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Materials Science in Space Workshop

Lunar Infrastructure and Surface Operations

John Vickers, Principal Technologist | 07.29.19

STMD Lunar Surface Innovation Initiative (LSII)

The STMD Lunar Surface Innovation Initiative (LSII) aims to spur the creation of novel technologies needed for lunar surface exploration and accelerate the technology readiness of key systems and components. The LSII activities will be implemented through a combination of unique in-house activities, competitive programs, and public-private partnerships.

LSII Roles and Responsibilities Include:

- Ensuring that there is an ambitious, cohesive, executable Agency strategy for development and deployment of the technologies required for successful lunar surface exploration.
- Integrating a broad spectrum of stakeholders to develop an acquisition strategy which efficiently facilitates robust collaborations and partnerships with industry and academia.
- Addressing planning, implementation, and budget needs to enable lunar surface activities across STMD Programs.
- Collaborating with Agency stakeholders, as well as Other Government Agencies (OGAs), universities, industry, and international partners in order to better align the Agency's investments relative to lunar surface demonstrations.

American Leadership in Space Exploration

EARTH ORBIT

- Grow a Robust Commercial Space Industry with a Constant Human Presence
- Expand our International Partnerships through the ISS
- Conduct exploration science and technology demonstrations aboard ISS
- Continue Critical Earth Science Research
- New Jobs through In-Space Manufacturing and Assembly
- Low-Earth orbit launches us to farther destinations

LUNAR ORBIT

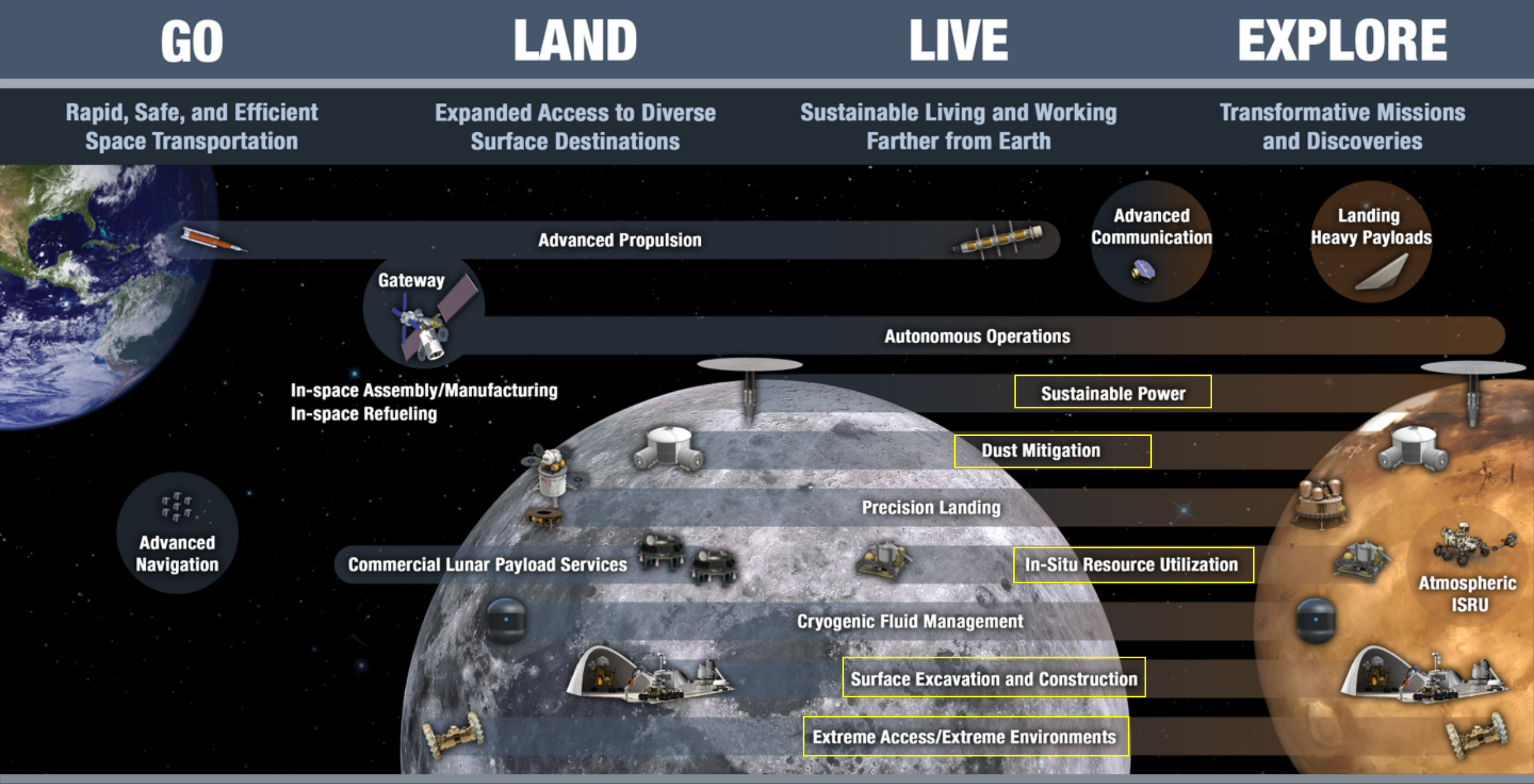
- The Next Step for Commercial Space Development
- Conduct Ground-Breaking Decadal Science
- A New Venue to Strengthen International Partnerships
- Stepping Stone and Training Ground for Extending Human Presence into Deep Space
- Sustainable and Affordable Human and Robotic Programs

LUNAR SURFACE

- Seed Investments in Commercial Lunar Landers
- Opportunities to Develop Technologies for Long-Term Survival
- Explore and Exploit Space Resources
- Create a Foothold on a New Frontier

MARS & BEYOND

- America's Next Giant Leap – Reaching New Worlds
- Push the Boundaries of Human Knowledge
- Answer the Question of 'Are we Alone?'
- Unlock the mysteries of the universe



Lunar Surface Innovation Initiative (LSII)

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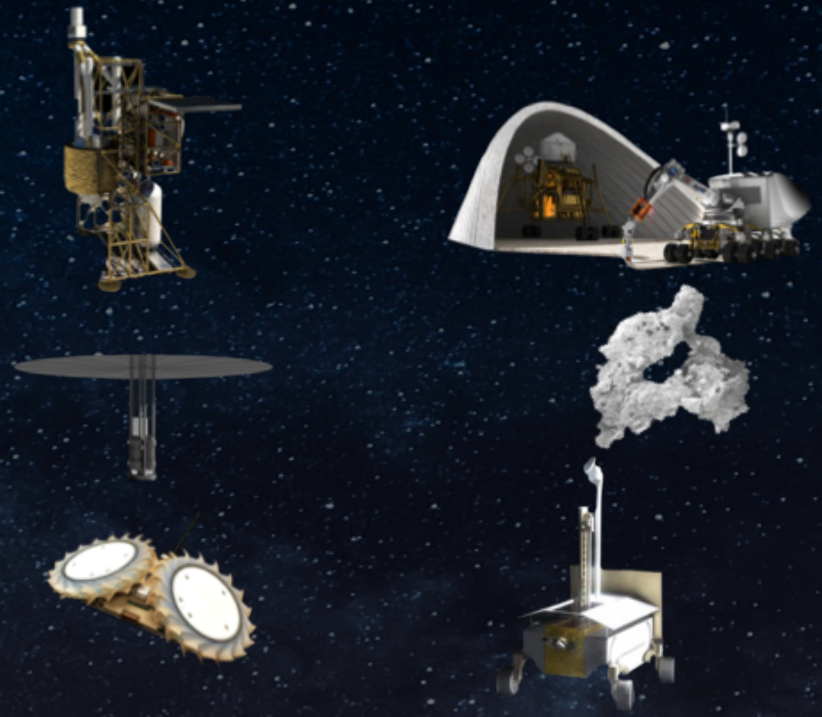
In Situ Resource Utilization
Collection, processing, storing and use of material found or manufactured on other astronomical objects

Sustainable Power
Enable continuous power throughout lunar day and night

Extreme Access
Access, navigate, and explore surface/subsurface areas



Surface Excavation/Construction
Enable affordable, autonomous manufacturing or construction

Lunar Dust Mitigation
Mitigate lunar dust hazards

Extreme Environments
Enable systems to operate through out the full range of lunar surface conditions

- Spurs the creation of novel technologies needed for lunar surface exploration
- Accelerates technology readiness of key systems and components.
- Addresses technology development needs for lunar surface operations, including surface payloads.
- Implements development through a combination of unique in-house activities, competitive programs, and public-private partnerships.
- Coordinates across Agency stakeholders in order to identify priorities.

ISRU Development and Demonstration Timeline

Reconnaissance, Prospecting, Sampling

Sub-system Demonstrations: Investigate, sample, and analyze the environment for mining and utilization.

CLPS Drill Down Select

High-fidelity Simulant Production

Resource Acquisition & Processing

Follow The Natural Resources: Demonstrations of systems for extraction and processing of raw materials for future mission consumables production and storage.

Oxygen from Lunar Simulant Ground Demos

Polar Ice-to-Water Extraction (CLPS)

Lunar Ice to Water Demos

Sustainable Consumable Production

Mars-Forward: Demonstrated, end-to-end systems for extraction, processing, production, and distribution of consumables to support sustained human presence.

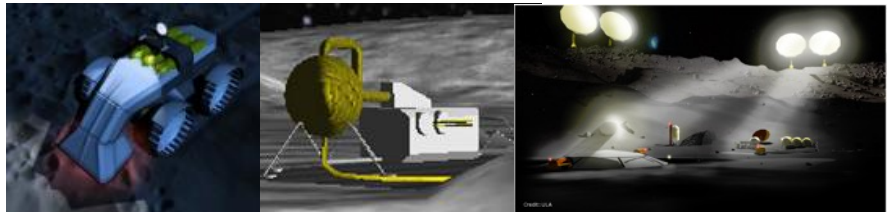
Full-scale, Sustainable ISRU Systems for Consumable Production

2019 ***2022*** ***2024*** ***2028***

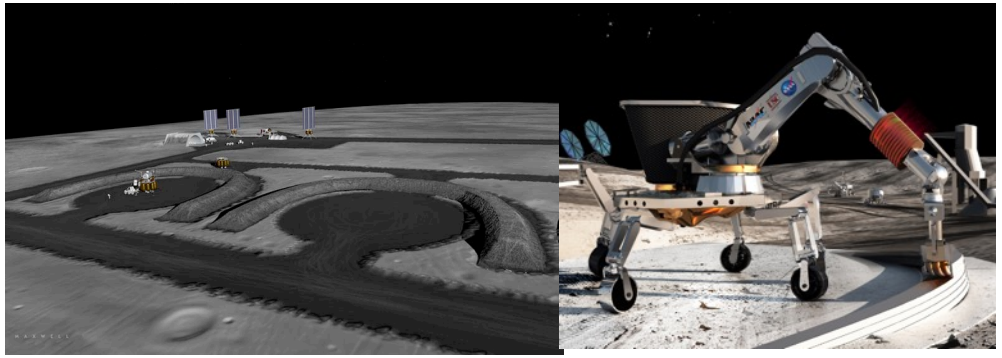
Lunar Surface ISRU Capabilities

Resource Prospecting – Looking for Water

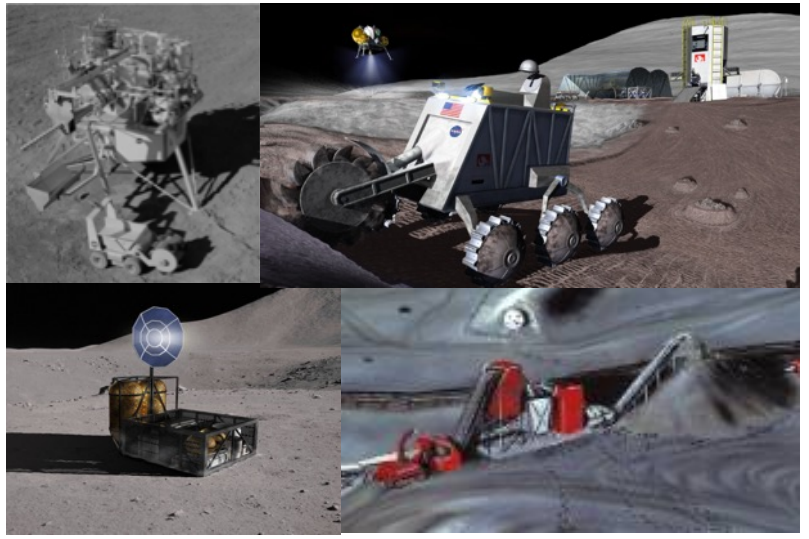
Mining Polar Water & Volatiles



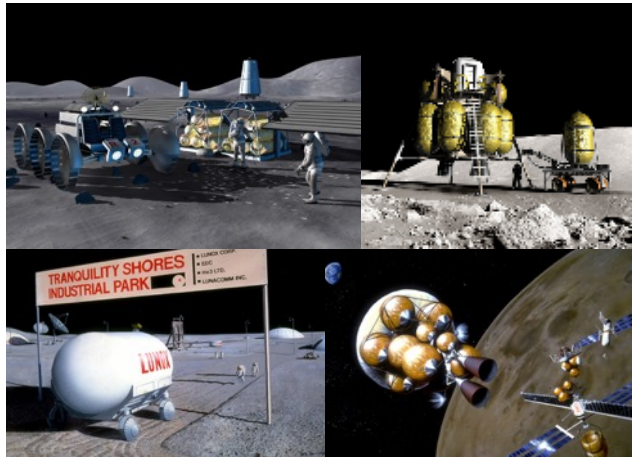
Landing Pads, Berms, Roads, and Structure Construction



Excavation & Regolith Processing for O_2 Production



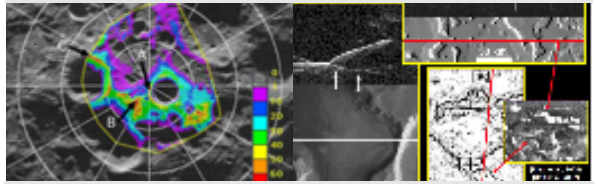
Refueling and Reusing Landers & Rovers



In Situ Resource Utilization (ISRU) Strategic Vector

Today
(Technology & Feasibility)

Significant Uncertainty with Water Resource



Technology/Concept Evaluation

Short Duration System Tests

Capability Feasibility Demonstrated

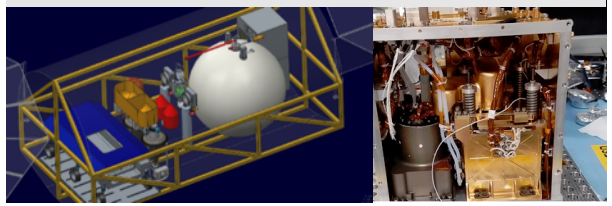
Near-Term
(Ground Dev. & Flight)

Resource & Water Characterization/Prospecting

Environmental & Long-Duration Ground Testing

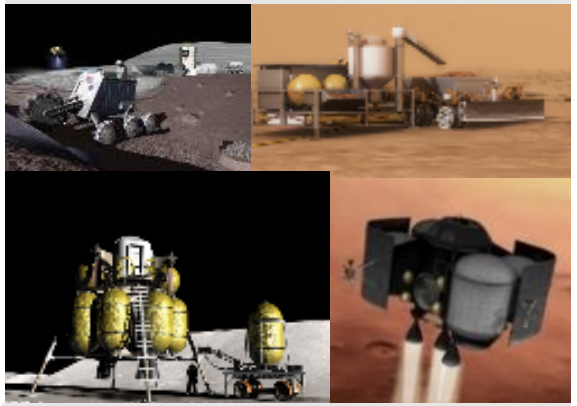
Technology Selection & System Development

Flight Demonstrations & Pilot Plants for Mission Enhancement

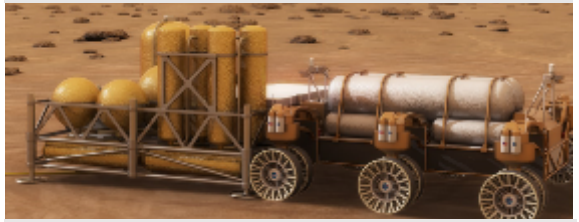


Goal
(Mission Utilization)

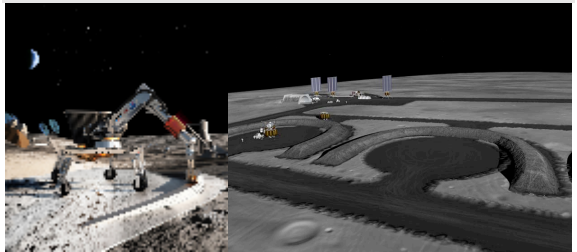
Oxygen & Propellant Production for Transportation



Consumables for Regenerative Power & Life Support



Manufacturing & Construction w/ In Situ Derived Materials



3D-Printed Habitat Challenge

Phase 1: Design Competition
Completed Sep. 2015
$50,000 prize purse

1st Place: SEArch and Clouds AO

2nd Place: Gamma

3rd Place: LavaHive

Phase 2: Structural Member Competition
Completed Sep. 2017
$1.1 million prize purse

Foster + Partners | Branch Technology

Pennsylvania State University

Phase 3: On-Site Habitat Competition
Completed Apr. 2019
$2 million prize purse

New York-based design agency AI SpaceFactory

SEArch+/Apis Cor first place for software modeling

Acknowledgements

Contributors

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- Gerald (Jerry) Sanders: NASA HQ In-Situ Resource Utilization System Capability Lead
- Robert Moses: NASA LARC In Situ Construction Integrated Steering Group Lead