

The background of the slide is a space-themed image. On the left, a large, detailed view of the Moon's surface is shown, with numerous craters and lunar maria. To its upper left, the reddish-orange planet Mars is visible. A small rocket or lander is positioned on the Moon's surface, emitting a bright blue beam of light that extends towards the center of the frame. The sky is a deep, dark blue, filled with numerous small white stars. In the bottom right corner, the silhouette of a person's head and shoulders is visible, looking towards the left. The bottom edge of the image shows a dark, silhouetted horizon line, possibly representing a landscape or the edge of a spacecraft.

EXPLORESPACE TECH
TECHNOLOGY DRIVES EXPLORATION

ISS R&D Conference 2019
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

GO

LAND

LIVE

EXPLORE

Rapid, Safe, and Efficient
Space Transportation

Expanded Access to Diverse
Surface Destinations

Sustainable Living and Working
Farther from Earth

Transformative Missions
and Discoveries



Advanced Propulsion



Advanced
Communication



Landing
Heavy Payloads



Gateway

Autonomous Operations

In-space Assembly/Manufacturing
In-space Refueling

Sustainable Power

Dust Mitigation

Precision Landing

Commercial Lunar Payload Services

In-Situ Resource Utilization

Cryogenic Fluid Management

Atmospheric
ISRU

Surface Excavation and Construction

Extreme Access/Extreme Environments

Advanced
Navigation



2020

Lunar Surface Innovation Initiative (LSII)

203X

Lunar Surface Innovation Initiative (LSII)

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



Oxygen from
Lunar Simulant
Ground Demos

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

Polar Ice-to-Water
Extraction (CLPS)



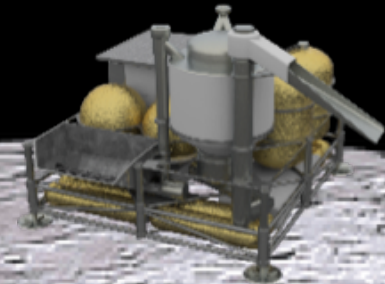
Lunar Ice to
Water Demos



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

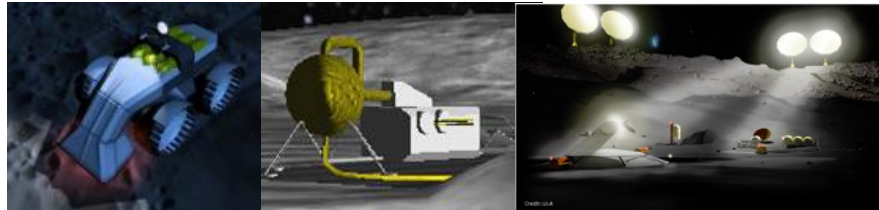
2028

Lunar Surface ISRU Capabilities

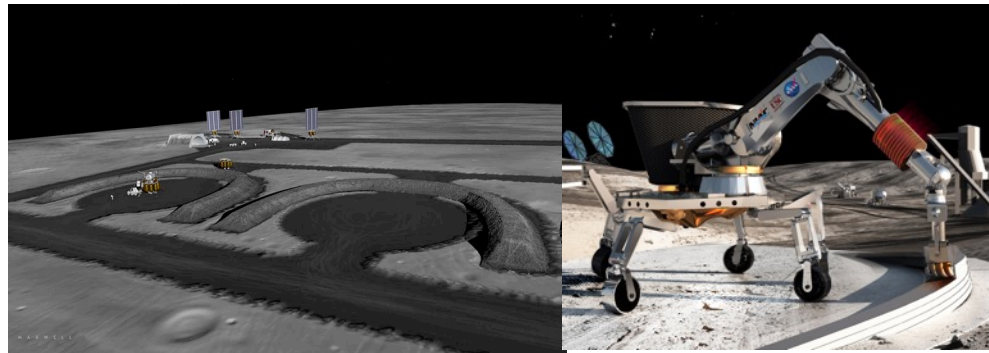
Resource Prospecting – Looking for Water



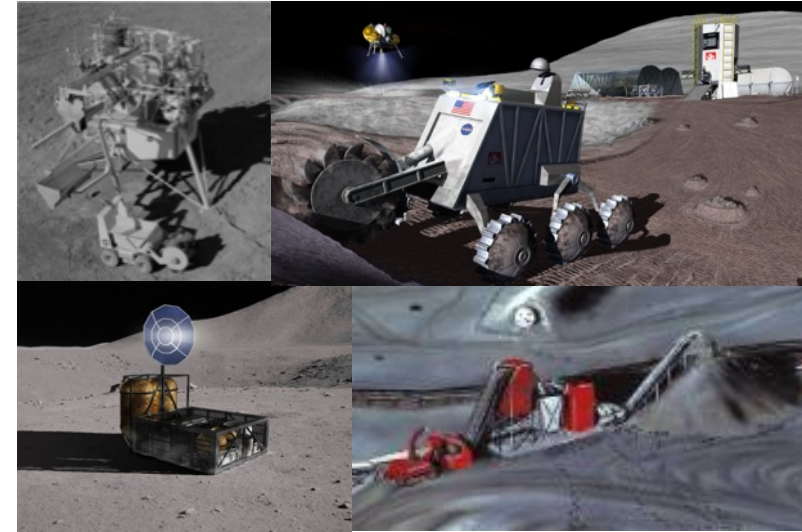
Mining Polar Water & Volatiles



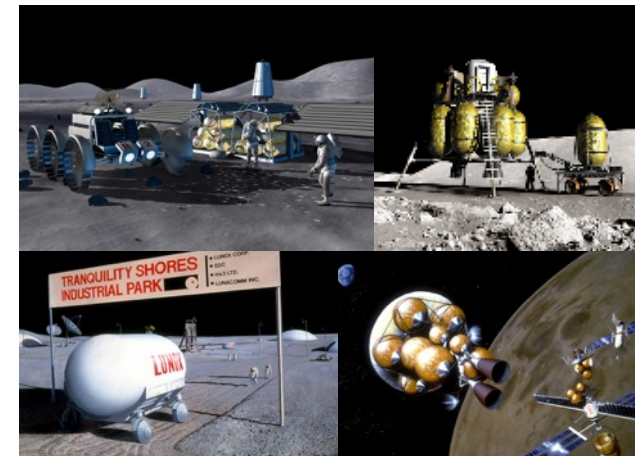
Landing Pads, Berms, Roads, and Structure Construction



Excavation & Regolith Processing for O₂ Production



Refueling and Reusing Landers & Rovers

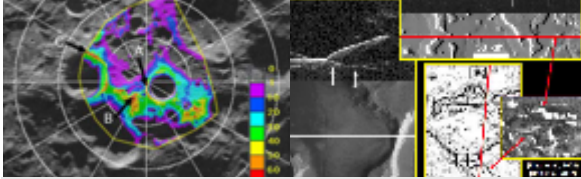


In Situ Resource Utilization (ISRU) Strategic Vector

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



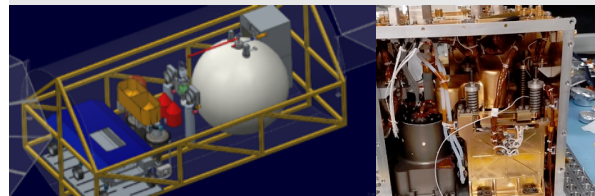
Environmental & Long-Duration Ground Testing



Technology Selection & System Development



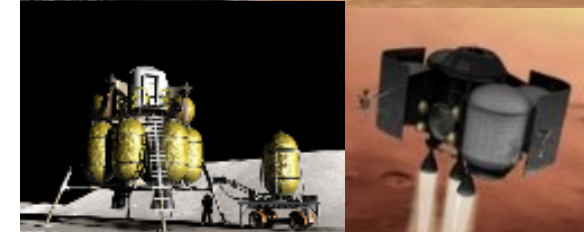
Flight Demonstrations & Pilot Plants for Mission Enhancement



Goal

(Mission Utilization)

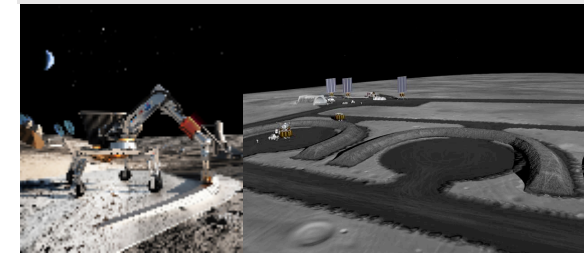
Oxygen & Propellant Production for Transportation



Consumables for Regenerative Power & Life Support



Manufacturing & Construction w/ In Situ Derived Materials



3D-Printed Habitat Challenge

NASA'S 3D-PRINTED HABITAT CHALLENGE

A NASA CENTENNIAL CHALLENGE

NASA's 3D-Printed Habitat Challenge is a competition to design and print habitats that could house humans as they live and work in space and here on Earth.

www.nasa.gov/3DPHab

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



1st Place

Foster + Partners | Branch Technology



2nd Place

Pennsylvania State University

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



1st Place

New York-based design
agency AI SpaceFactory



1st Place

SEArch+/Apis
Cor first
place for
software
modeling

Acknowledgements

Contributors

- Niki Werkheiser: NASA MSFC In Space Manufacturing, Program Manager
 - R.G. Clinton Jr.: NASA MSFC Associate Director Science and Technology Office
 - Monsi Roman, Manager for NASA's Centennial Challenges Program
 - Gerald (Jerry) Sanders: NASA HQ In-Situ Resource Utilization System Capability Lead
 - Robert Moses: NASA LARC In Situ Construction Integrated Steering Group Lead
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