
Global Exploration Roadmap Science White Paper Overview & Status

Greg Schmidt

Deputy Director, SSERVI

Exec. Secretary, GER SWP

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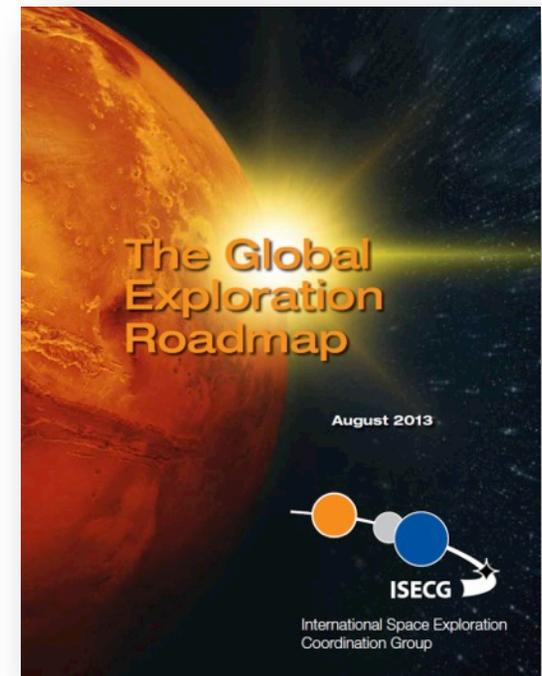
- ◆ **International Space Exploration Coordination Group**
- ◆ **ISECG is a non-political agency coordination forum of 14 space agencies**
 - Website: www.globalspaceexploration.org
- ◆ **Work collectively in a non-binding, consensus-driven manner towards advancing the Global Exploration Strategy**
 - 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



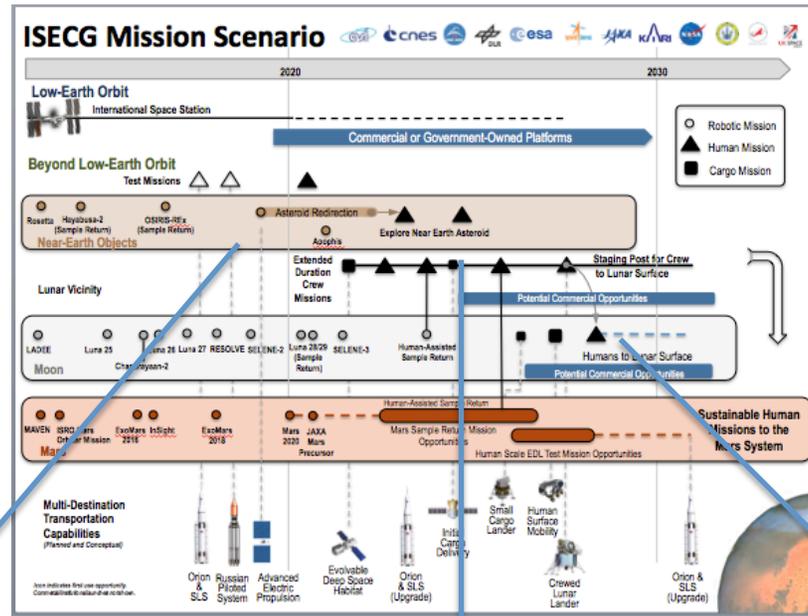
Global Exploration Roadmap



- ◆ **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**
 - China (CNSA) has joined the dialog
 - 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**
- ◆ **Version 3 to be completed in 2016**



GER Mission Themes



Exploration of a Near Earth Asteroid

Human exploration of an asteroid which has been captured and redirected to lunar vicinity

Enabling Capabilities

- NASA's SLS and Orion
- Advanced Electric Propulsion
- Extra Vehicular Activity

Contributions to Mars Mission Readiness

- Demonstration of the following core capabilities:
 - Space Launch System and Orion
 - 30-50kW Solar Electric Propulsion System
- Spacewalk, rendezvous, proximity operations, docking or grapple, deep space navigation and communications.

Mission Activities

- Characterize the composition of the asteroid
- Identify any resources and assess their potential for extraction
- Apply human evaluation capabilities to select samples for return to Earth laboratories
- Demonstrating sample acquisition, caching, storage operations, and crew transfer operations for future human-assisted sample return mission.

Extended Duration Crew Missions

Visits to an evolvable Deep Space Habitat in the lunar vicinity

Enabling Capabilities

- NASA's SLS and Orion
- Russian Piloted System
- Evolvable Deep Space Habitat
- Cargo Delivery

Contributions to Mars Mission Readiness

- Demonstrate deep space exploration capabilities such as SLS, Orion, advanced Russian crew transportation capabilities and life support systems, achieving an acceptable level of risk prior to travel to destinations away from the relative safety of Earth's orbit
- Demonstrate autonomous crew operation capability
- Demonstrate operations with reduced supply chain
- Increase experience with complex deep space staging operations
- Advance core technologies and radiation protection strategies for long duration missions
- Demonstrate interactive human and robotic operations analogous to Mars operational concepts
- Gain experience with solar electric propulsion used on a crewed spacecraft

Mission Activities

- Advancing deep space human space flight operations and techniques, including staging operations
- Conducting high priority science benefiting from human presence, including human-assisted lunar sample return.
- Testing technologies and subsystems benefiting from the deep space environment
- Characterizing human health and performance in a deep space environment

Humans to the Lunar Surface

Using evolvable Deep Space Habitat as staging post

Enabling Capabilities

- NASA's SLS and Orion
- Russian Piloted System
- Evolvable Deep Space Habitat
- Lunar Lander
- Cargo Delivery

Contributions to Mars Mission Readiness

- Demonstrate staging operations with an Earth-return vehicle
- Demonstrate extended crew mobility and habitation systems
- Demonstrate advanced power systems
- Characterize human health and performance, combining deep space and partial gravity environment exposure
- Demonstrate operations concepts and enhanced crew autonomy for surface exploration
- Potentially provide the opportunity for advancing concepts related to the use of local resources

Mission Activities

- Test advanced surface power technologies
- Address high priority objectives of the science community which benefit from human surface presence
- Characterize human health and performance in a partial gravity environment
- Demonstrate long distance mobility concepts
- Explore concepts for human-robotic partnership in planetary surface exploration
- Utilize precision landing technologies demonstrated on robotic missions
- Explore landing sites of interest for extended durations

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

Science White Paper – Concept & Scope



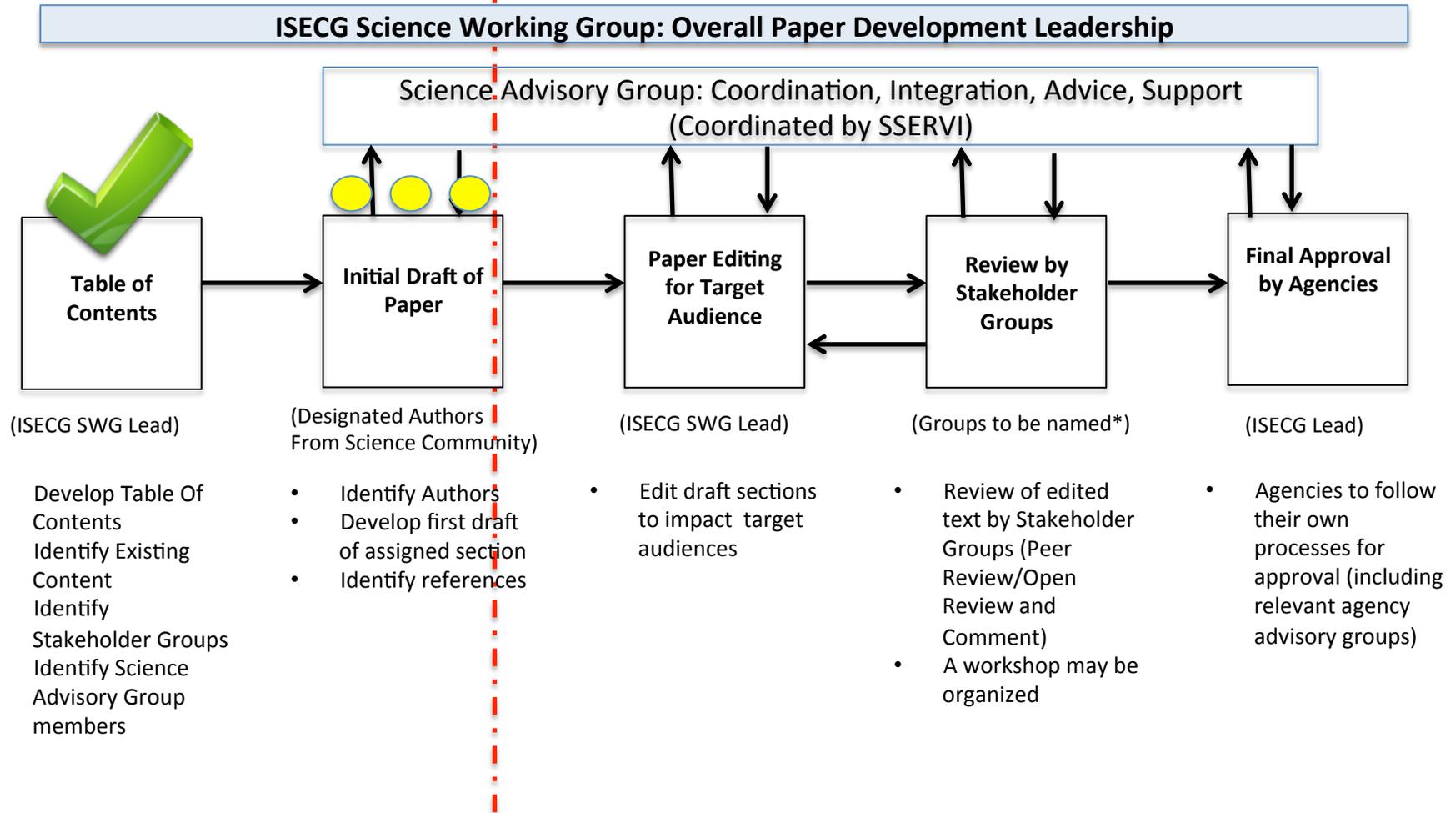
- ◆ **Target Audience: agency-level policymakers**
- ◆ **Describe an international view of the science that could be enabled by missions in the GER**
 - Engage the scientific communities in identifying these opportunities
 - Target the same stakeholder community as the GER – stakeholders, decision makers, broader human space exploration community while engaging the scientific community → concise formulation
 - Distribute as a companion document to the GER with next update (2016)
 - Focus on human missions and human/robotic concepts with emphasis on early mission themes, but incorporate the driving science priorities up to Mars
- ◆ **Foster a deeper mutual understanding of priorities, challenges and opportunities for both scientific and exploration communities**
- ◆ **Incorporate interdisciplinary scientific themes that**
 - involve various communities, e.g. Planetary Science, Space Science, Life Sciences, Astrobiology, Astronomy, Physical Sciences, potentially including Strategic Knowledge Gaps
 - Links to and translates substantive authoritative literature from the international science community
- ◆ **Transparent, interactive process allows for two-way communication on science opportunities and feedback on GER missions**

Paper Development Process



All dates
TBC

Oct 2014 → Feb 2015 → Summer 2015 → Jan 2016 → April 2016 → Summer 2016



* Groups expected to include LEAG, SBAG, MEPAG, COSPAR, IMEWG, IPEWG, ISLSWG, national science groups, others

SAG Membership



◆ Co-chairs:

1. Ben Bussey (NASA HEOMD Chief Scientist, USA) david.b.bussey@nasa.gov
2. Jean-Claude Worms (ESF, France) jcworms@esf.org

◆ Members

3. Gilles Clement (Univ. of Lyon, France) gilles.clement@inserm.fr
4. Ian Crawford (Univ. of London, UK) i.crawford@ucl.ac.uk
5. Mike Cruise (Univ. of Birmingham, UK) a.m.cruise@bham.ac.uk
6. Masaki Fujimoto (JAXA, Japan) fujimoto@stp.isas.jaxa.jp
7. Dave Hart (Univ. of Calgary, Canada) hartd@ucalgary.ca
8. Ralf Jaumann (DLR, Germany) Ralf.Jaumann@dlr.de
9. Clive Neal (Notre Dame Univ., USA) neal.1@nd.edu
10. Gordon Osinski (Univ. of West. Ontario, Canada) gosinski@uwo.ca
11. Masaki Shirakawa (JAXA, Japan) shirakawa.masaki@jaxa.jp
12. Tim McCoy (Smithsonian, USA) mccoyt@si.edu

◆ Executive Secretary

- Greg Schmidt (SSERVI lead, USA) gregory.schmidt@nasa.gov

KEY MESSAGE: THE SAG MEMBERSHIP IS STILL OPEN, ESPECIALLY TO ISECG AGENCIES AND COUNTRIES NOT YET REPRESENTED

SAG-SWP Support



- ◆ **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.**

SWG Product Development



Table of Contents (as of 04/2015) – total ~20 pages

- ◆ **Exec. Summary (2)**
 - Methodology / Process
 - Document is developed by ISECG agencies incorporating science community perspectives
- ◆ **1. Linkage to GER (2)**
 - GER approach
 - Connection to GER Goals & Objectives (?)
 - Long-term horizon goal (Mars)
 - Near-term destination focus
 - Human-robotic partnership / Value of human presence
- ◆ **2. Science Topics (2)**
 - Capture the scientific interest of Moon/Asteroid research
 - Science topics (overview)
- ◆ **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 → SWG
 - Scientific opportunities in relation to the science topics → SAG
 - Science recommendations → SAG
- ◆ **Conclusion (1)**
- ◆ **References (1)**
 - E.g. GER3, COSPAR PEX, Decadal Surveys, MEPAG report, ILEWG, others

◆ Living and working in space (= applied science ?)

- Overarching question(s):
 - How do we become a spacefaring species?
 - How do we sustain life in hostile environments? / Is life outside Earth sustainable? / Is human life confined to Earth?
- Disciplines involved, e.g.
 - Human physiology, life sciences and life support
 - Prospecting and utilizing local resources

◆ Our Place in the universe (= fundamental science ?)

- Overarching question(s):
- Disciplines involved, e.g.
 - Astronomy
 - Planetary formation and evolution
 - Solar physics, space physics
- Co-evolution of life in the planetary environment ?
- Understanding the building blocks of life = astrobiology ?

Discussion



- **Website – up soon!**
 - **Check sservi.nasa.gov**
- **Drafts will be released to the community ~Fall 2015**
- **Future review sessions**
 - **LEAG annual meeting**
 - **AGU?**
 - **LPSC**
 - **Online**