



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

# Space Science and Human Exploration: Opportunities for Collaboration

for

## AIAA/NSC/NASA Town Hall

April 26, 2007

**Charles Elachi, Director  
NASA Jet Propulsion Laboratory  
California Institute of Technology**



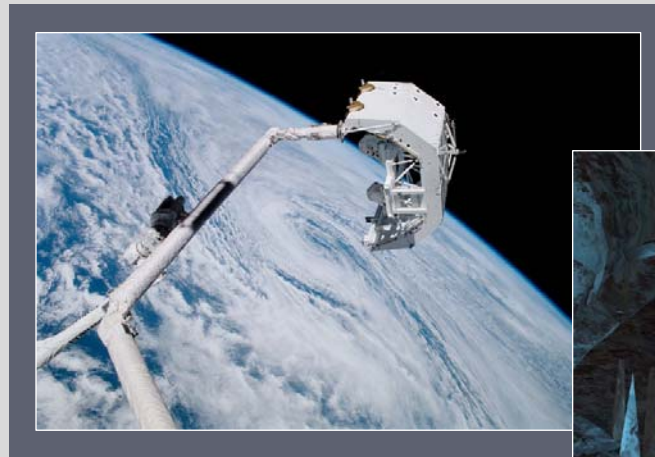
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# Lessons from 45 years of exploration

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- **Robotic Exploration**

- Pathfinders/Scouts
- Long term measurements
- High risk environment
- Assistant
  - Heavy lifting, routine activities, work in dangerous places



# Lessons from 45 years of exploration

- Robots come in many forms:
  - Mobile systems
    - On planetary surfaces
    - In atmospheres
    - Sub-surface
    - In space
  - Fixed-but-flexible
  - “Behind-the-panel”



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function SLIDE_forward()
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SLIDE_slide();
if (SLIDE_status != "SLIDE_pause") SLIDE_timeout = setTimeout("SLIDE_play()", SLIDE_speed);
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{
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{
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}
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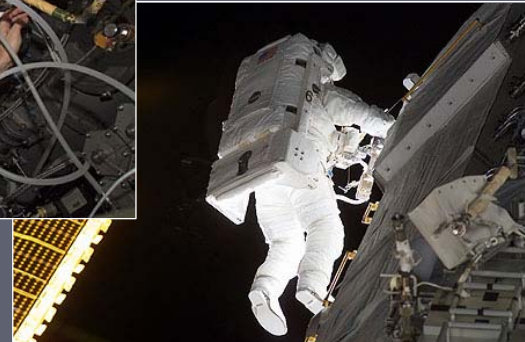


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# Lessons from 45 years of exploration

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- **Humans excel at problem solving, agile responses to unanticipated events, and complex activities requiring judgment and dexterity.**



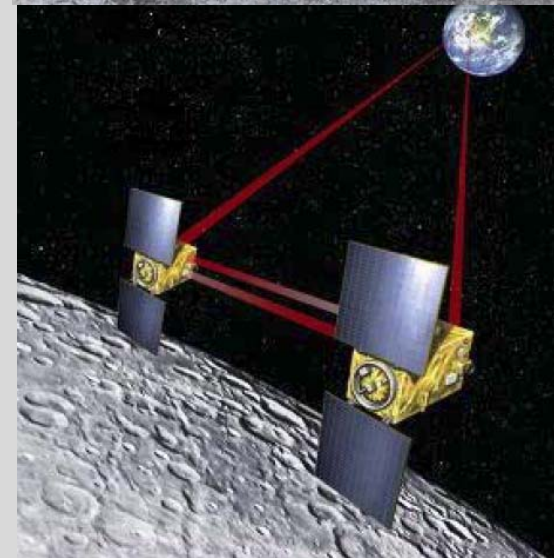
NASA's challenge is to develop a powerful partnership between the two domains to leverage the strengths of both.

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## Recently proposed New Frontier and Discovery robotic lunar missions

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- Moonrise would return samples from the south pole Aitkin Basin.
- Gravity Recovery and Interior Laboratory (GRAIL) would map lunar gravity.

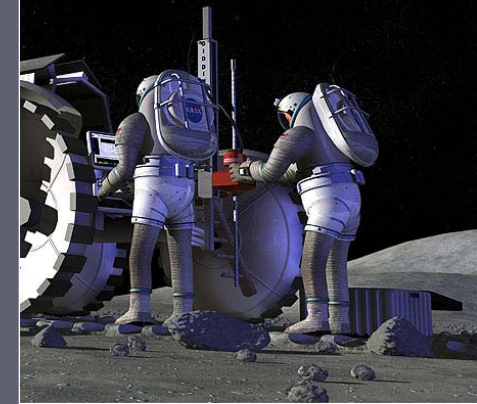
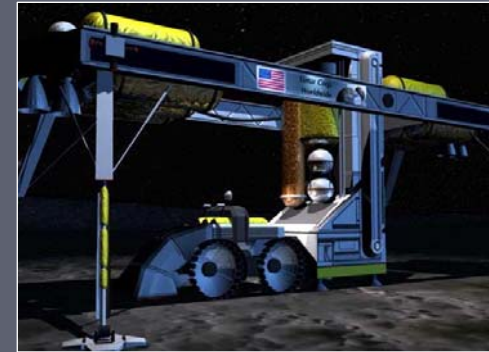


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# Lunar outpost as a human/robot testbed

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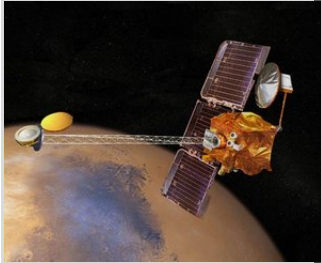
- Scouting the landing site to correlate overhead measurements with in situ measurements.
- Pre-positioning equipment.
- Exploring permanently shadowed areas.
- Housekeeping between human visits.
- Extending range of detailed exploration:
  - Acquire and return samples;
  - Sample processing and initial measurements.



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# A continuous presence on Mars

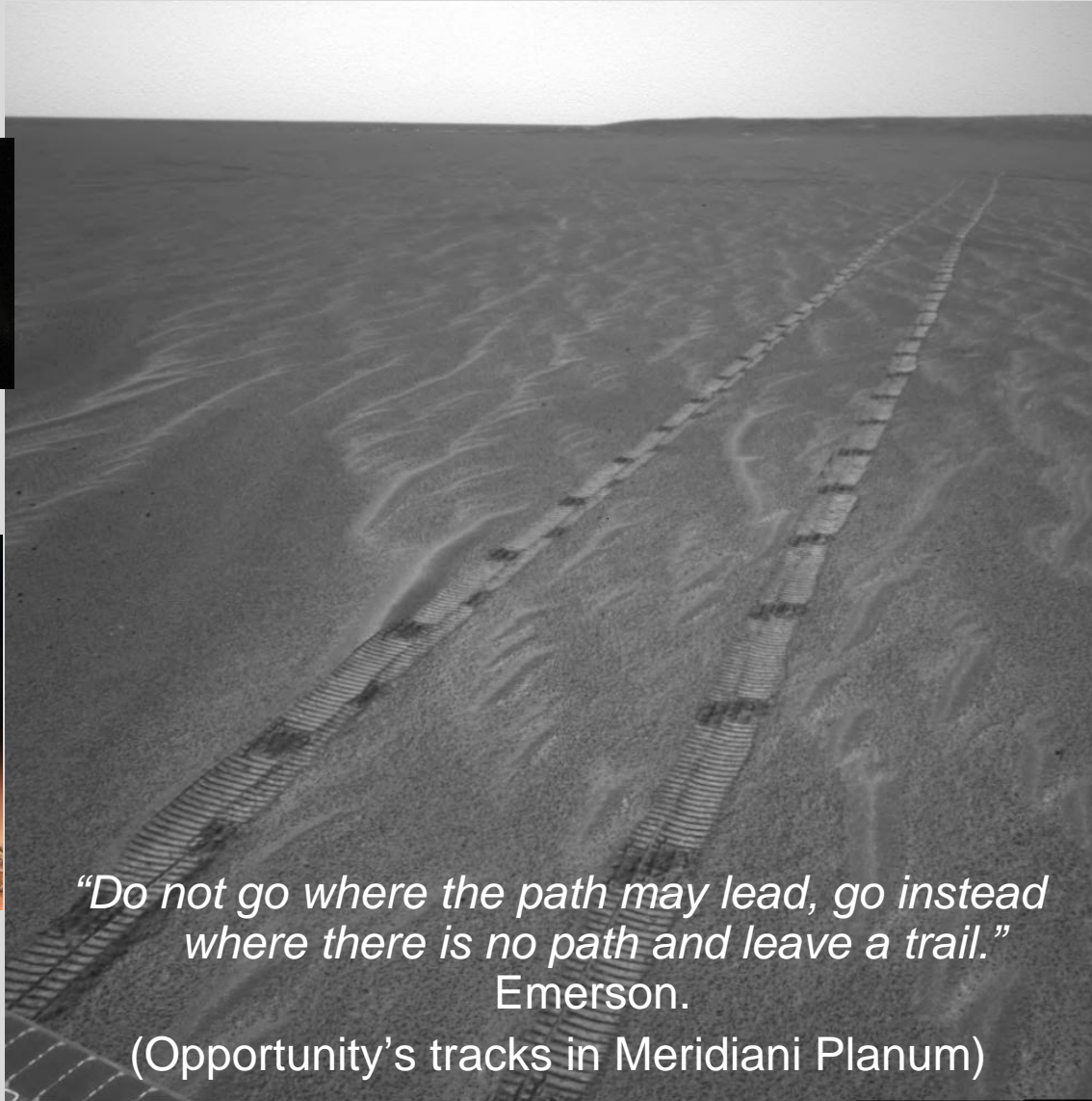
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**2001 Mars  
Odyssey**



**Mars  
Reconnaissance  
Orbiter**

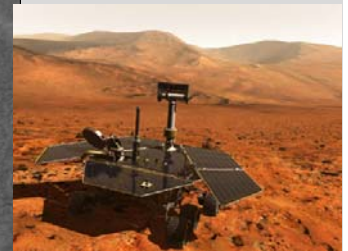


*“Do not go where the path may lead, go instead  
where there is no path and leave a trail.”*  
Emerson.

(Opportunity’s tracks in Meridiani Planum)



**Spirit**



**Opportunity**

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## Current example of science/exploration leveraging

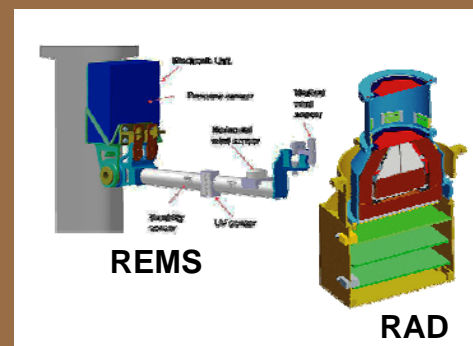
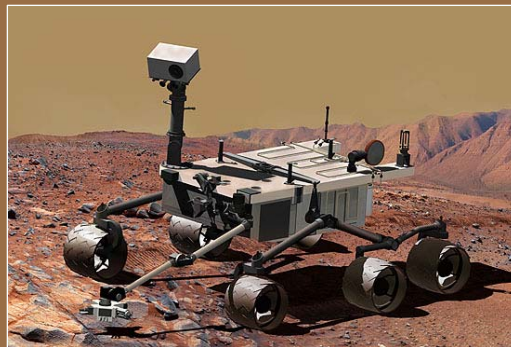
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- **Mars Science Laboratory Mission:**

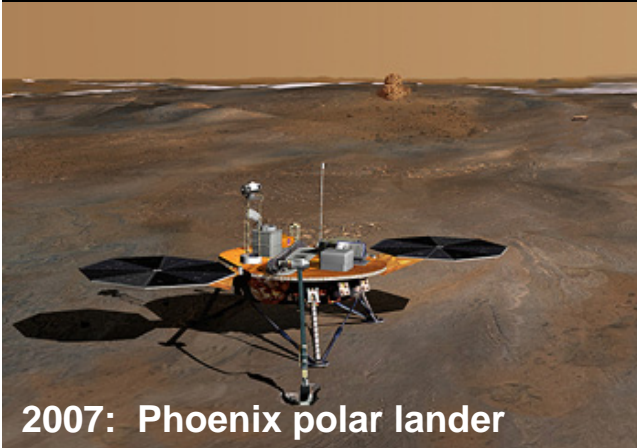
- Launch to Mars in 2009.
- Measuring radiation on Mars surface and heat shield performance during entry/descent/landing phase.



- Exploration leveraging a science mission by making key measurements not possible in Earth based simulations:
  - Heat shield measurements during entry;
  - In situ radiation monitoring.



# Future Mars spacecraft



2007: Phoenix polar lander

Mars science orbiters



Mid-rovers



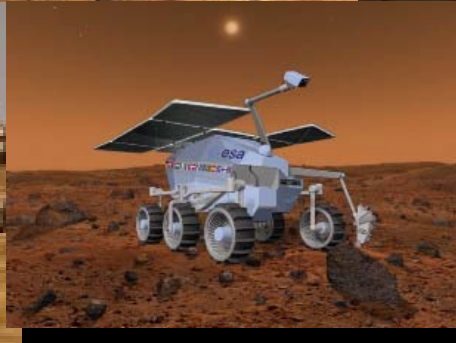
Astrobiology field laboratories



2009: Mars Science Laboratory rover



Planetary evolution and meteorology networks



ESA ExoMars



Mars sample return

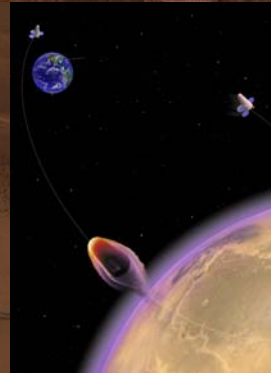
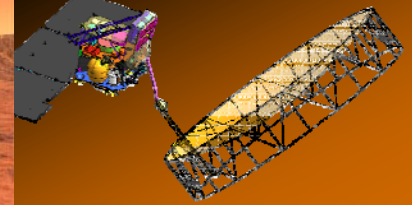
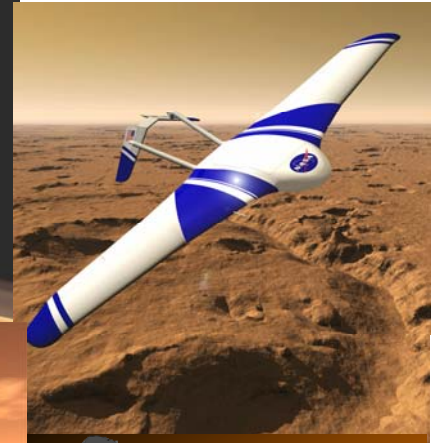
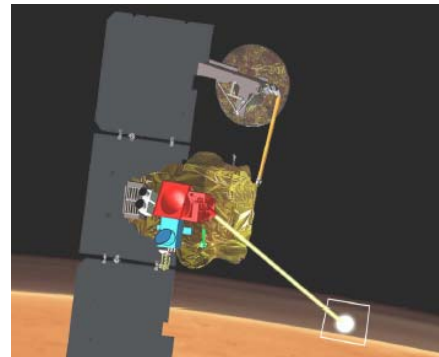
**Proposals for 2013-2020**

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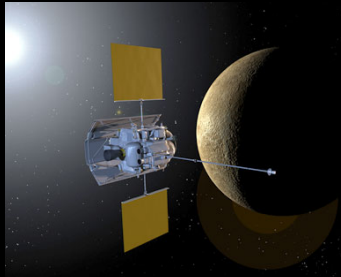
# Potential future robotic Mars missions

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- Typical science objectives:
  - Origin and evolution of remnant crustal magnetism
  - Atmospheric chemistry and trace gas studies
  - Near-surface geophysics
  - Current climate and past history
  - Search for subsurface water and habitable zones
  - Search for organics
  - Subsurface geomorphology



# Ongoing missions, and planned/potential future New Frontier and Flagship missions



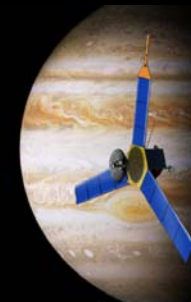
**Messenger to  
Mercury**



**Dawn asteroid  
mission**



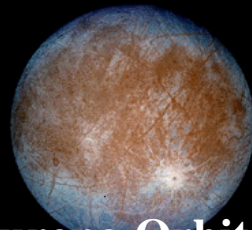
**Pluto New  
Horizons**



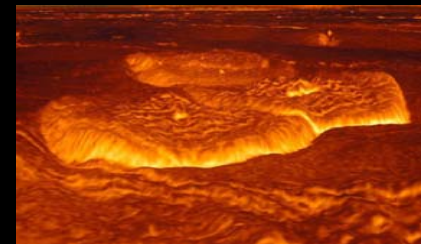
**Juno**



**Lunar Aitken Basin  
Sample Return**



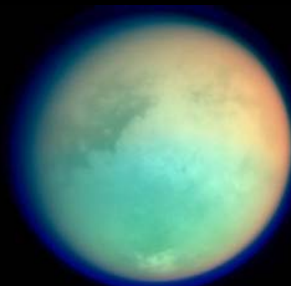
**Europa Orbiter**



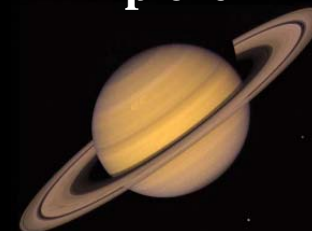
**Venus In Situ  
Explorer**



**Comet Surface  
Sample Return**



**Titan Orbiter**



**Saturn Orbiter**

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## Possible outcomes

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- Likely outcomes are going to be different than we anticipate today.
- Understanding how to use robotic systems to extend capability of humans will have major value to an ever more productivity-driven Earth.
- Taking new paths always opens unanticipated vistas.

**The adventure has already begun!**