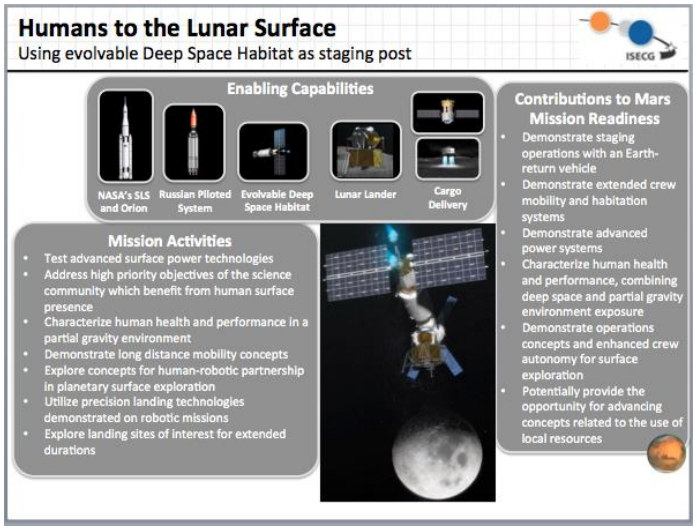
Science Enabled by Humans to a NEA

- **Sample return provides key science**
  - Humans permit careful selection of samples for high sample quality
  - Larger sample return mass compared to robotic missions
  - Increase the value of the current meteorite collections
  - Provide an archive of samples for analyses that must be done on Earth
- **Increased surface access**
  - Multiple drilling sites
  - Exposure ages at different depths
- **Instrument deployment**
  - Placing instruments on the surface enabled by humans
  - Long-term instrument deployment



Science Enabled by Humans to the Lunar Surface

- **Sample return provides key science**
  - Humans best at identifying scientifically important samples
  - Improve our understanding of impact cratering
  - Provide insight into the evolution of the terrestrial planets
  - Study the history of the Sun
- **Understand lunar volatiles**
  - Record of the flux and composition of volatiles
  - Help answer astrobiological questions
  - Install and maintain resource utilization equipment (i.e. generate water)
- **Emplacement of delicate or large astronomical instruments**
- **Understand the physiological effects of the lunar environment on human health, contributing to medical benefits on Earth**
- **Understand how plants and other non-human forms of life adapt to, or can be protected from, the conditions on hostile planetary surfaces**
- **Feed-forward activities (using the Moon as a gateway to the Solar System)**



SSERVI

SSERVI is a virtual institute established to advance basic and applied lunar and planetary science research and to advance human exploration of the solar system through scientific discovery.

SSERVI ***builds bridges*** between:

- SMD and HEOMD
- Destinations (comparative planetology)
- Teams (rapid inter-team collaborations)
- Teams and the wider scientific community
- Disciplines
- International and domestic partners
- Government and commercial partners
- Generations of researchers