Future of Field Campaign Research

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On detail to
NASA Headquarters (Science Mission Directorate / Planetary Sciences Division)
NASA Goddard Spaceflight Center

Field Campaigns

Field Investigations to Enable Solar System Science and Exploration

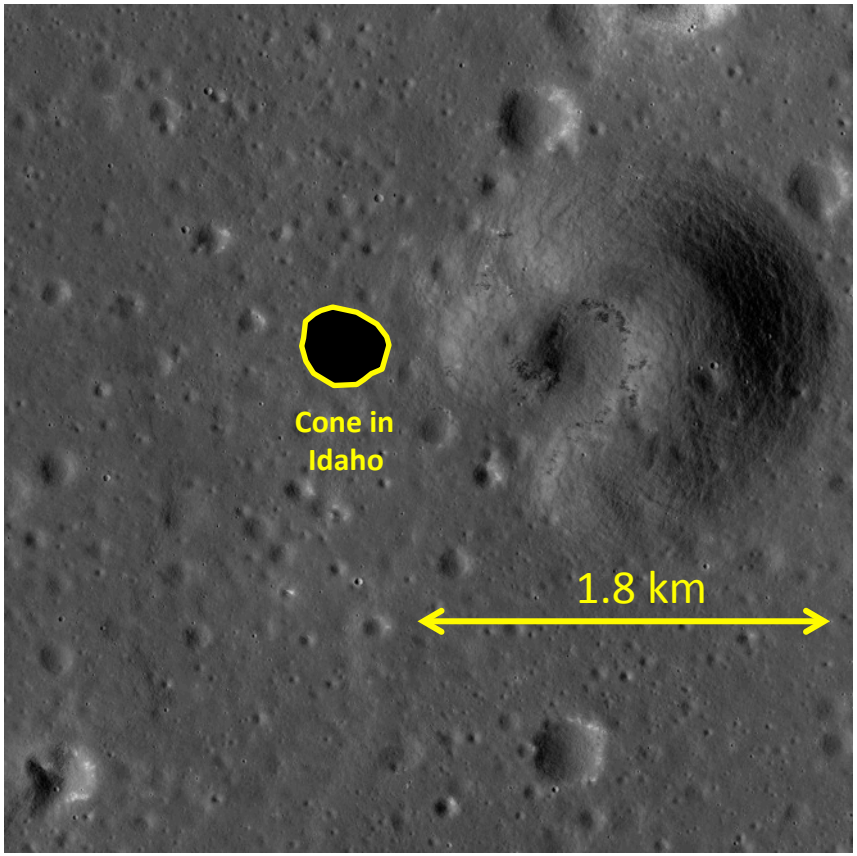
Field Campaigns

What are the main tenets of field campaign research?

Field Campaigns

Field campaigns can fulfill the following functions:

1) LEARN (by comparison)

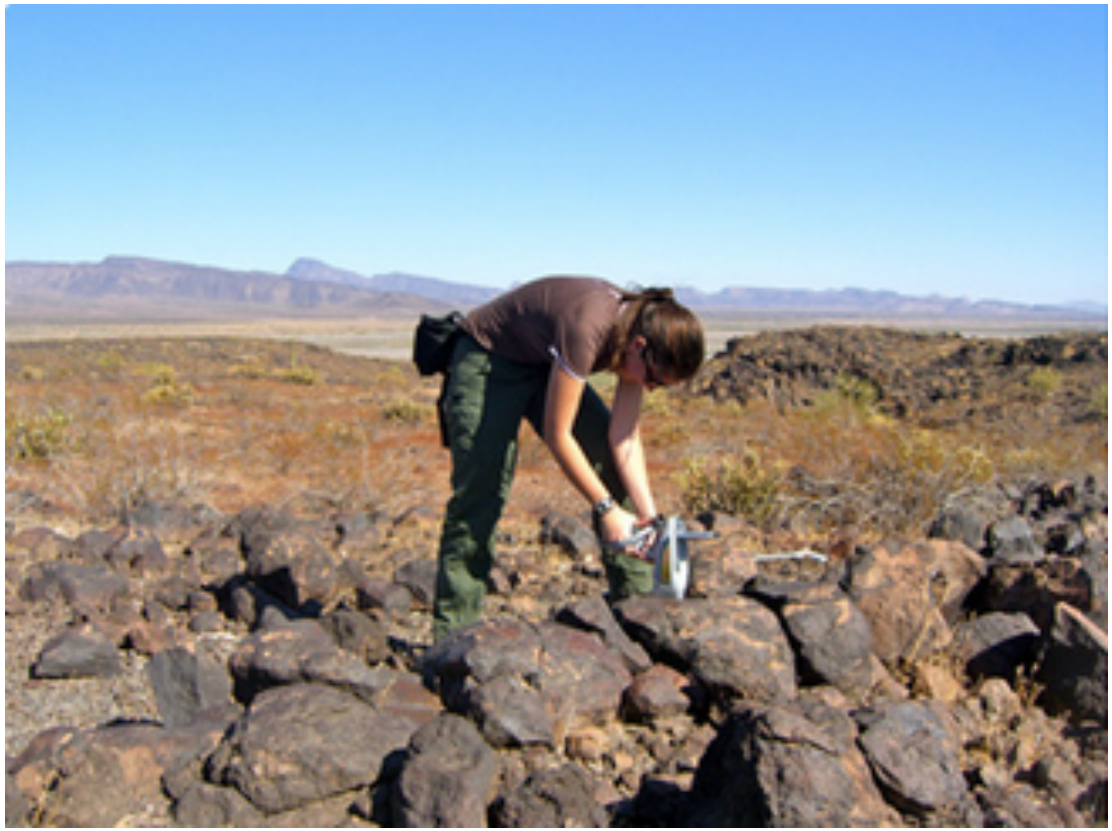


Lee et al. 2010

Field Campaigns

Field campaigns can fulfill the following functions:

2) TEST (hardware, hypotheses, strategies)



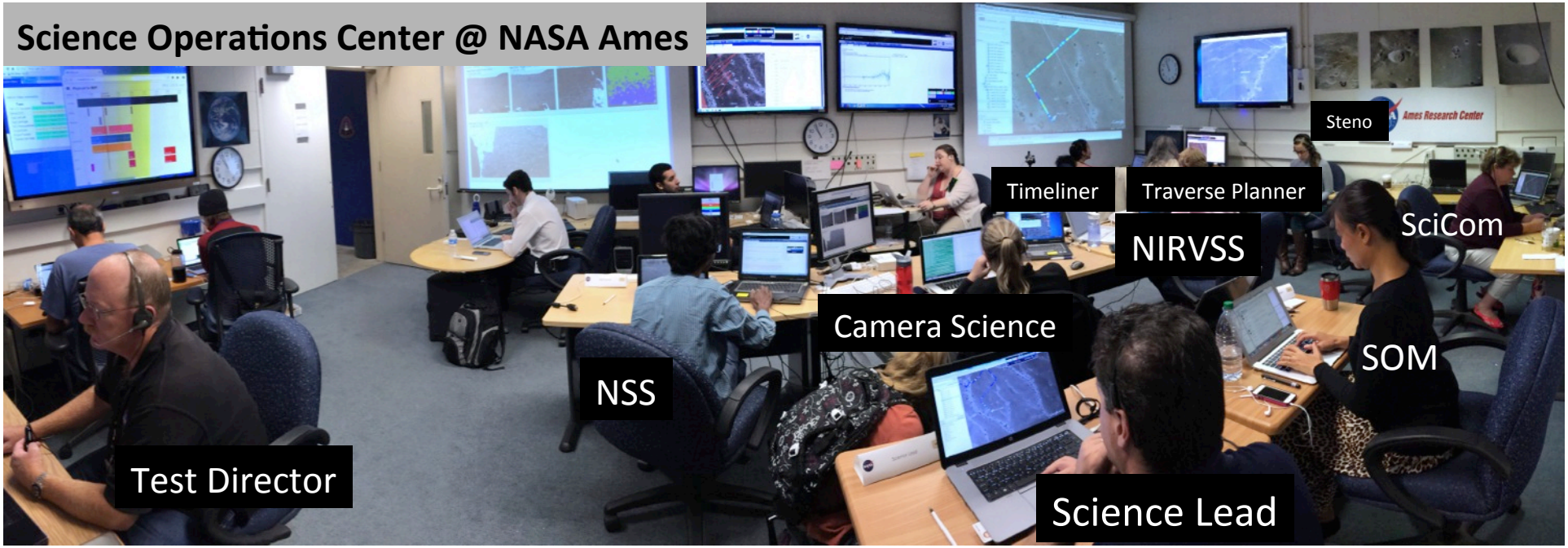
Kelsey Young testing field geology instrumentation.

Lee et al. 2010

Field Campaigns

Field campaigns can fulfill the following functions:

3) TRAIN (to train crews and ground personnel)



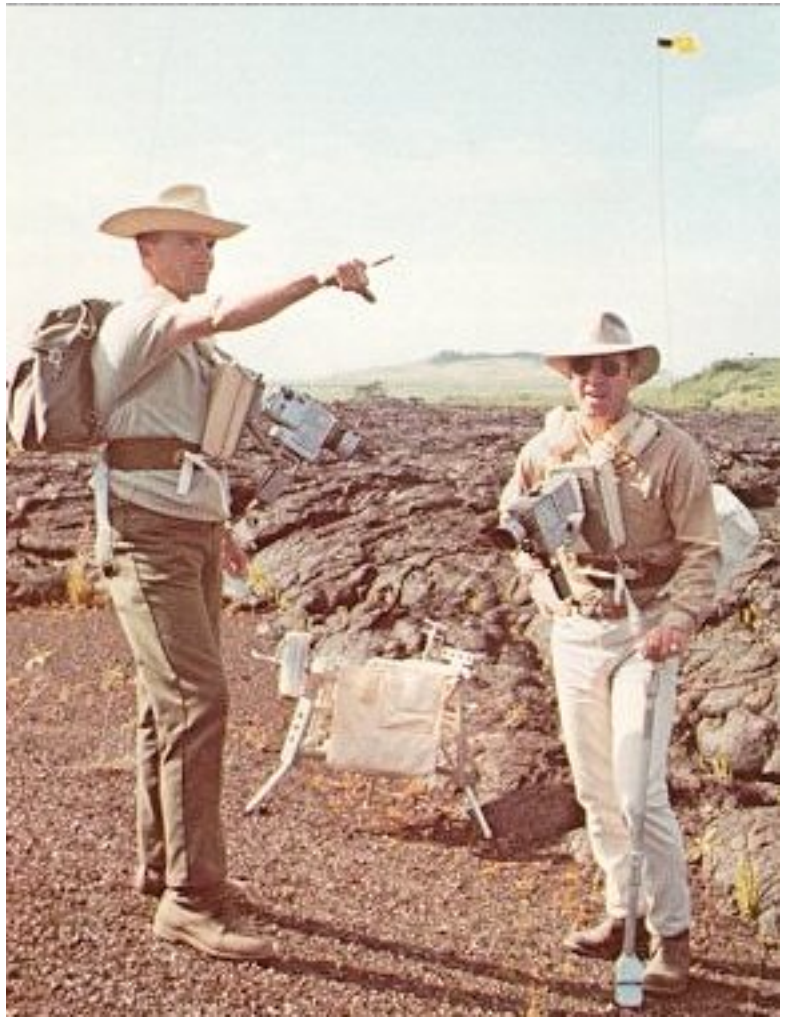
Lee et al. 2010

Field Campaigns

Field campaigns can fulfill the following functions:

4) ENGAGE (international partners, the public, students)

Fieldwork is not new



Apollo 13 Astronauts Fred Haise and Jim Lovell observe features of a lava flow near Hilo, Hawaii.

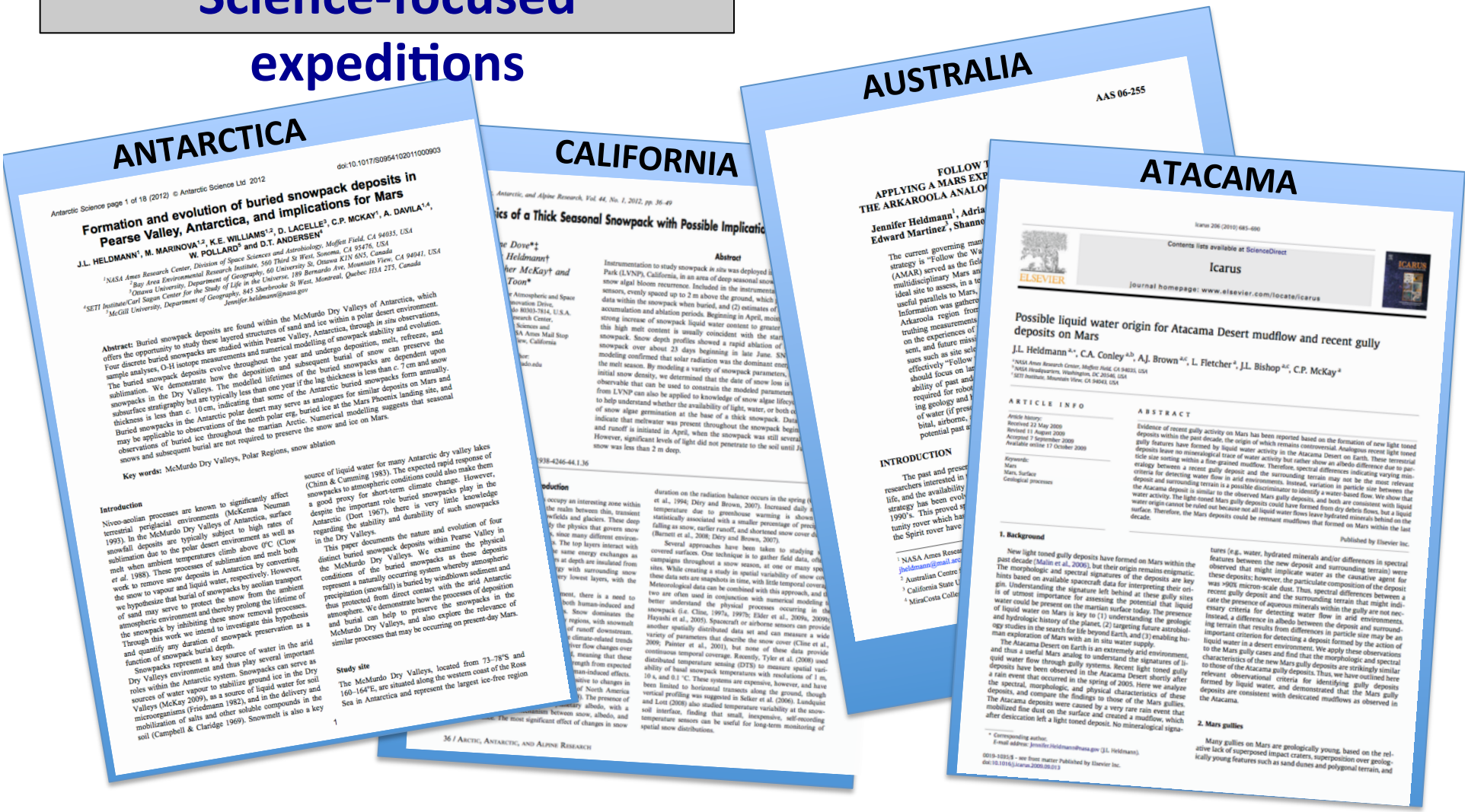
Gordon Swann testing geologic field procedures in a simulated pressure suit in Arizona, mid-1960s.

Fieldwork is not new

Two Apollo 15 crew members, riding a Lunar Roving Vehicle (LRV) simulator, participate in geology training at the Cinder Lake crater field in Arizona in 1970. Astronauts David R. Scott and James B. Irwin.

Science and Exploration

Science-focused expeditions



Science and Exploration

Exploration-focused expeditions

Science and Exploration

Science field campaigns infused with *EXPLORATION*.

Science and exploration field-based research program aimed at generating strategic knowledge in preparation for the human and robotic exploration of the Solar System.

Science program infused with leading edge exploration concepts:
"**science enables exploration and exploration enables science.**"

Emphasis on *near-term* return on technology development and operational trades.

Mojave Volatiles Prospector

- *Motivated by HEOMD Resource Prospector (RP) mission concept (Phase A).*

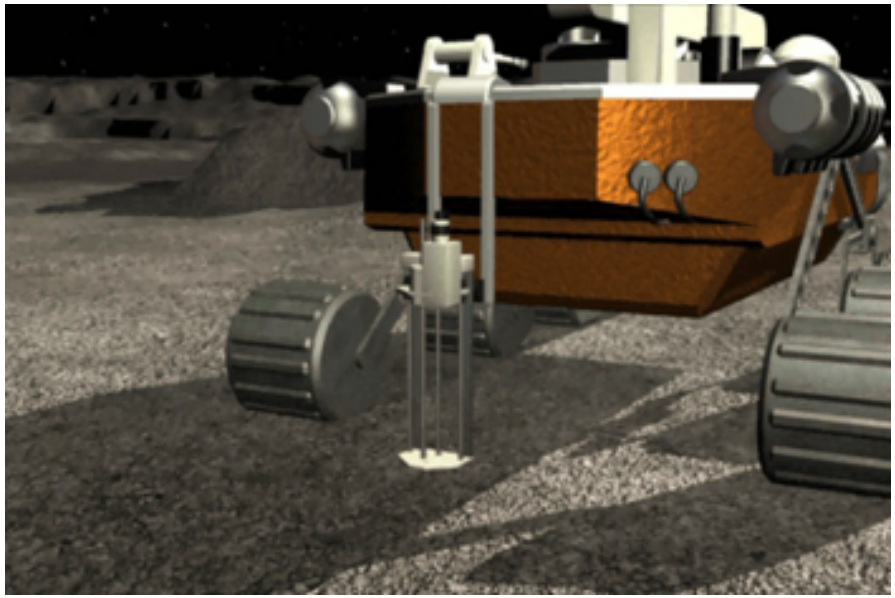
RP is a lunar rover mission to

(1) locate near subsurface volatiles,
(2) excavate & analyze samples of volatile-bearing regolith,
(3) demonstrate the form, extractability and usefulness of the materials.

Prospecting payload

- **NIR spectrometer (NIR)**: surface volatiles
- **Neutron spectrometer (NS)**: volumetric volatiles

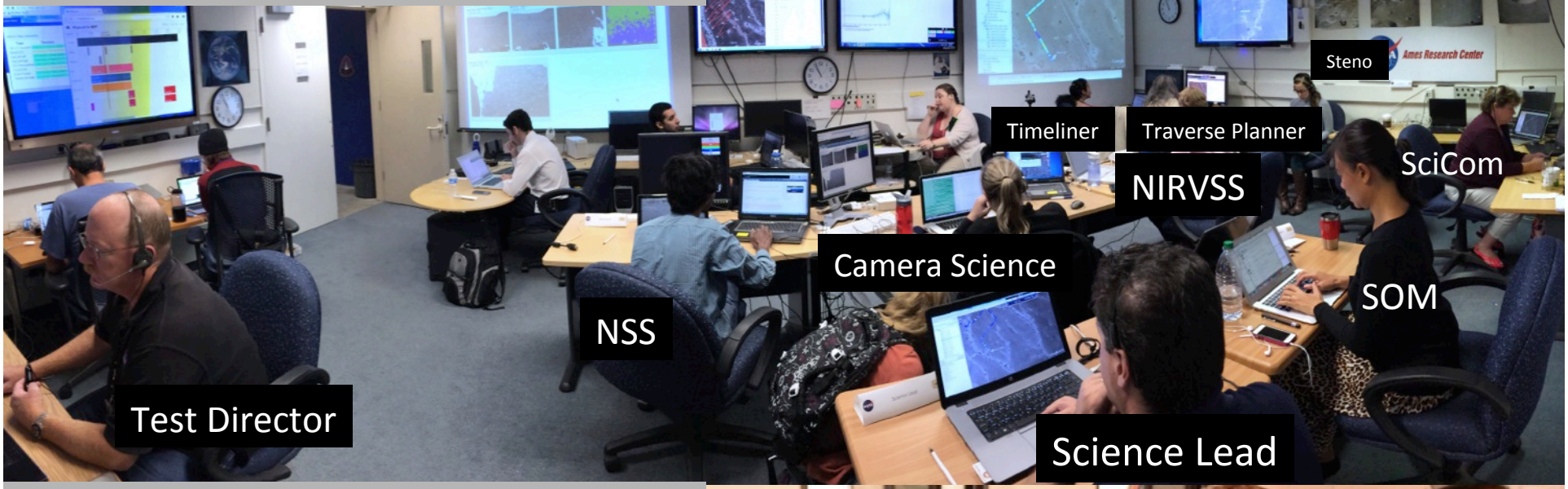
NASA Ames K-Rex rover



Notional rover concept

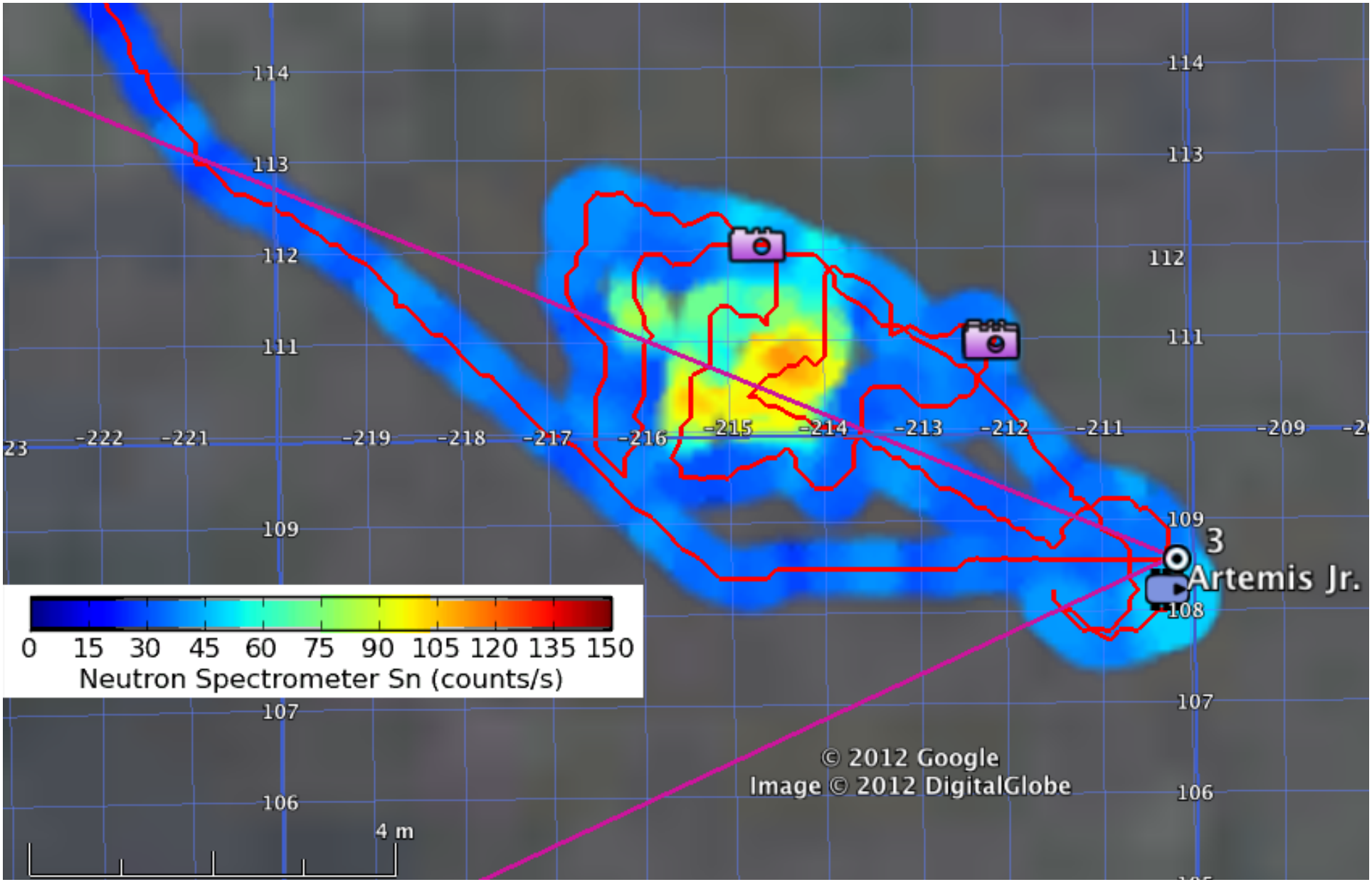
Mojave Volatiles Prospector

Science Operations Center @ NASA Ames



Rover Operations Center @ Mojave

Exploration Ground Data Systems



Risk Reduction

MVP: Resource Prospector Mission Relevance

- Instrument Maturation
  - →Increase TRL of RP prospecting instruments through field testing (NIRVSS and NSS)
  - →Demonstrate instrument performance & ops w/lunar-relevant water abundances

Risk Reduction

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- Ground Data Systems Development
  - →Identify, produce, and test RP-specific real-time analysis tools & displays
    - →instrument strip charts, raster maps, etc.
    - →real-time mission operations modification capabilities (incl. traverse & activity planning for robotic ops)

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- Reconfigure mission operations console & command architecture
  - → Insert Real-time Science position (RT Sci)
  - → RT Sci in direct comm with Rover Nav
  - → Decision-making authority with SciLead, Science Ops Manager

Science and Exploration

Science: Planetary studies of target bodies
Exploration: Understand which exploration concepts of operations (ConOps) and capabilities enable and enhance scientific return.

Science Ops Capabilities

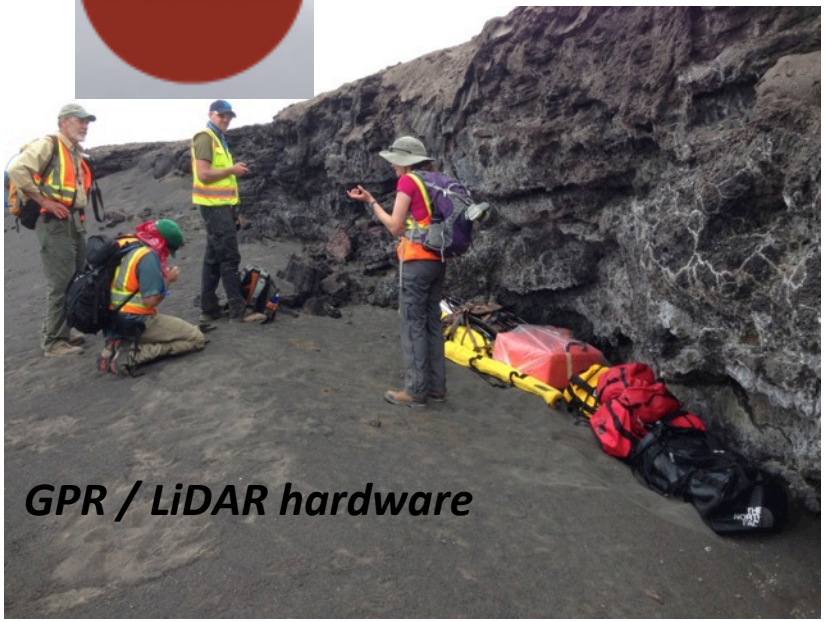
- Habitat Intravehicular (IV) Workstation
- Mobile Instrument Platforms (MIP)
- EVA / Shirtsleeve Backpacks
- distributed Science Backroom Team (dSBT)
- Exploration Ground Data Systems (xGDS, Playbook, etc.)

Playbook

Modular backpack (MIT)

Portable Field Instruments

- All data provide new science….
- But, what are the right instruments and how well must they perform?
- Evaluating state of existing portable science instruments
- Can assess people hours per insight gained
- Will provide recommendations for tech development to maximize time/volume/cost vs science
- Hardware, integration time, precision, software, etc



Science Ops – Human Factors

PRE-MISSION INPUT REQUIREMENTS TO ENABLE SUCCESSFUL SAMPLE COLLECTION BY A REMOTE FIELD/EVA TEAM

Barbara A. Cohen[1], Darlene S. S. Lim[2,3], Kelsey E. Young[4,5], A. Brunner[6], Richard E. Elphic[2], A. Horne[6], M. Kerrigan[7], R. Misener[7], Gordon O. Osinski[7], J. R. Skok[8], Steven W. Squyres[9], D. Saint-Jacques[10], R. Wilks[7], and Jennifer L. Heldmann[2].

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[5]NASA Goddard Space Flight Center, Greenbelt MD 20771
[6]Arizona State University, Tempe AZ 85287
[7]University of Western Ontario, London ON, N6A 3K7 Canada
[8]SETI Institute, Mountain View CA 94043
[9]Cornell University, Ithaca NY 14850
[10]Canadian Space Agency, St-Hubert QC, J3Y 8Y9 Canada

Focus on astronaut training

Simulations yield
Astronaut training wisdom:
Good sampling takes time

ABSTRACT:
We used a field excursion to the West Clearwater Lake Impact structure as an opportunity to test factors that contribute to the decisions a remote field team (for example, astronauts conducting extravehicular activities (EVA) on planetary surfaces) makes while collecting samples for return to Earth. We found that detailed background on the analytical purpose of the samples, provided to the field team, enables them to identify and collect samples that meet specific analytical objectives. However, such samples are not always identifiable during field reconnaissance activities, and may only be recognized after outcrop characterization and interpretation by crew and/or science team members. We therefore recommend that specific time be allocated in astronaut timeline planning to collect specialized samples, that this time follow human or robotic reconnaissance of the geologic setting, and that crew member training should include exposure to

Journal of Human Performance in Extreme Environments

Risk Reduction

HARI Challenges for Exploration Missions

* HARI = Human and Automation/ Robotic Integration

- Long & intermittent communication time-delays
- Tele-operations and autonomous commanding of robotic agents at variant distances
- Supervisory control of complex, automated vehicle systems
- Variety of mixed-agents, different types of automation & robotic agents
- Human-robot team coordination
- Crew autonomy, planning and execution

Slide courtesy Dr. Jessica Marquez (NASA ARC), HRP/HARI POC & Discipline Scientist.

Risk Reduction

Human Research Program (HRP) Roadmap

Co-Is: Group Performance Environments Research Lab @ Purdue Univ.

- **Behavior Health and Performance**

  →Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team

  →Team Gap 2: Identify a set of validated measures, based on the key indicators of **team function, to effectively monitor and measure team health and performance** fluctuations during autonomous, long duration and/or distance exploration missions.

  →Team Gap 5: Identify validated **ground-based training methods** that can be both preparatory and continuing to maintain team function in autonomous, long duration, and/or distance exploration missions.

  →Team Gap 6: Identify methods to **support and enable multiple distributed teams** to manage shifting levels of autonomy during long duration and/or distance exploration missions.

  →Team Gap 9: Identify spaceflight **acceptable thresholds (or ranges) of team function, based on key indicators**, for autonomous, long duration and/or distance exploration missions.

Risk Reduction

Human Research Program (HRP) Roadmap

- **Behavior Health and Performance**

  →Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team

  Crew Scheduling Tools: Risk of inadequate critical task design.

  →SHFE-TASK-03: How can a capability for **semi-autonomous planning and dynamically replanning** of crew schedules be developed?

Risk Reduction

Human Research Program (HRP) Roadmap

- **Space Human Factors and Habitability**

  →Risk of Inadequate Design of Human and Automation/Robotic Integration

  →SHFE-HARI-01: We need to evaluate, develop, and validate methods and guidelines for **identifying human-automation/robot task information needs, function allocation, and team composition** for future long duration, long distance space missions.
  →SHFE-HARI-02: We need to develop design guidelines for **effective human-automation-robotic systems in operational environments that may include distributed, non-colocated adaptive mixed-agent teams with variable transmission latencies**.
  →SHFE-HARI-03: We do not know how to quantify overall **human-automation-robotic system performance to inform and evaluate system designs** to ensure safe and efficient space mission operations.
  →SHFE-HARI-04: What are the effects of the **delays typical of different mission regimes** on teleoperations and how do we mitigate these effects?
  →SHFE-HARI-05: We need to identify and scope the **critical human-automation/robotic mission activities** and tasks that are required for future long duration, long distance space missions.

Risk Reduction

Human Research Program (HRP) Roadmap

- **Space Human Factors and Habitability**

  →Risk of Performance Errors Due to Training Deficiencies

  →SHFE-TRAIN-01: We do not know which validated objective **measures of operator proficiency and of training effectiveness** should be used for future long-duration exploration missions.

  →SHFE-TRAIN-02: We need to identify **effective methods and tools that can be used to train** for long-duration, long-distance space missions.

Future

Science enabling Exploration

&

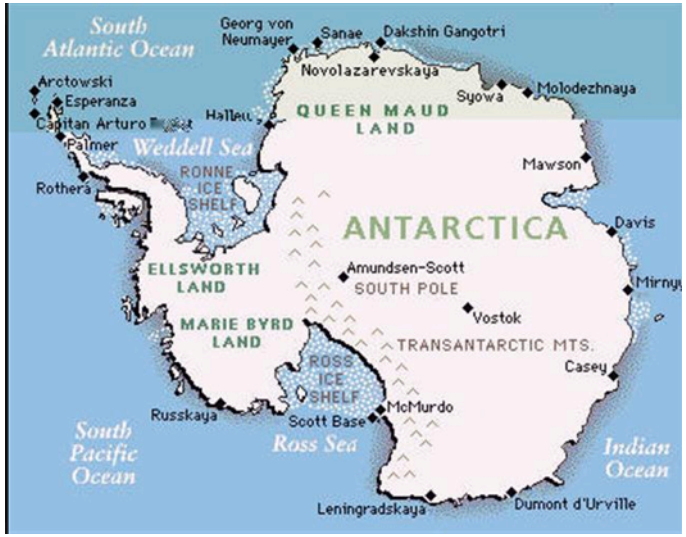
Exploration enabling Science.

Future

Lunar Base

(Antarctica model) – graduate students and researchers routinely conducting fieldwork on the Moon.

McMurdo Station, Antarctica (2015)



Andersen et al. 1990; 1992

Future

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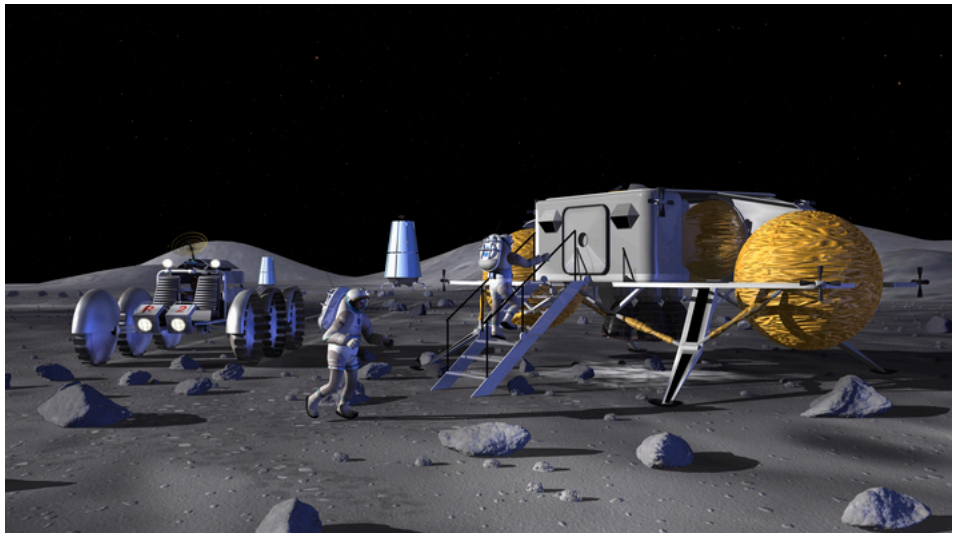
Why?

1. Maintain international influence



Lunar Base

McKay 2013

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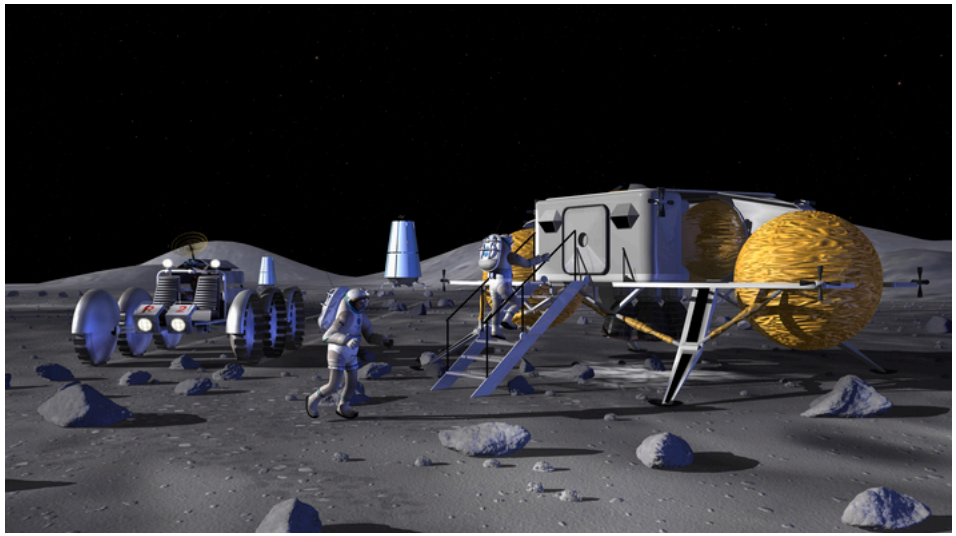
2. Pave the way for other applications



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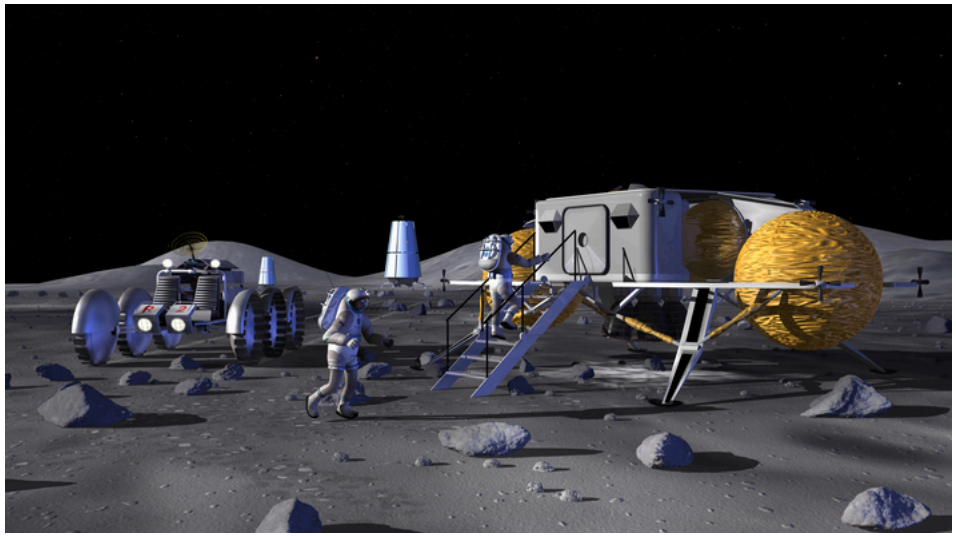
3. Learn more about the Moon



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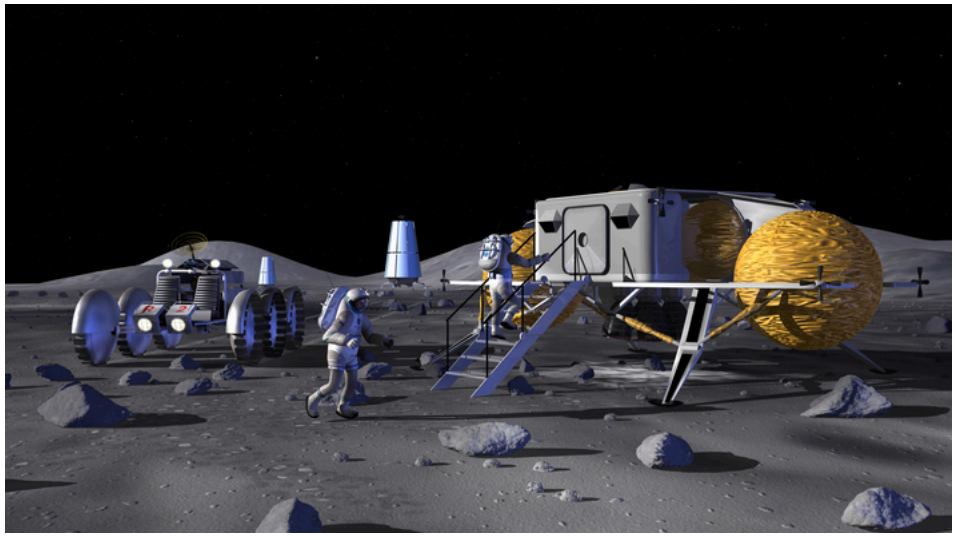

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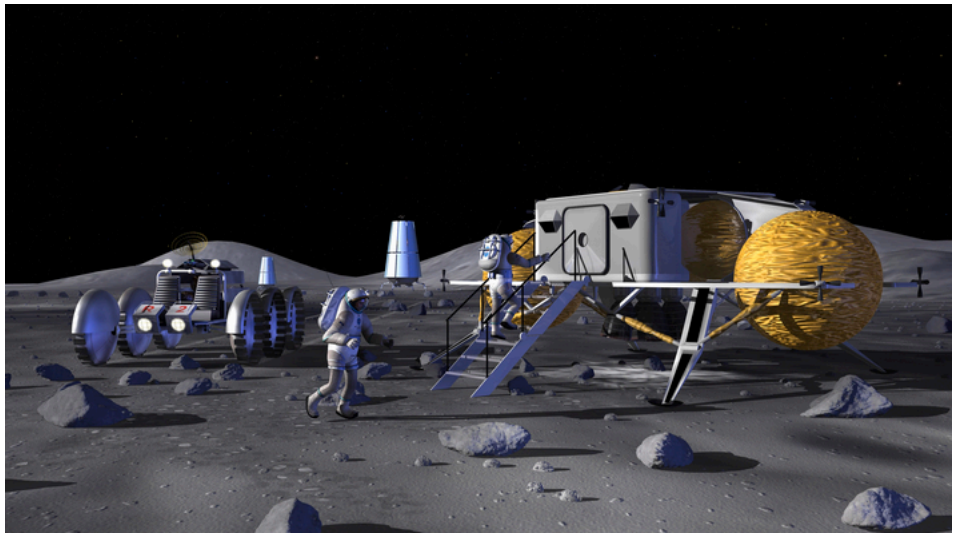
5. Learn to build & operate an extraterrestrial base



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McKay 2013

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Why?

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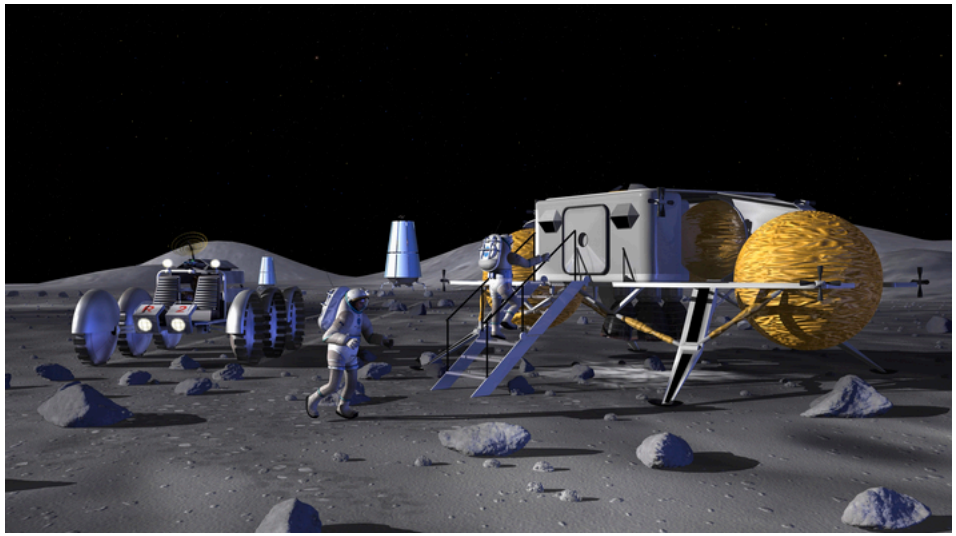
2. Pave the way for other applications
3. Learn more about the Moon
4. Assess health impacts of living in space
5. Learn to build & operate an extraterrestrial base
6. Become an interplanetary species

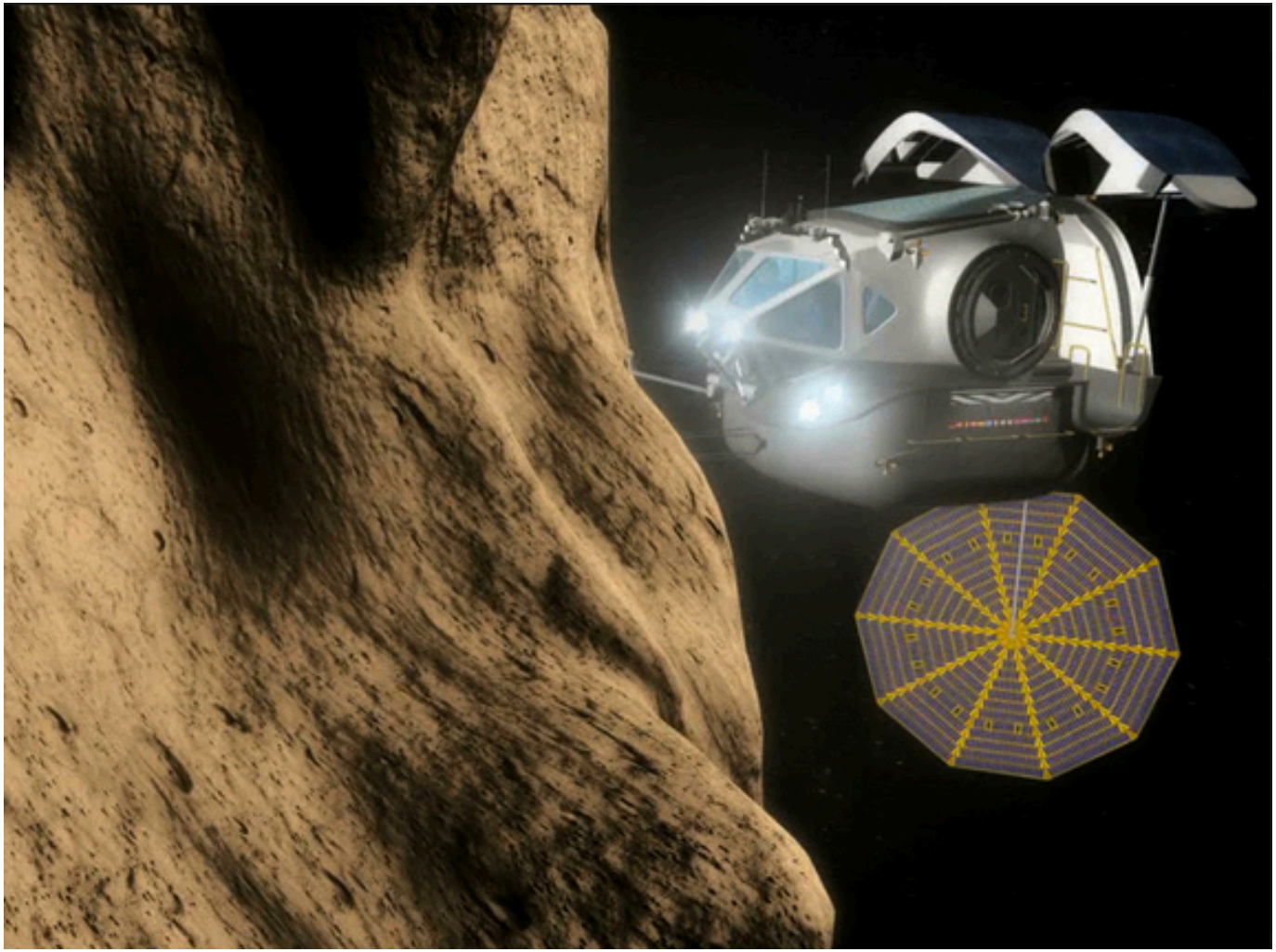


Lunar Base

McKay 2013

Future

Routine science and exploration in space – to lead to new destinations



Future

Routine science and exploration in space – to lead to new destinations

SSERVI CAN-22

SSERVI CAN-22

Fieldwork on the Moon and at asteroids by both humans and robots is encouraged.

Proposed research should include both scientific and exploration driven activities.

SSERVI CAN-22

Proposers are encouraged to make use of the lunar base and research station that has been established on the Moon.

Sorties from this site are encouraged to fulfill science and/or exploration objectives.

Proposers must include a LBLR (Lunar Base Logistics Request) with their submitted proposal.

SSERVI CAN-22

Proposers are encouraged to make use of the lunar base and research station that has been established on the Moon (& Mars).

Sorties from this site are encouraged to fulfill science and/or exploration objectives.

Proposers must include a LBLR (Lunar Base Logistics Request) with their submitted proposal.

Transport to/from the Moon is at no cost to the PI.
Logistics services on the Moon will be provided by NASA.

Thank you!