

DEEP SPACE GATEWAY CONCEPT SCIENCE WORKSHOP
FEBRUARY 27-MARCH 1, 2018 • DENVER, CO

Lunar Lander Deployment

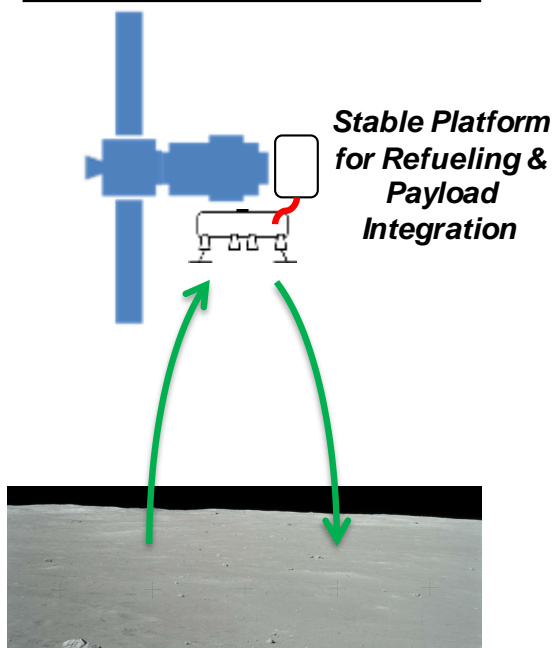
February 28th, 2018

Tara Polsgrove; MSFC

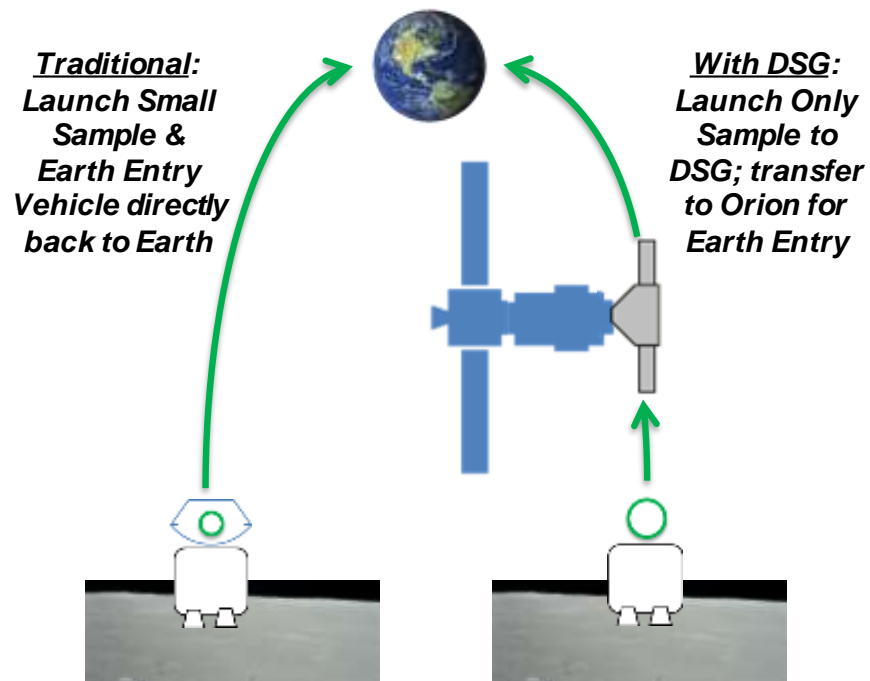
Enhancing Lunar Surface Missions

- Lunar surface access is required to support the 7 highest priority lunar science objectives identified in the National Research Council, 2007 report
 - Surface access supports missions such as lunar sample return & multi-site coordinated investigations
 - The DSG can **substantially enhance** the return from both robotic & crewed round-trip lunar surface missions.

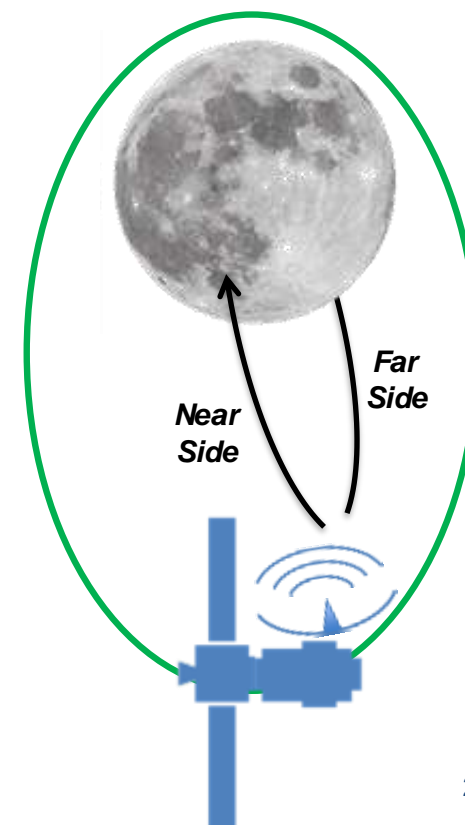
Reusable Lander Support

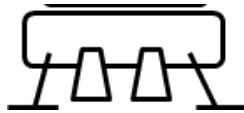


Sample Return Enhancement



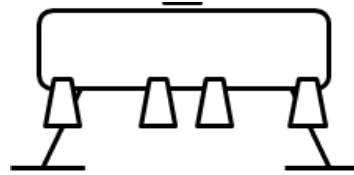
Surface Communications Support





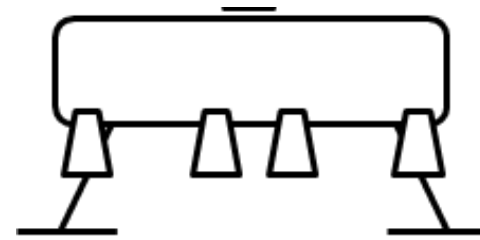
100 kg – Class

- Near-Term
- Storable Propellant
- Current Launch Fleet



1000 kg – Class

- Mid-Term
- Storable or Cryo Propellant
- Next-Gen Launch Fleet



10000 kg – Class

- Long-Term (Mars Evolutionary)
- Cryo Propellant
- Next-Gen LV & SLS

<i>Lunar Science</i>			
Rovers	Small Rovers (Spirit-Class)	Large Rovers (Curiosity-Class)	
Fixed Position Science	Small, single site	Larger or Multi-Site	
Sample Return		Small Ascent	
<i>Prospecting & Preparation</i>			
Resource Prospecting	Small Rovers	Large Rovers	
Landing Site Prep		Robotic Pre-work	Robotic Heavy Equipment
Equipment Prepositioning		Small Human-Class	Large Human-Class
<i>Human Presence</i>			
Logistics Delivery			Consumables/Equipment
ISRU Propellant Supply to Orbit			Propellant Launch
Human Landing			Human-Class Lander



Lunar CATALYST

Lunar Cargo Transportation And Landing by Soft Touchdown



Overview

- **In 2014, NASA competitively selected U.S. private-sector partners, based on likelihood of successfully fielding a commercially-viable lunar surface cargo transportation capability**

- Evaluation criteria included:
 - Technical approach and development schedules
 - Technical risks and mitigation plans
 - Business plans and market strategies
 - Equity and debt financing
 - Transportation service customer agreements



Leveraging NASA expertise
(Above: NASA Mighty Eagle & Morpheus vehicles)

- **Lunar CATALYST Space Act Agreement (SAA) Partnerships**

- Term: 3 years (2014-2017) with option to extend
- No-funds-exchanged
- Substantial in-kind contributions from NASA (~\$10M/year)
 - Technical Expertise
 - Test Facilities
 - Equipment loans
 - Software



Close Technical Collaboration

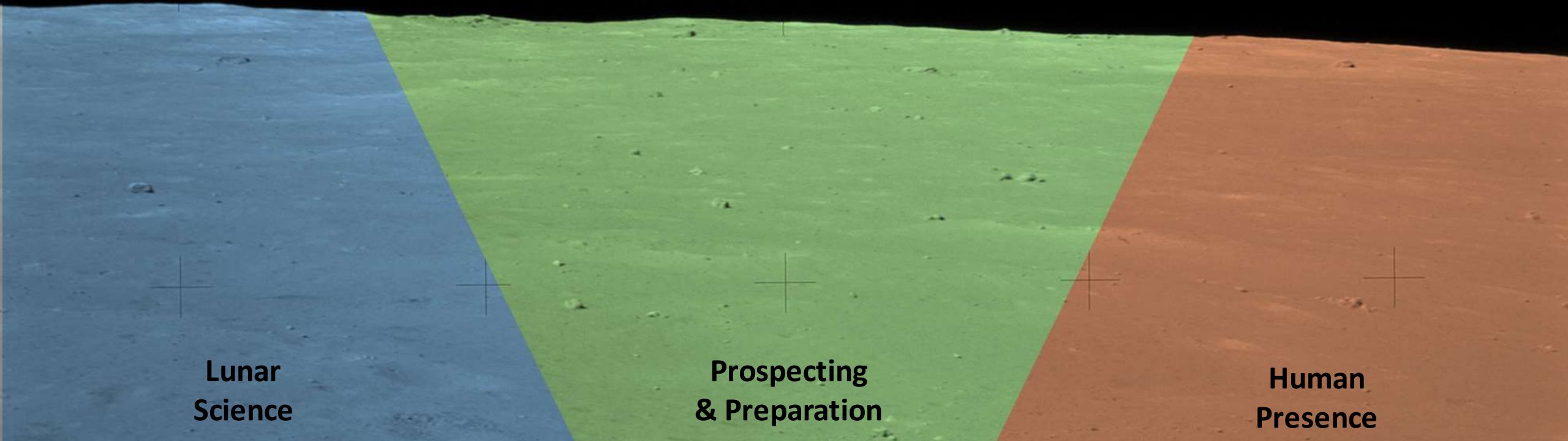
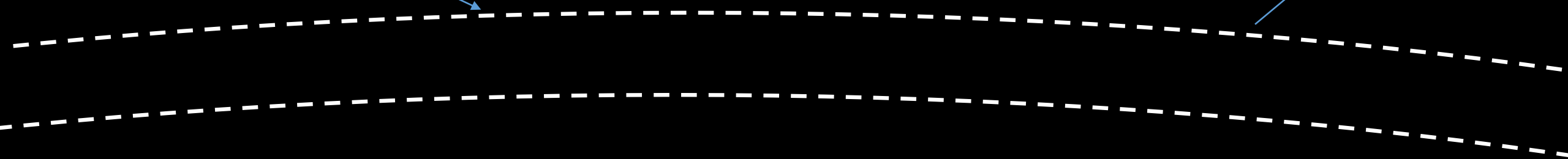
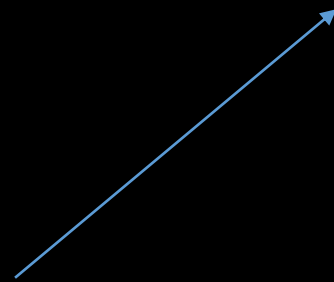
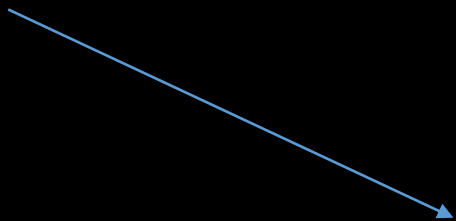
- Technical and financial milestones
- Partners:
 - Astrobotic Technology
 - Masten Space Systems
 - Moon Express

Through Lunar CATALYST, NASA is helping partners lower risks, conduct tests, and accelerate vehicle development to launch



Technology and System
Development and Testing

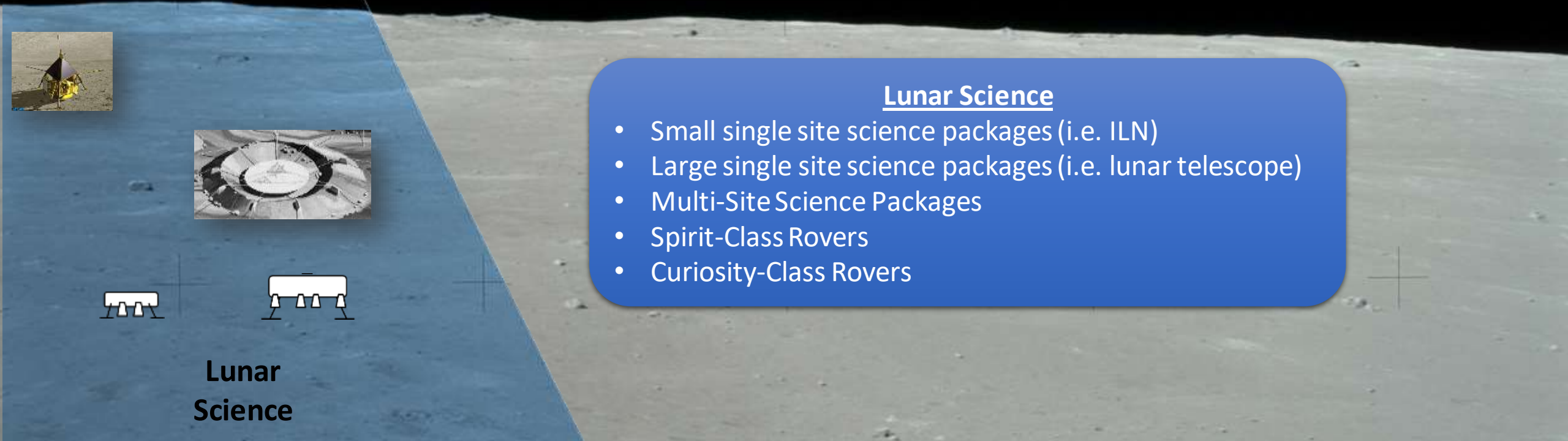
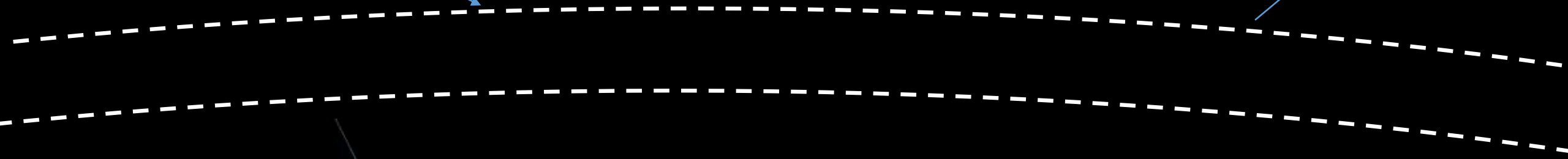
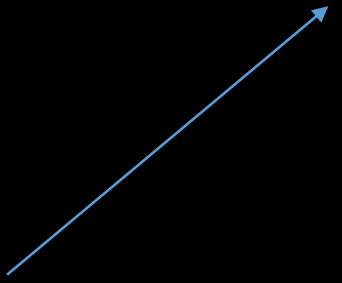
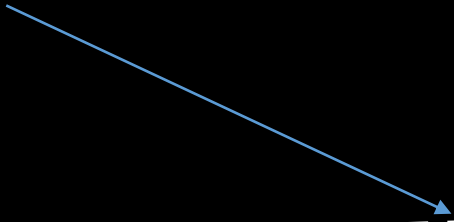
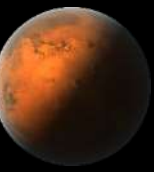
- <http://www.nasa.gov/lunarcatalyst>



**Lunar
Science**

**Prospecting
& Preparation**

**Human
Presence**



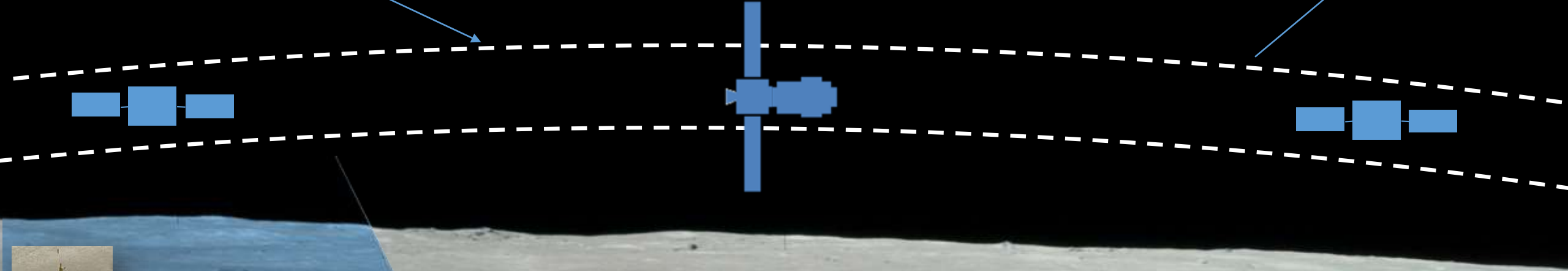
**Lunar
Science**

- Lunar Science**
- Small single site science packages (i.e. ILN)
 - Large single site science packages (i.e. lunar telescope)
 - Multi-Site Science Packages
 - Spirit-Class Rovers
 - Curiosity-Class Rovers



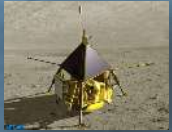
Orbital Assets

- Communications Relay Satellites
- Deep Space Gateway Build

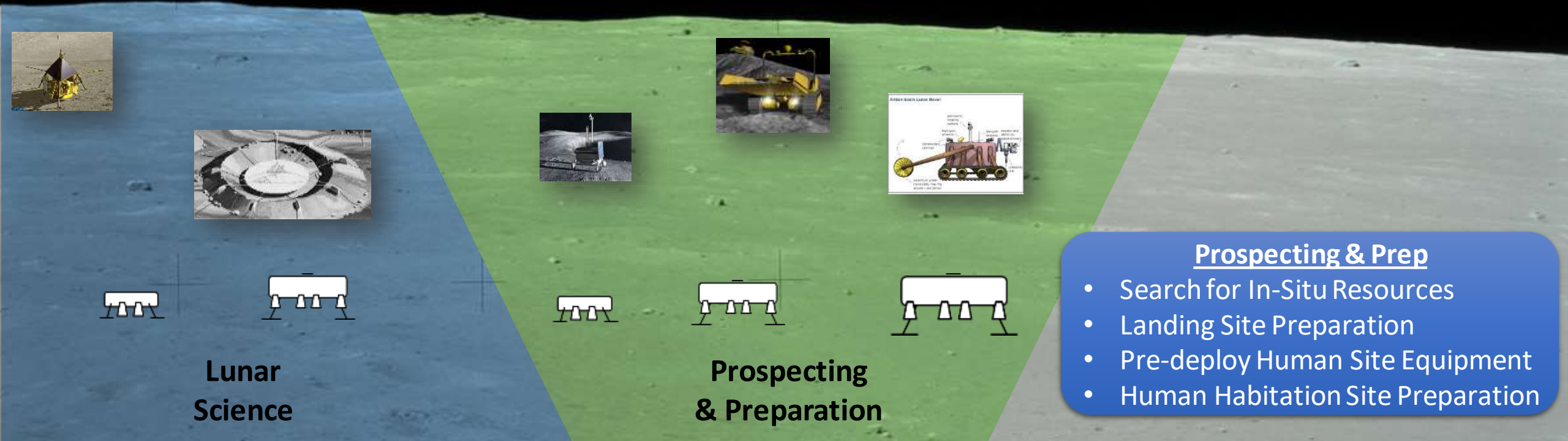
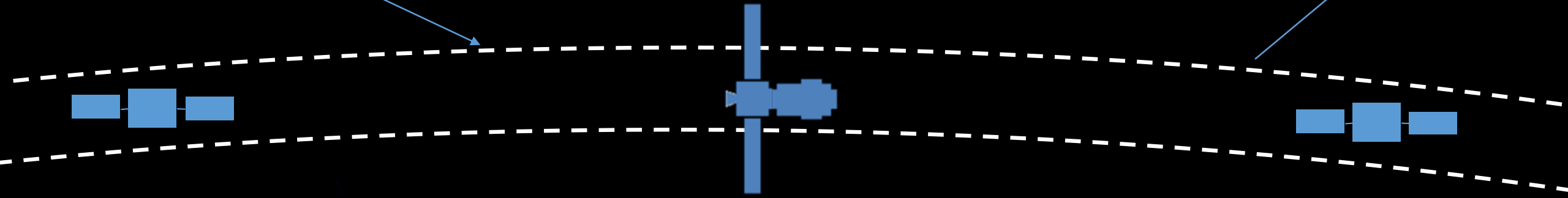
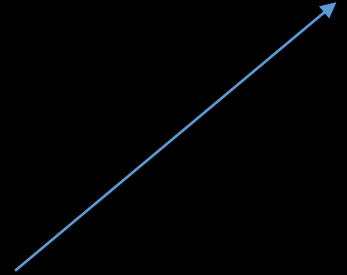
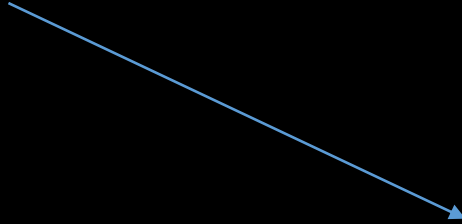


Lunar Science

- Continue to evolve and expand lunar surface science
- Leverage DSG for lander reuse
- Leverage DSG & Orion for Sample Return



**Lunar
Science**

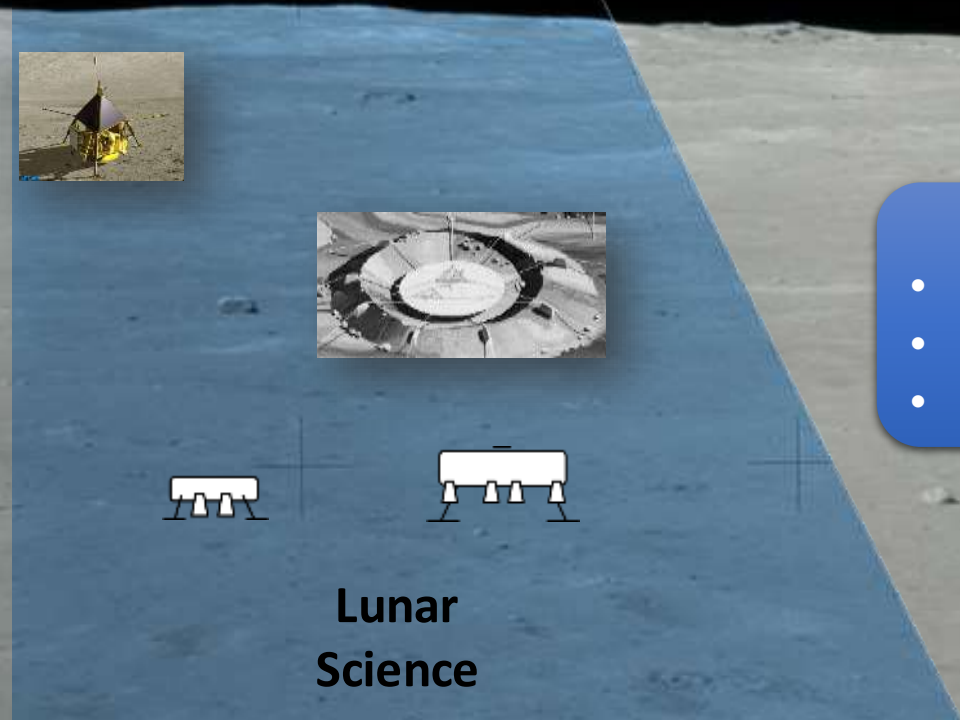
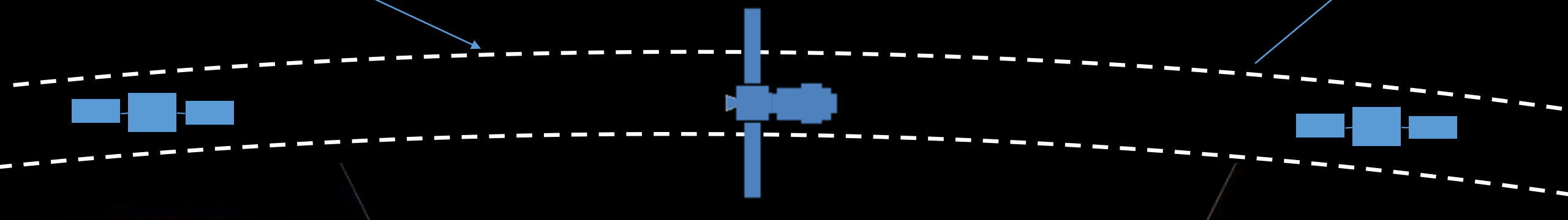


**Lunar
Science**

**Prospecting
& Preparation**

Prospecting & Prep

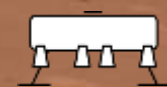
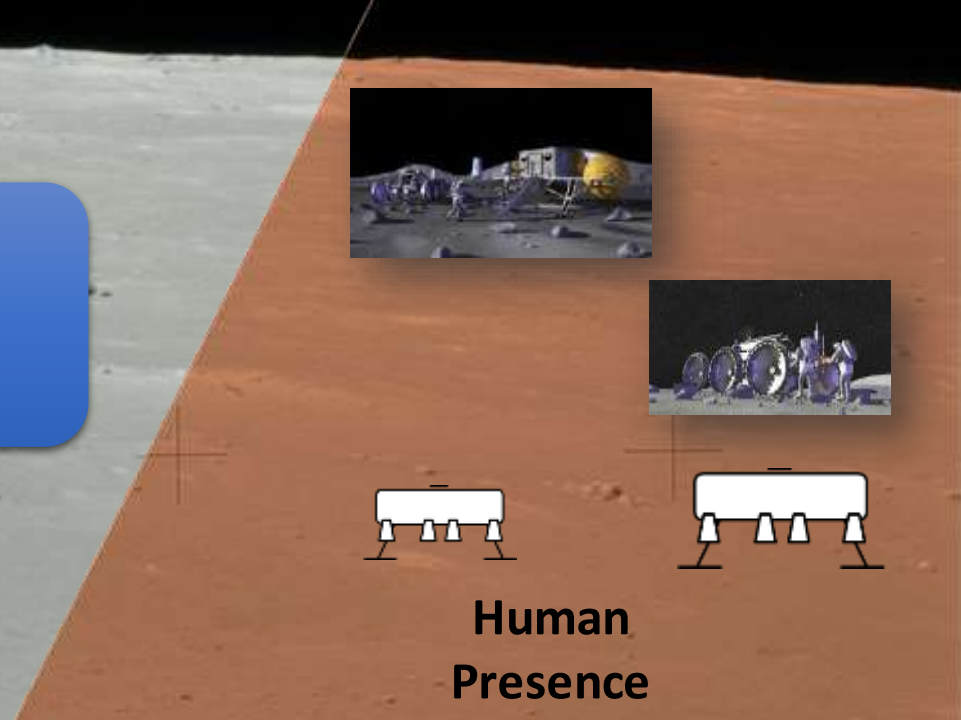
- Search for In-Situ Resources
- Landing Site Preparation
- Pre-deploy Human Site Equipment
- Human Habitation Site Preparation



**Lunar
Science**

Human Presence

- Human-Class Landing
- Large Equipment Delivery
- Logistics Resupply



**Human
Presence**



- **Lunar Surface Access w/ Reusable Lander**

- Benefits / Functional Support

- Platform to support lander refueling operations
- Platform for integrating surface payloads with landers

- Functional Requirements

- Multiple docking ports
- Attitude control
- Robotic arm for berthing support

- **Lunar Sample Return**

- Benefits / Functional Support

- Reduction in ascent ΔV requirements
- Sample retrieval and caching
- Sample return to Earth via Orion

- Functional Requirements

- Science Airlock (~0.2-0.5m diameter)
- Crew access to sample canisters
- Sample stowage accommodations
- Orion docking port

- **Crew presence can be enhancing but should be capable of supporting operations remotely as well**

- **Use of Orion for returning samples is a key benefit for Sample Return Missions**

- Requires appropriate sample stowage accommodations in Orion.