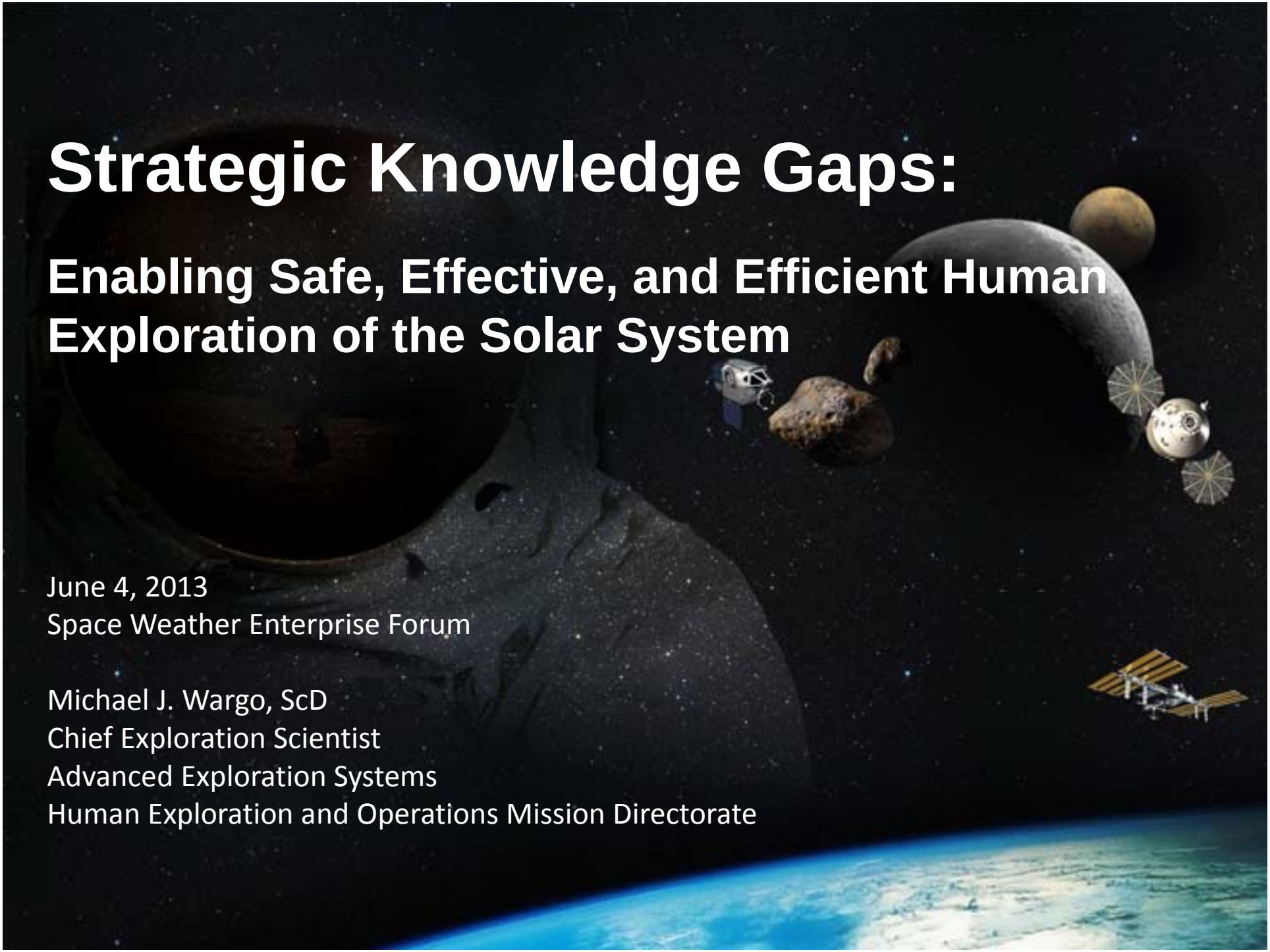

Strategic Knowledge Gaps:

Enabling Safe, Effective, and Efficient Human Exploration of the Solar System

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Michael J. Wargo, ScD
Chief Exploration Scientist
Advanced Exploration Systems
Human Exploration and Operations Mission Directorate

Background and Context

Science Enables Exploration

Exploration Enables Science

Background and Context

NASA has recently created the Joint Robotic Precursor Activities (JRPA) effort.

- It is a joint effort between the Advanced Exploration Systems Division within Human Exploration and Operations, and the Planetary Science Division of the Science Mission Directorate.
- These precursor activities will strive to characterize the engineering boundary conditions of representative exploration environments, identify hazards, and assess resources.
- These activities will provide knowledge to inform the selection of future destinations, support the development of exploration systems, and reduce the risk associated with human exploration.
- Strategic Knowledge Gap identification, prioritization, and phasing provides a capable tool to inform our investment strategy.

Informing Exploration: Strategic Knowledge Gaps

- **To inform mission/system planning and design and near-term Agency investments**
  - Human Spaceflight Architecture Team (HAT) Destination Leads were asked to identify the data or information needed that would reduce risk, increase effectiveness, and aid in planning and design
  - The data can be obtained on Earth, in space, by analog, experimentation, or direct measurement
- **For some destinations, significant work has already been done, and the needed knowledge is well identified**
  - Community based fora, such as the Lunar Exploration Analysis Group (LEAG) and the Mars Exploration Program Analysis Group (MEPAG), have identified pertinent measurements to gain the needed knowledge regarding the Moon and Mars
  - Significant advances in filling the knowledge gaps have been made [examples: Lunar Reconnaissance Orbiter (LRO), the Mars Reconnaissance Orbiter (MRO), and now, the Mars Science Laboratory (MSL)]
- **The Strategic Knowledge Gaps (SKGs) identified here will:**
  - Provide NASA's foundation for achieving an internationally developed and accepted set of integrated and prioritized SKGs through the International Space Exploration Coordination Group's (ISECG's) Strategic Knowledge Assessment Team (SKGAT)
  - Form the basis for near-term Agency investments in robotic precursor missions and activities

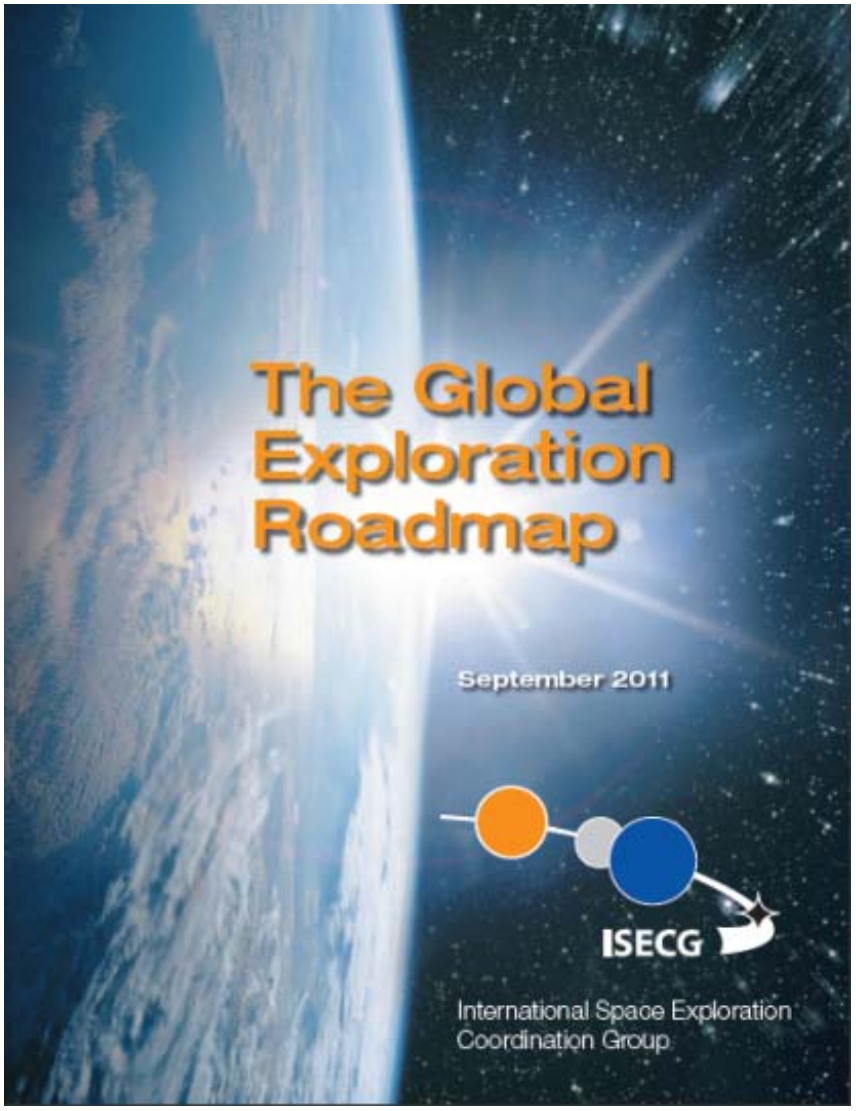
Informing Exploration Planning: Strategic Knowledge Gaps

- **Based on this draft version of the Strategic Knowledge Gaps…**
  - NASA engaged the external Science and Exploration communities to further vet and refine the SKGs.
    - Lunar Exploration Analysis Group
    - Small Bodies Assessment Group
    - Mars Exploration Program Analysis Group
  - The summary of their analyses is available at: http://www.nasa.gov/exploration/library/skg.html
  - NASA will further integrate the results from the individual Analysis/Assessment Groups by creating a joint Specific Action Team comprising members from LEAG, MEPAG, and SBAG. Formulation and scheduling is in process.

SKGs: Common Themes and Some Observations

- **There are common themes across destinations (not in priority order)**
  - The three R's for enabling human missions
    - Radiation
    - Regolith
    - Reliability
  - Geotechnical properties (Moon, NEAs, Mars)
  - Volatiles (i.e., for science, resources, and safety) (Moon, NEAs, Mars)
  - Propulsion-induced ejecta (Moon, NEAs, Mars)
  - In-Situ Resource Utilization (ISRU)/Prospecting (Moon, NEAs, Mars)
  - Operations/Operability (all destinations, including transit)
  - Plasma Environment (Moon, NEAs)
  - Human health and performance (all destinations, including transit)
- **Some Observations**
  - The required information is measurable and attainable
  - These measurements do not require "exquisite science" instruments but could be obtained from them
  - Filling the SKGs requires a well-balanced research portfolio
    - Remote sensing measurements, in-situ measurements, ground-based assets, and research & analysis (R&A)
    - Includes science, technology, and operational experience

The Global Exploration Roadmap



Status and Way Forward

- **International Coordination of Strategic Knowledge Gaps**
  - The Strategic Knowledge Gap Assessment Team (SKGAT) has been formed within the Exploration Roadmap Working Group of the International Space Exploration Coordination Group (ISECG) (Chaired by M. Wargo)
  - The NASA set of ***draft*** SKGs were used as the starting point for the assessment; final results from LEAG, MEPAG, and SBAG were subsequently incorporated along with additional input from ESA Topical Teams, and JAXA assessments
  - The SKGAT is nearing completion of the process of identifying, prioritizing and time phasing an “international set of SKGs” tied to the Global Exploration Roadmap mission scenarios, Asteroid First, and Moon First
  - The prioritized and integrated “international set of SKGs” will be incorporated into the upcoming revision of the Global Exploration Roadmap

Lunar Strategic Knowledge Gaps - 1

Strategic Knowledge Gap	Description	Relevant Location/Context	Crew Safety Risk if GAP not Filled	Mission Risk if GAP not Filled
Regolith Volatiles: Quality/ quantity/ distribution/form of H species and other volatiles in mare and highlands regolith.	Measure volatiles and organics returned in "pristine" Apollo samples, and robotic in situ measurements of volatiles and organics on the lunar surface and eventual sample return of "pristine" samples.	**Earth-based testing** **Robotic Lunar Missions**	Low	Medium
Lunar Cold Trap Volatiles: Composition/quantity/ distribution/form of water/H species and other volatiles associated with lunar cold traps.	"Ground truth" in-situ measurement within permanently shadowed lunar craters or other sites identified using LRO data. Technology development required for operating in extreme environments.	**Robotic Lunar Missions** **Research & Analysis** **Earth based Testing**	Low	Medium
Composition/volume/distribution/ form of pyroclastic/dark mantle deposits and characteristics of associated volatiles.	**Required robotic exploration of deposits and sample return.**	**Robotic Lunar Missions** **Research & Analysis** **Earth based Testing**	Low	Medium
Solar event prediction	Establish space weather modeling, forecasting and monitoring capabilities to warn transit/surface crews of potentially hazardous solar events. The goal of these systems should be to provide as early a warning as possible of dangers. Two time scales for consideration: alert on ~5- 10 days as active regions rotate s into moon-view (Sentinel monitor) and 10's of minutes to protect from an immediate release of an Earth-directed CME and associated Solar Energetic Particles (SEP)	**Research & Analysis** **Robotic Lunar Missions**	High	High

Final Thoughts

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