

A blueprint of an International Lunar Robotic Village



Leon Alkalai

Jet Propulsion Laboratory

California Institute of Technology

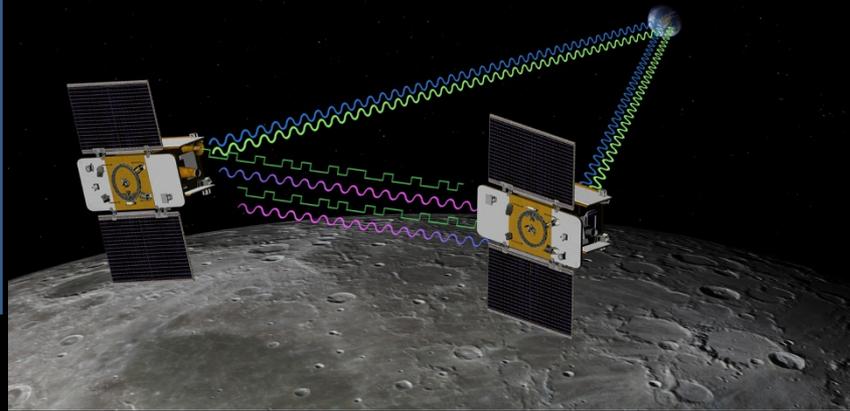
Lunar Robotics Exploration Office

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Solar System Science Mission Formulation

Robotic Capabilities

GRAIL – 9/10/2011:
precision formation flying



MoonRise – Proposed
Sample Return



Lunette: Proposed Network of Small
Landers
6/19/2012



InSight: Proposed Robotic Payload
Deployment

Motivation and Vision

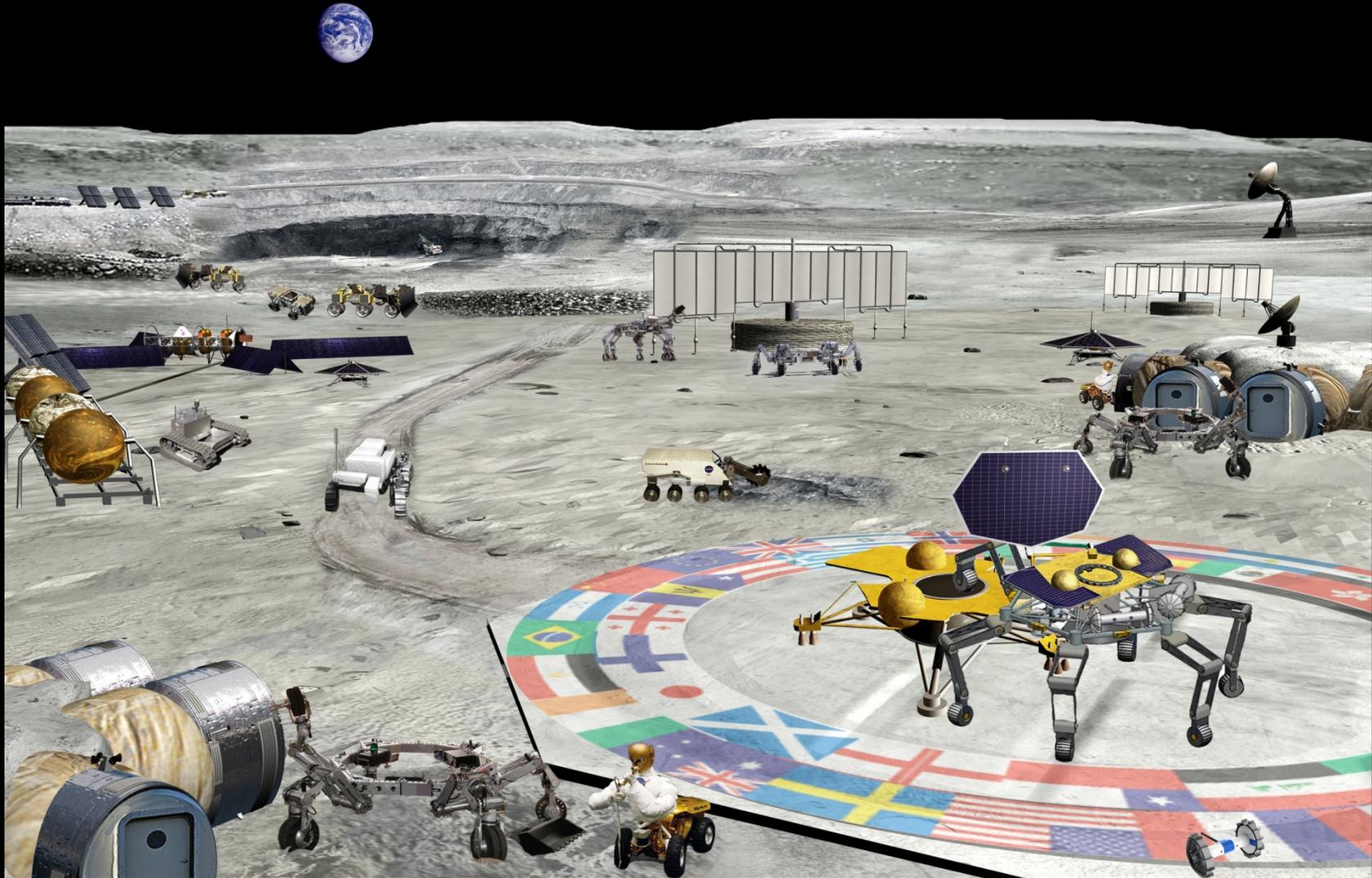
MOTIVATION:

- Human civilization is destined to look, find and develop a second habitable destination in our Solar System, besides Earth:
 - Moon and Mars are the two most likely and credible places based on proximity, available local resources and economics
- Recent international missions have brought back valuable information on both Moon and Mars:
 - Moon: GRAIL (USA) LRO/LCROSS (USA), Kaguya (Japan), Chandrayaan-1 (India), Chang'e (China)
 - Mars: MER (USA), Phoenix (USA) and upcoming MAVEN (USA), MSL (USA)

VISION:

- A permanent presence on the Moon using advanced robotic systems as precursors to the future human settlement of the Moon is possible in the near-term. An international effort should be initiated to create a permanent robotic village to demonstrate and validate advanced technologies and systems across international boundaries, conduct broad science, explore new regions of the Moon and Mars, develop infrastructure, human habitats and shelters, facilitate development of commerce and stimulate public involvement and education.

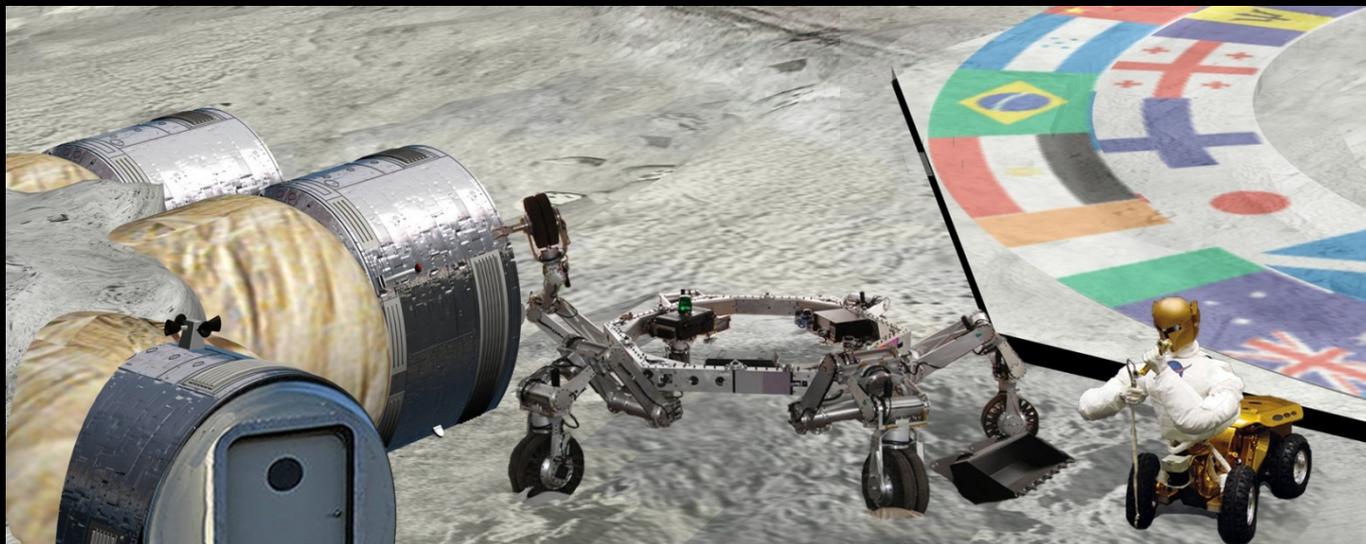
A Proposed Vision of a Permanent Robotic Village on the Moon



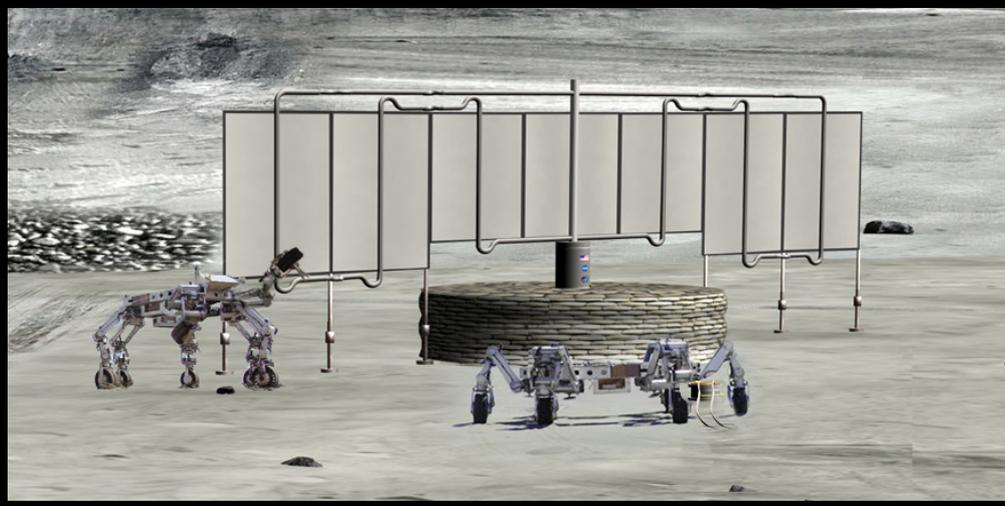
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Robotic Assembly of Human Habitats, Infrastructure on the Moon



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ATHLETE Transportation of Human Habitat Modules



ATHLETE example of scale



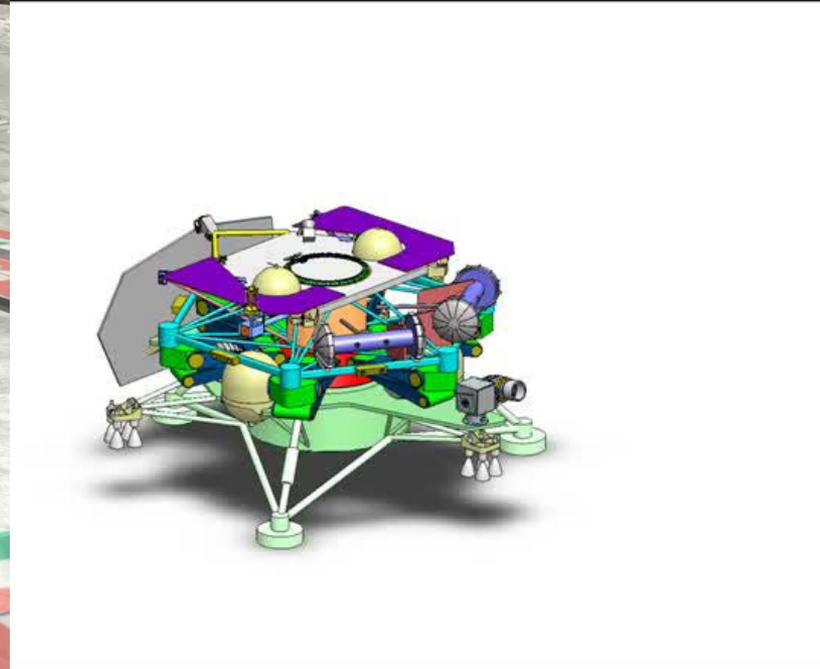
Large Scale Landers can deliver 1-10 MT of payload





Medium Scale Landers

~ 1000 kg payload delivery to the Moon



Low –Cost Small Landers for Environmental Monitoring and Geophysical package deployment



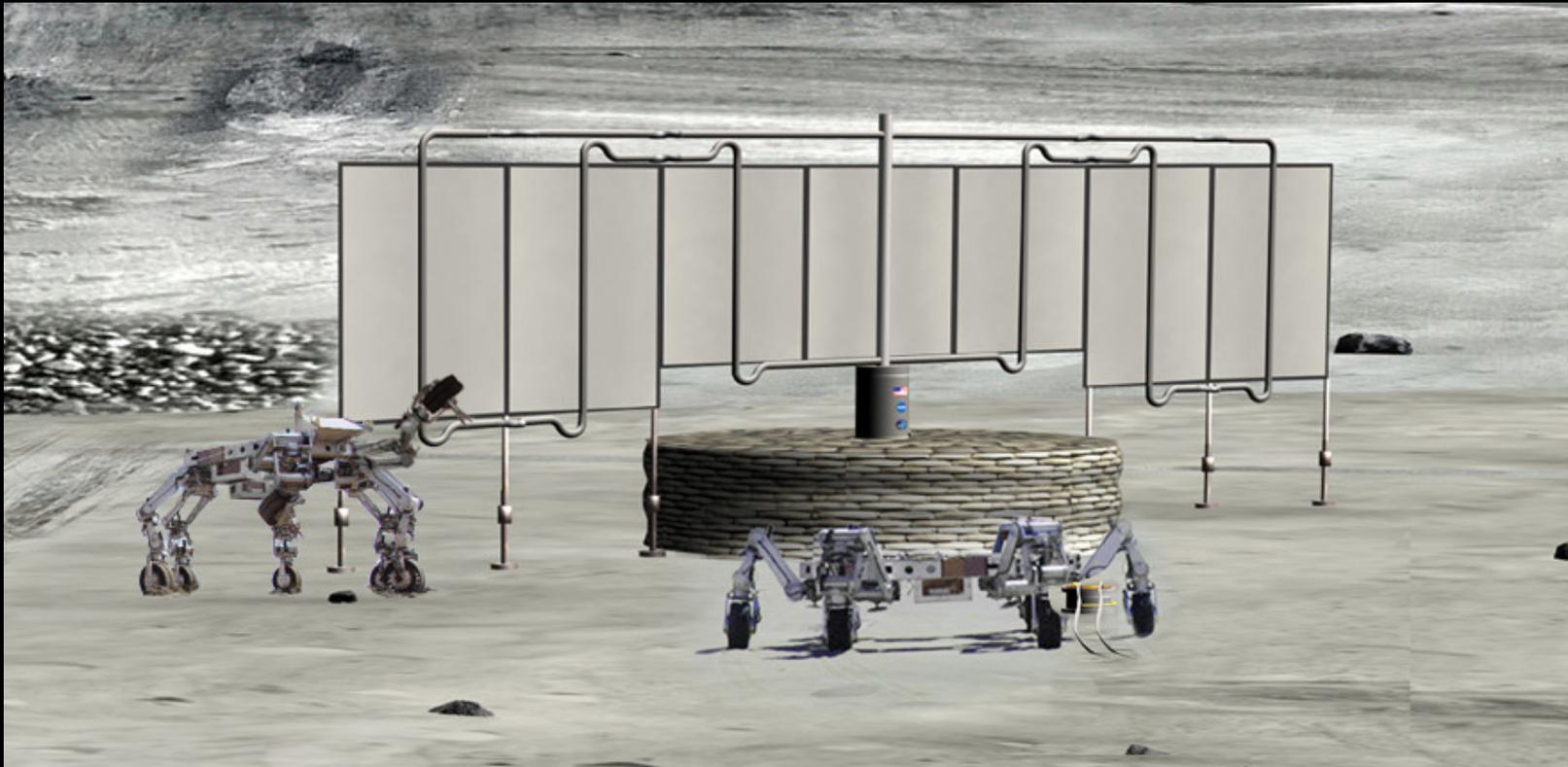
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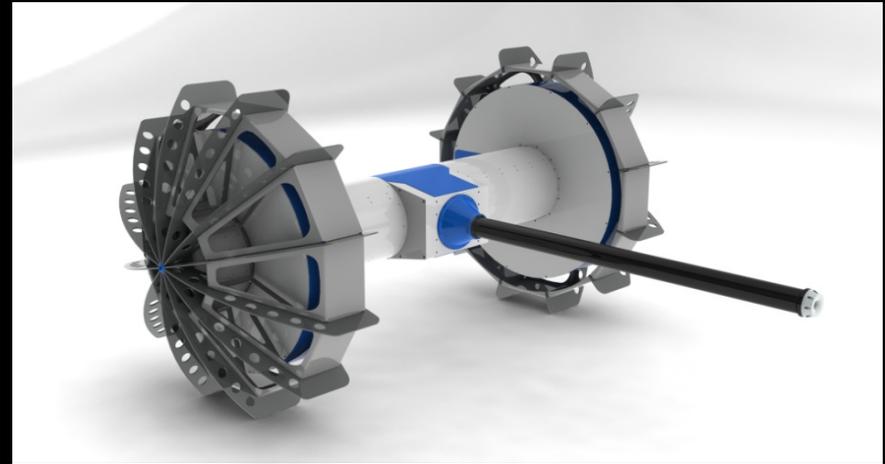
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Collaborative Assembly of Large Systems and Repair

- [Collaborative precision assembly](#)
- [Collaborative lifting](#)
- [Robot repair tools](#)



Exploring Cold Traps on the Moon using AXEL



- [Cold Trap Exploration mission concept](#)

Other Potential Exciting Robotic Projects as Precursors to Human Presence

- In Situ Resource Utilization
- Digging, sieving, movement of regolith on a small and large scale
- Studies of regolith properties, deep excavation and mining
- Pavement of roads
- Establishment of power supply stations
- Telecommunications infrastructure
- Establishment of human/robotic shelters
- Assembly of human habitat modules
- Public engagement and Education
- Mission operations studies, tele-operations, autonomous operations.

An International Robotic Village ... requires

- A common vision and leadership
- International agreements for collaboration
- Establishments of standards and procedures of interoperability
- Development of infrastructure and utility services such as:
 - power, tele-communications, storage, waste management, shelters, repair shops

Recent References and further reading

- The ISECG Reference Architecture for Human Lunar Exploration, Summary Report, ISECG Architecture Working Group, July 2010
- Flexible-Path Human Exploration, B. Sherwood, M. Adler, L. Alkalai, G. Burdick, D. Coulter, F. Jordan, F. Naderi, L. Graham, R. Landis, B. Drake, S. Hoffman, J. Grunsfeld, B. Seery, AIAA Space 2010, Anaheim, August 2010.
- Review of US Concepts for Post-ISS Space Habitation Facilities and Future Operations, H. Thronson, D. Lester, R. Moe, G. Sullivan, AIAA Space 2010, Anaheim, August 2010.
- National Space Policy of the United States of America, June 28, 2010
- Beijing Lunar Declaration 2010, 11th ILEWG Conference on Exploration and Utilization of the Moon (ICEUM11), Beijing, May 31st – Jun 3rd, 2010.