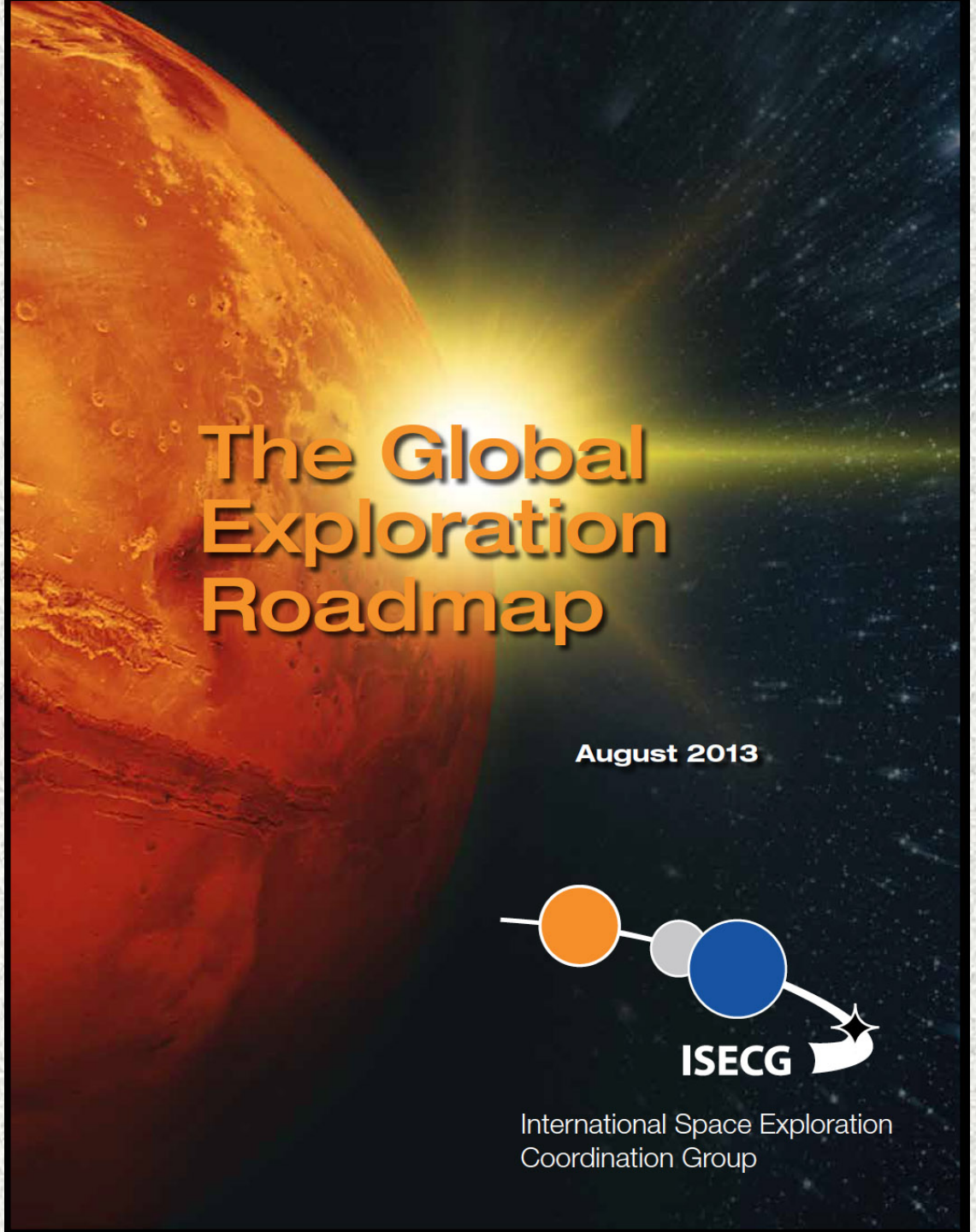
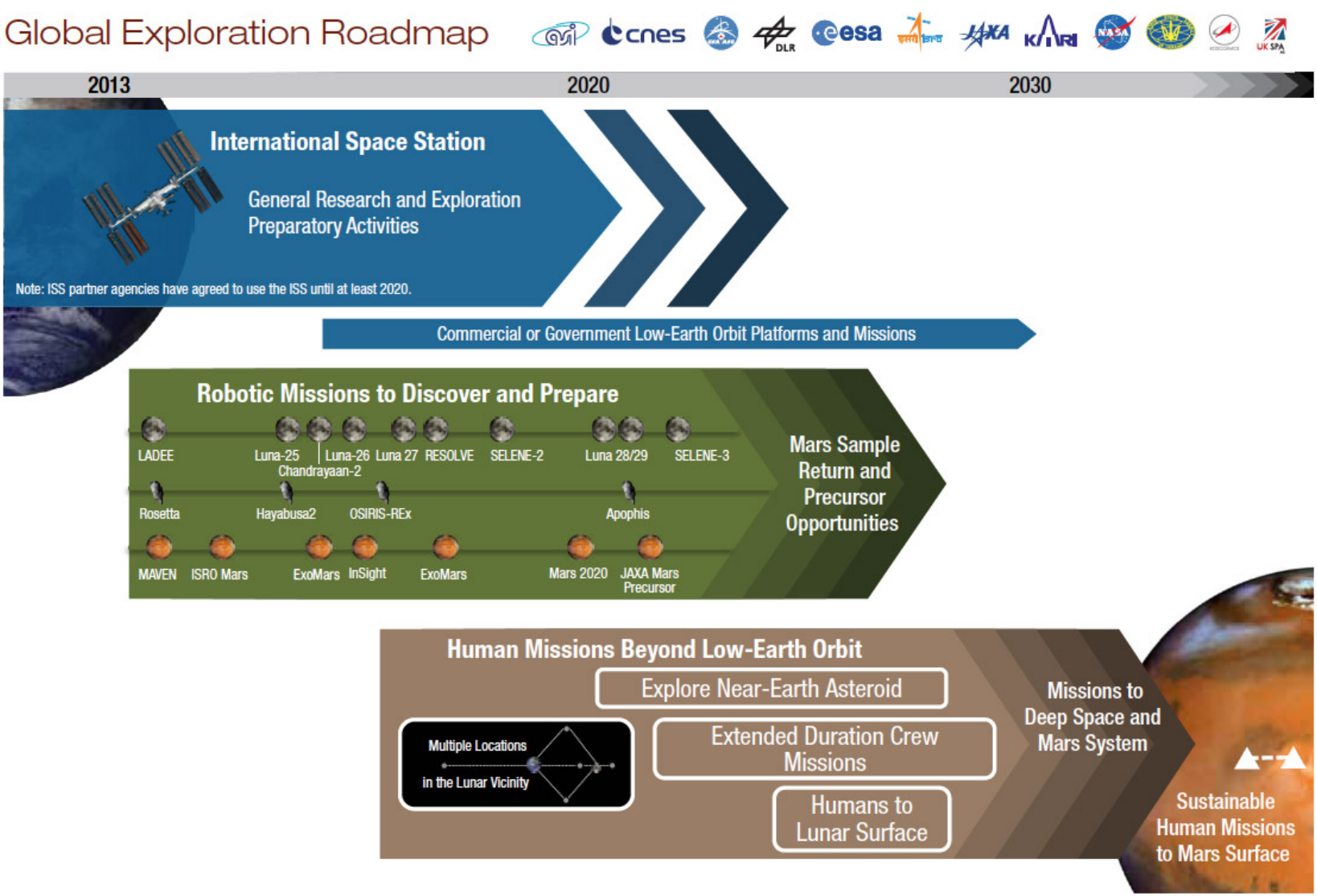
The Global Exploration Roadmap

International Space Exploration Coordination Group (ISECG)


The Global Exploration Roadmap
August 2013
ISECG
International Space Exploration Coordination Group

Roadmap


Global Exploration Roadmap
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

Global Exploration Roadmap

- ISS
  - Research and technology demonstration
  - Foundation of exploration
- Robotic Missions
  - New discoveries, precursors to human exploration
  - Expand synergies between human and robotic missions
- Human Missions Beyond LEO
  - Lunar vicinity and on the surface allow partners to advance capability needed for future Mars missions, while using presence of crew to explore Moon and NEA.

Goals and Objectives

- Develop Exploration Technologies and Capabilities
  - Knowledge, capabilities, infrastructure
- Engage the Public in Exploration
- Enhance Earth Safety
- Extend Human Presence
  - Explore variety of destinations – increase crew size and duration
- Perform Science to Enable Human Exploration
  - Health in space environment
- Perform Space, Earth and Applied Sciences
  - Research of and from, applied research
- Search for Life
- Stimulate Economic Expansion

ISECG Mission Scenario

2020 2030

Low-Earth Orbit

International Space Station

Commercial or Government-Owned Platforms

Beyond Low-Earth Orbit

Test Missions

Robotic Mission
Human Mission
Cargo Mission

Near-Earth Objects

Rosetta
Hayabusa2 (Sample Return)
OSIRIS-REx (Sample Return)
Asteroid Redirection
Apophis
Explore Near-Earth Asteroid

Lunar Vicinity

Extended Duration Crew Missions
Staging Post for Crew to Lunar Surface
Potential Commercial Opportunities

Moon

LADEE
Luna 25
Chandrayaan-2
Luna 26
Luna 27
RESOLVE
SELENE-2
Luna 28/29 (Sample Return)
SELENE-3
Human-Assisted Sample Return
Humans to Lunar Surface
Potential Commercial Opportunities

Mars

Human-Assisted Sample Return
MAVEN
ISRO Mars Orbiter Mission
ExoMars 2016
InSight
ExoMars 2018
Mars 2020
JAXA Mars Precursor
Mars Sample Return Mission Opportunities
Human Scale EDL Test Mission Opportunities
Sustainable Human Missions to the Mars System

Multi-Destination Transportation Capabilities

(Planned and Conceptual)

Icon indicates first use opportunity.
Commercial/Institutional launchers not shown.

Orion & SLS
Russian Piloted System
Advanced Electric Propulsion
Evolvable Deep Space Habitat
Orion & SLS (Upgrade)
Initial Cargo Delivery
Small Cargo Lander
Human Surface Mobility
Crewed Lunar Lander
Orion & SLS (Upgrade)

Mission Scenario

- Mars is the long-term goal.
- Set of mission in lunar vicinity and on the lunar surface that advance readiness for human Mars mission after 2030.
- Extended duration crew mission in lunar vicinity and mission to easily accessible asteroid.

Preparatory Activities

- Use ISS for Exploration
- Robotic Missions
  - SKGs
- Advanced Technology Demonstration
- Development of New Space Systems and Infrastructure
- Analogue Activities
- Managing Health and Human Performance Risks

Scenario Principles

- Affordability
  - Budget constraints
- Exploration Value
  - Generate public benefits and meet exploration objectives
- International Partnerships
  - Provide early and sustained opportunities for diverse partners
- Capability Evolution
  - Increasing complexity based on stepwise development of capabilities
- Human/Robotic Partnership
  - Maximize synergy between human and robotic missions
- Robustness
  - Resilience to programmatic and technical challenges

Mission Themes

- Exploration of a Near-Earth Asteroid
  - Robotically deflect an asteroid to enable its exploration in the lunar vicinity to demonstrate electric propulsion, crew transportation, operation capability.
- Extended Duration Crew Missions
  - Long duration in lunar vicinity for advancing deep space exploration capabilities, creating innovative opportunities for exploration of the Moon through human-robotic partnership
- Humans to the Lunar Surface
  - Provides opportunities to address lunar exploration objectives benefiting from human presence. "*Lunar missions are favored by agencies who view the Moon as the next step for human exploration…*".

Exploration of a Near-Earth Asteroid

- Robotic mission to redirect asteroid
  - Rendezvous and capture – deliver to stable lunar orbit
  - Astronauts visit and explore, possible spacewalks
- Activities
  - Characterize composition
  - Identify resources, extraction
  - Apply human evaluation to select samples for return

Extended Duration Crew Missions

- Evolvable deep space habitat in lunar vicinity
- Activities
  - Advancing deep space human flight ops and techniques
  - High priority science benefiting from human presence, human-assisted sample return
  - Testing technologies
  - Characterizing human health and performance in deep space
- SLS delivery of Deep Space Habitat to L2
  - Use SEP to relocate
  - Stays up to 90 days

Human Lunar Surface Missions

- From Deep Space Habitat

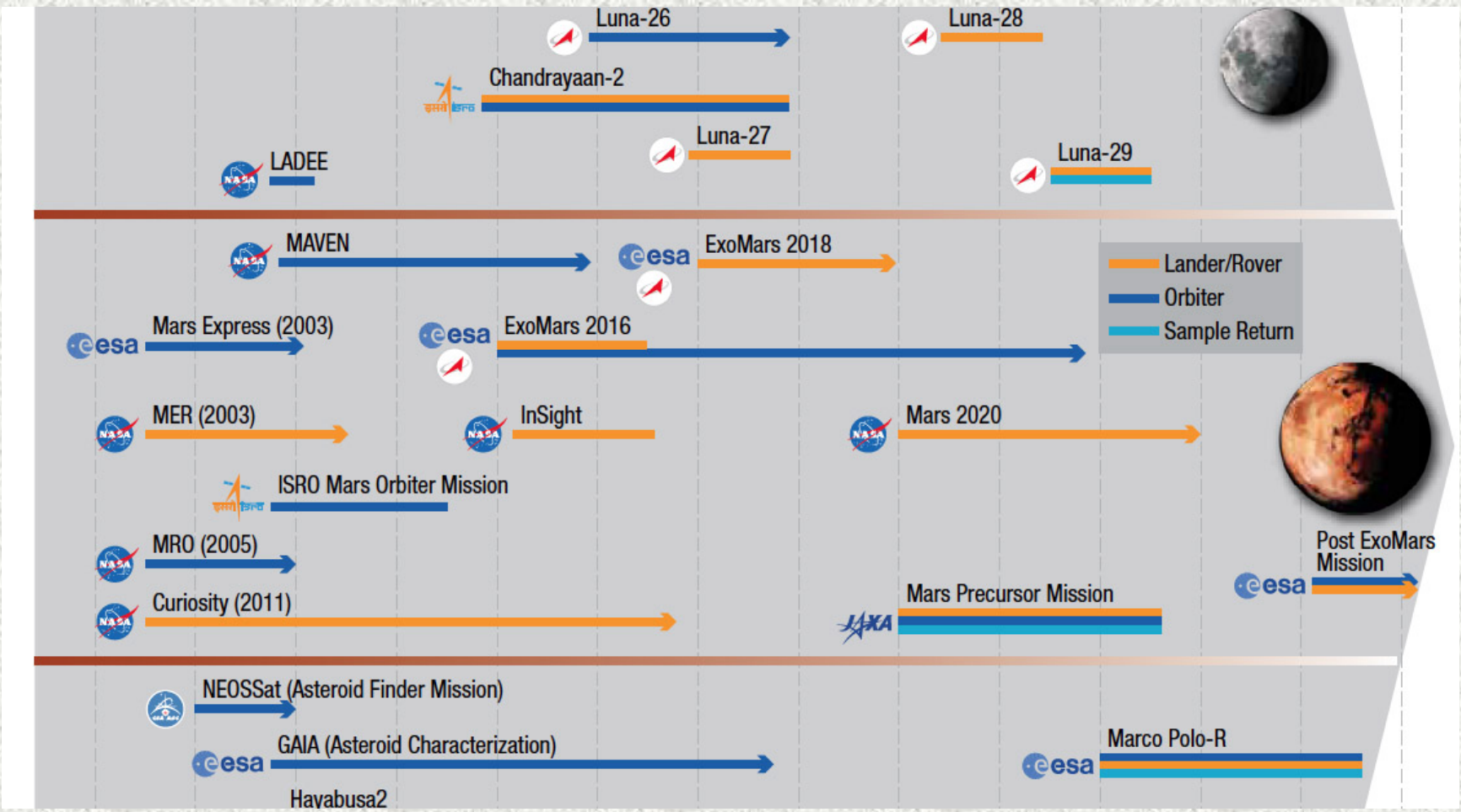
- Fulfillment of key lunar science and Mars preparation objectives, "*defines a lunar campaign with an 'exit strategy' consistent with moving forward with mars mission readiness*."

- Activities
  - Test advance surface power
  - High priority science which benefits from human presence
  - Human health and performance
  - Long distance mobility
  - Human-robot partnerships
  - Precision landing
  - Lunar resources – look for, not use
  - Exploration landing sites of interest

Strategic Knowledge Gaps

Destination	Knowledge Domain	Strategic Knowledge Gap: Description and Priority	Target Measurement	Mission or Ground Based Activity Addressing the SKG	Additional Measurements: R = Robotic Mission SR = Sample Return G = Ground Based Activities
Moon	**Resource Potential**	**Lunar Cold Trap Volatiles:** Composition/quantity/distribution/form of water/H species and other volatiles associated with lunar cold traps.	In-situ measurement of volatile characteristics and distribution within permanently shadowed lunar craters or other sites identified using remote sensing data (e.g., from LRO)	Roscosmos Luna-25/ Luna-27/Luna-28 and 29 NASA-CSA RESOLVE	R, SR
Near-Earth Objects (NEO)	**Human Mission Target**	**NEO Composition/Physical Characteristics:** Rotation State	Light curve and radar observations from different ground (Earth based telescopes) and space based assets.	e.g.: Goldstone Observatory (US); Bisei Spaceguard Center (Japan), Observatoire du Pic du Midi (France)	G, R
Mars	**Atmosphere**	**Atmospheric Modeling:** The atmospheric models for Mars have not been well validated due to a lack of sufficient observational data, and thus confidence in them is limited.	Density, pressure, temperature, and wind data, trajectory performance information	NASA Viking, Pathfinder, MGS, MERs, Phoenix, MRO, MSL ESA Mars Express ESA-Roscosmos ExoMars 2016, 2018	G, R

Future Robotic Missions



Issues Relevant to the Lunar Community

- Moon features prominently in the GER, but….
  - No US lunar mission after LADEE as RESOLVE is a pre-Phase-A concept study.
  - It is unclear how the non-specific human lunar mission in the late 2020s builds upon the planned missions by the international partners.
  - Page 17 states that the US may contribute to such a mission
    - This has been interpreted to mean the path the US is on is not flexible;
    - After having rebuilt the lunar community, it appears that it will now be left to atrophy.