The International Lunar Decade

Louis Friedman, The Planetary Society
Wesley T. Huntress, Jr., Geophysical Laboratory,
Carnegie Institution of Washington

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Rationale for Lunar Exploration

Approximately 100 spacecraft and 24 people have been to the moon; no economic or national security advantage has been found; Why go to the Moon?

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- **Political Factors**
  - Economic
  - Geopolitical
  - Peaceful Space Development and Cooperation
- **Stepping Stone**
  - National interest in China and India demonstrate that it is a stepping stone for space and broad technology development
  - Japan, Europe interest demonstrate the stepping stone from robotic science missions to human space flight
  - US and Russian interest demonstrate that the Moon is a stepping stone into the solar system, particularly to Mars

The ILD provides a framework to maximize international benefits of lunar exploration

WHY THE MOON?

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ILD Purpose

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1. Cooperation among spacefaring missions planning lunar missions
   - Coordinating mechanism is needed
2. Framework for support to scientists in developing countries for lunar research and space program participation
3. Public education and outreach bridging interest in science and exploration, including in human return to the Moon

The Moon is a Stepping Stone

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- **No *single* destination for human spaceflight-- exploration and discovery will continue to draw us into the solar system**
- **A logical progression to successively more difficult destinations--*Mars is the goal* that frames our investments in the next 50 years**
- **An evolutionary approach leading to human presence at the Moon, Sun-Earth L2, NEO's, Mars**
- **Incremental investments and important discoveries ensure sustainability -- adjust destinations and schedule to manage cost and risk**

Moon

Sun-Earth L2

Near-Earth Objects

Phobos/Deimos

Mars

Ref: Next Steps in Space, IAA

Destination: Moon

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Lunar outposts for exploration

- Search for evidence of the origin of the Earth-Moon system
- Investigate the history of asteroid and comet impacts on Earth
- Obtain evidence of the Sun's history and its effects on Earth through time
- Discover samples from the earliest episodes in the history of the Earth
- Determine the form, amount, and origin of putative lunar ice

Part of the exploration architecture

- A proving ground: *Learn to explore* the way we will ultimately explore Mars
- Transportation systems can be common with SE-L2 requirements
- Extended human presence on the Moon is an important cultural milestone
- But Moon is stepping stone, not end point, and part of moon **-->** Mars

Ref: Next Steps in Space, IAA

Human space flight interest

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- Public and popular interest connects robotic missions with eventual human interest
- The moon is first stop outward of any potential space-faring nation
- U.S, - Back to the moon is part of “Vision”
- Russia – Human space flight drives space program goals and support
- China – Emerging human space flight program and lunar program fuel global public interest
- Europe – Aurora program set human and robotic goals
- Japan – Participant in International Space Station and new long range plan cites human lunar goals
- India – News reports of human space flight commitment

Lunar Missions

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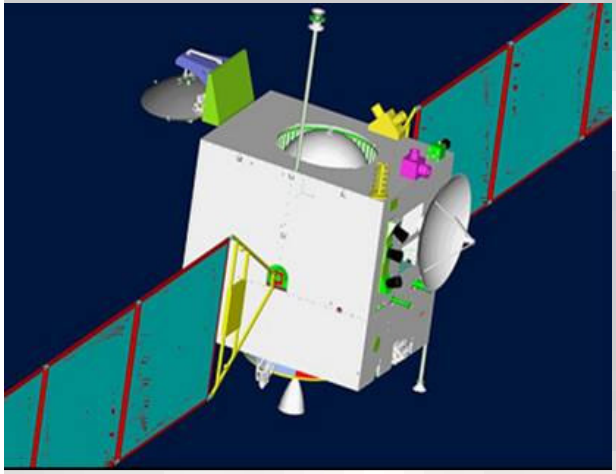
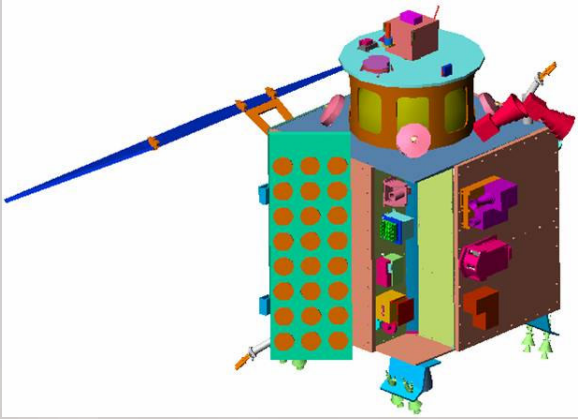
SMART-1



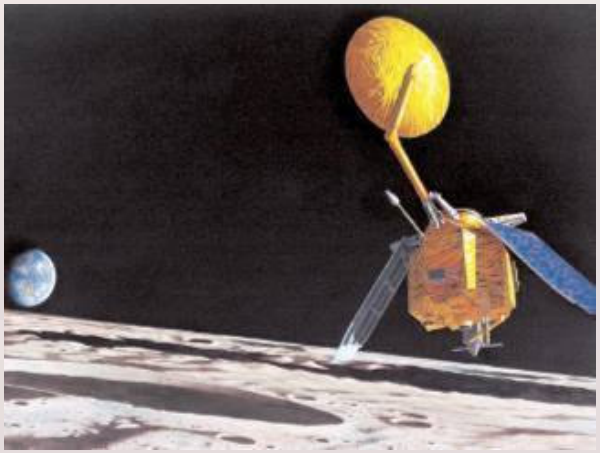
Chang'E-1

Chandrayaan-1

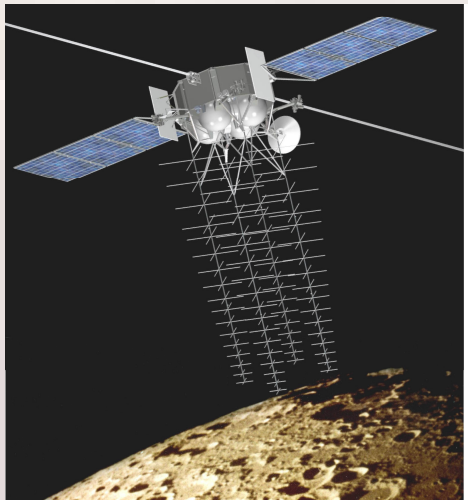


Selene

Lunar Reconnaissance Orbiter



Globe



Lunar Mission Information

	Smart-1	Chang'E	Selene	Chandra-yaan	LRO
Country	Europe	China	Japan	India	U.S.
Launch Vehicle	Ariane5	LM3-A	H-IIA	PSLV	At5
Launch Date	Sept 2003	Mid 2007	Mid 2007	Early 2008	Late 2008
Orbit altitude	450x2900 km	200x200 km	100x100 km	100x100 km	50 x 50 km
Lifetime	18 mos	>1 year	2 years?	2 years	1 year
Sub-satellite	None	None	2: gravity and relay	Impactor	Impactrs

Instruments on Missions

	Smart-1	Chang'E	Selene	Chandra-yaan	LRO
Cameras	X	X	X	X	X
IR spectrom.	X	X	X	X	
UV					X
Laser altimeter		X	X	X	X
Neutron				X	X
X-ray	X	X	X	X	
Gamma		X	X	X	
Microwave		X			X
Radar			X	X	X
Particle	X	X	X	X	X
Magnet.			X		

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Possible lunar schedule

To Mars

Humans

Robotic SR

Landers

Orbiters

2007 2013 2019

Lunar ventures should be global

- Public perception, interest and support is global
- National plans independent
  - Partially redundant
  - All lead to robotic base and human operations
- US Vision is noble and worth the cost and risk of human space flight
  - But it is not sustainable nationally
  - Global Strategy just beginning
- European and Japanese roadmaps require international cooperation
- Without international cooperation China and India will likely repeat Soviet and American experiences 40-50 years later

Precedents

- International Geophysical Year: 1957-58
  - The space age
- International Polar Years: 1882-83; 1932-33; 2007-08
- International Space Year: 1992-94
  - Mission to Planet Earth
  - US-Russian cooperation
- International Halley Watch 1981-87
  - Astronomy observations
  - Mission navigation coordination
- International Heliophysical Year 2007
  - Science Goals and Themes

Cooperation Models

for space missions

- **National - with non-critical path partners (Giotto, Nozomi, Mars Exploration Rovers)**
- **Bilateral - one lead partner with other critical contributions (Vega, Phobos, Galileo, Cassini-Huygens)**
- **Bilateral - roughly equal participation (Apollo-Soyuz, Topex-Poseidon)**
- **Multilateral - one lead partner with other critical contributions (International Space Station)**
- **Multilateral - weighted participation (ESA optional programs such as ENVISAT or Aurora)**
- **Multilateral - coordination (Halley's Comet missions)**

Antarctic Model for the Moon Exploration and Development

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- 2017-20: Scientific way-station established on Moon.
  - Human and robotic (including robotic village)
  - Multi-national
- 2020-23: Transition to International Base . .
  - Space agencies focus on Mars exploration operations
  - Private sector transport to and from Moon
  - Government and Private sector other facilities for various purposes: science, engineering, commercial.
- NASA, ESA, Russia, others(?) focus humans to Mars
  - Robotic precursors 2017-2022
  - Human preparations 2020-2023

Antarctic Model for the Moon Exploration and Development

Lunar Exploration

To Mars

Firsts → Exploration → Utilization

Apollo

Scientific bases
Tourism, etc.

1968 2000 2025

Antarctic Exploration

To Space
(IGY)

Firsts → Exploration → Utilization

Scott,
Amundsen

Scientific bases
Tourism, etc.

1900 1925 1960

Example ILD agenda items

- Coordinate, expand opportunities for involvement
  - science: observations, experiments, instrument development, research and data analysis
  - education and public outreach
- Enhance multi-lateral, global mission cooperation
  - In-space & Earth-space communication standards
  - Relay satellites, cooperative gravity mapping
  - Lunar internet protocol
- Lunar way-station development
  - Inspection
  - Navigation
  - Power management
  - Science and surface operations: use of robotics
- In-situ propellant production development

International Lunar Decade Summary

- 2007 – 2019; open for discussion
  - 2007: Selene & Chang'E, 50th Anniversary
  - 2019: Humans on the moon?
- Framework for mission cooperation
  - Space agencies forum or coordinating group
- Boost for scientific cooperation
  - Also encouraging participation from non-mission countries

Conclusion

- International Lunar Decade is an opportunity
  - to enhance science participation and coordination
  - to enhance mission cooperation and benefits
  - to provide great public interest and support
- International frameworks are need for both mission cooperation and development of a global vision for space exploration
  - The ILD can help
- International organization support and space agency advocacy is needed
  - COSPAR, IAF
- Next Steps
  - UN COPUOS
  - Space agencies

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