BUILDING THE MOON BASE

Carlos Garcia-Galan
Moon Base Program Executive

CAPABILITY EVOLUTION

Gateway Pivot

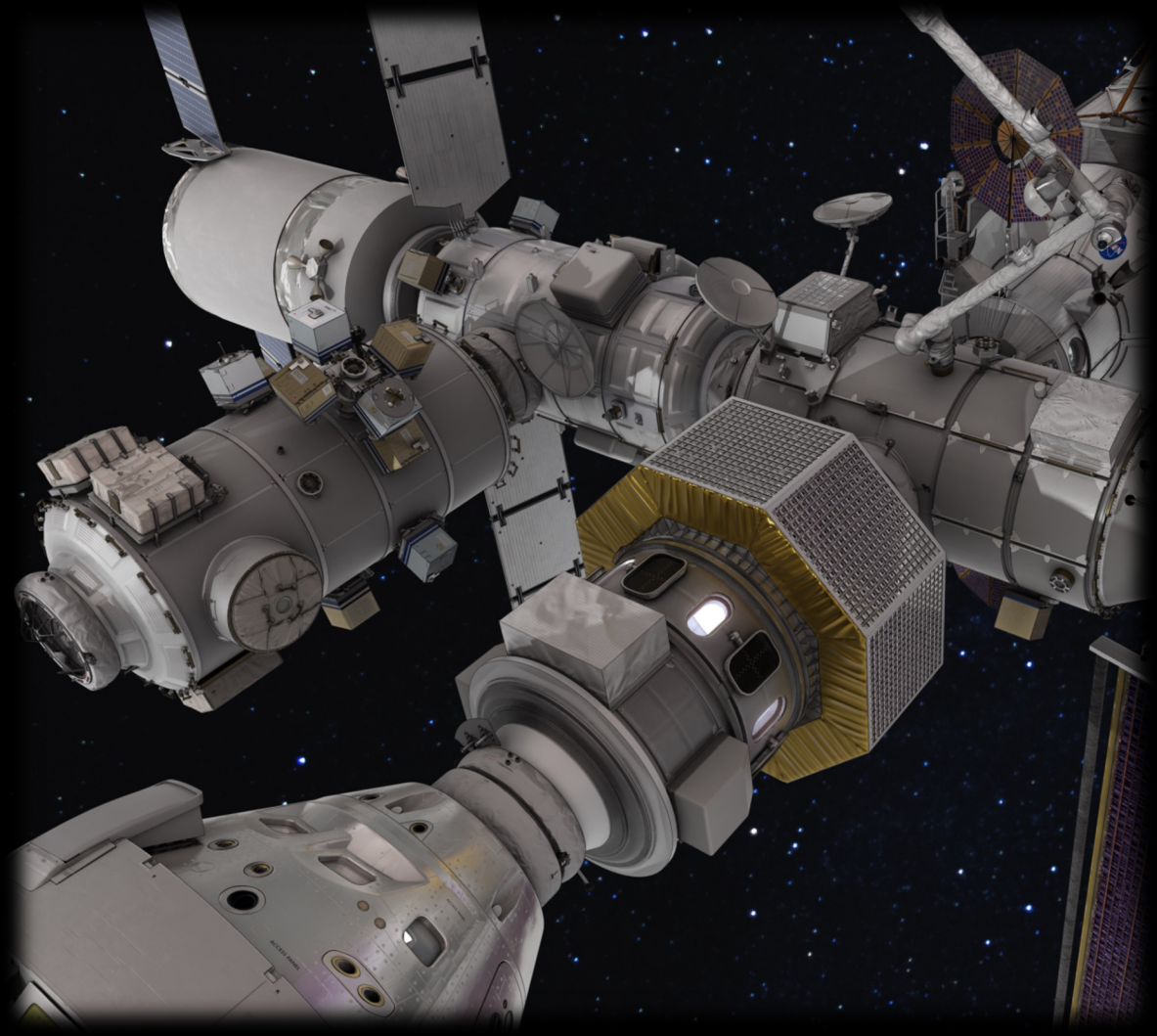
National space policy prioritizes sending astronauts back to the lunar surface and building a lunar outpost on the surface of the Moon.

The current Gateway architecture, while relevant to long term exploration goals, is not required to accomplish the primary objectives of landing humans on the Moon and establishing a Moon Base.

As a result, NASA is using Gateway elements to enable building the Moon Base, shifting the focus of the resources and people to the surface, which will also include orbital elements to support surface ops.

Additional considerations:

- HLS providers do not require Gateway to accomplish their missions. Docking with orbiting platform came with performance penalties
- Gateway launch to lunar orbit is significantly behind schedule: PPE+HALO launch will likely be further delayed due to on-going HALO corrosion mitigation. Not expected to reach initial operational status until 2030+
- Other Gateway modules also behind schedule, with significant technical challenges ahead: corrosion mitigation (same issues as with HALO), overweight, complex assembly sequence



CAPABILITY EVOLUTION

Gateway Evolution

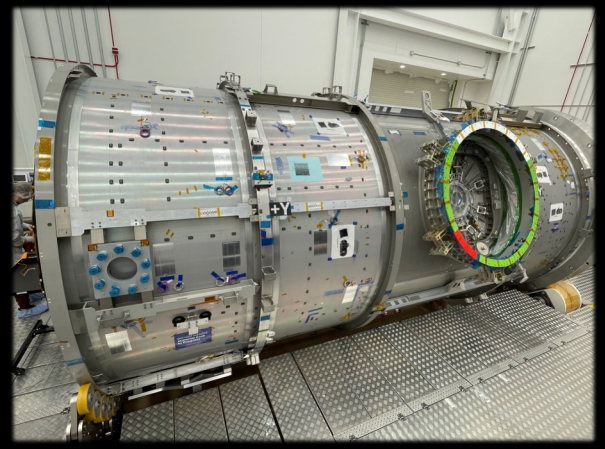
Significant parts of existing Gateway hardware and facilities can be directly repurposed to support near-term exploration objectives along with those orbital elements needed to support a surface-focused mission.

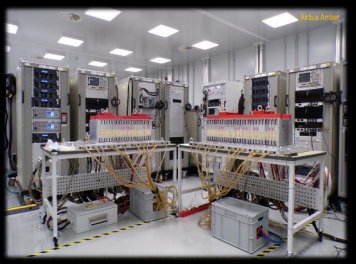
NASA, industry, and international partners are assessing best repurposing ideas of existing hardware.

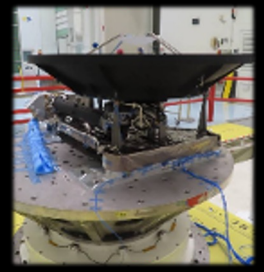
- Many of the facilities are designed for an evolving architecture and can be adapted to current near-term needs in test, verification, and assembly/integration
- Repurposing options include using PPE for other high-priority missions, existing communications HW on the Moon Base, HALO subsystems/components/structures on future Moon Base modules

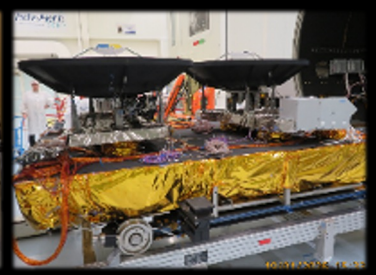
The NASA Gateway team will pivot to support Moon Base development efforts or other high priority initiatives.

We’re working with our international partners to make this transition together and repurpose our partnerships towards building Moon Base.









Phase 1:

Secure reliable access to the surface and experiment

Starts now

Phase 2:

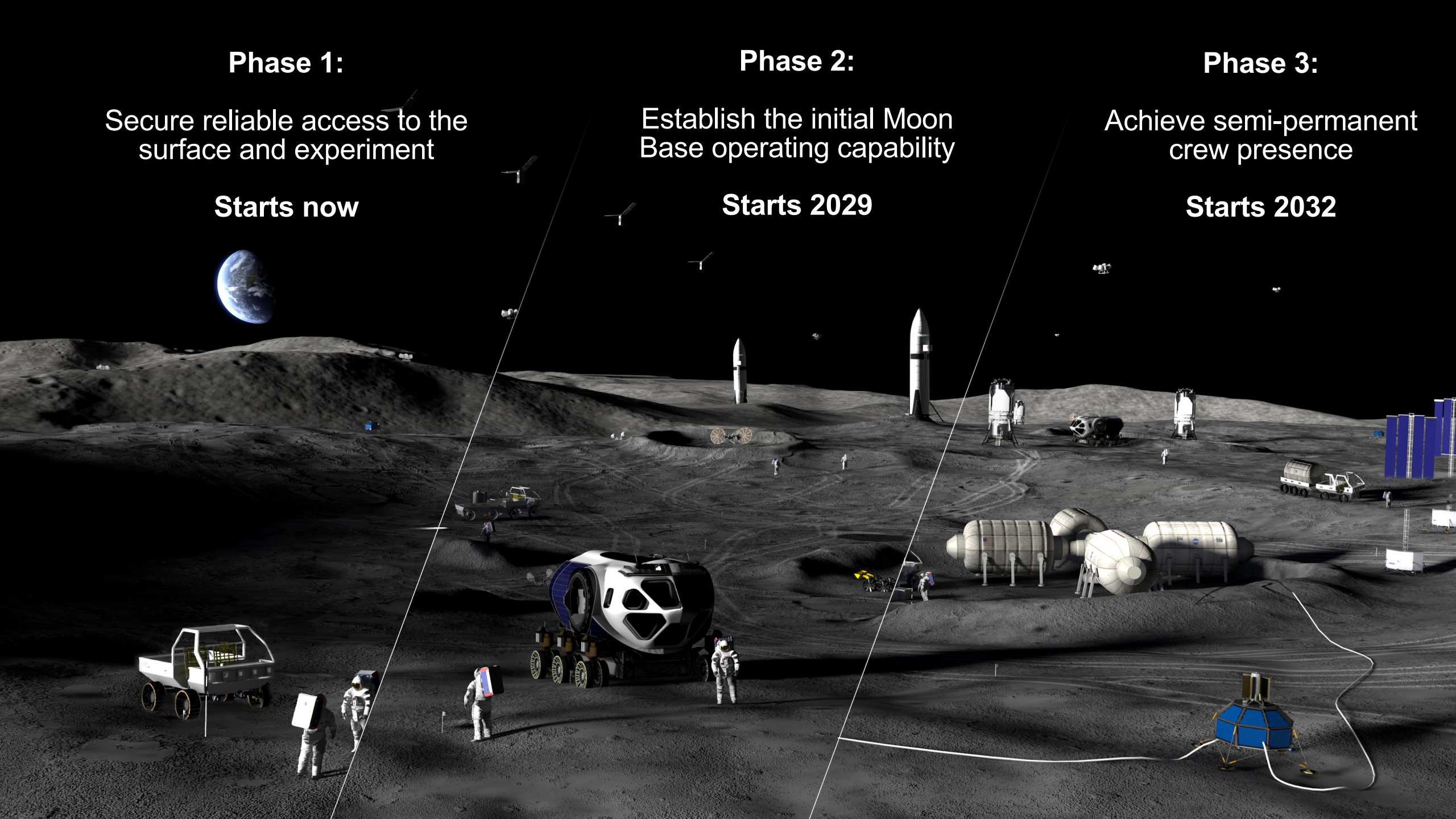
Establish the initial Moon Base operating capability

Starts 2029

Phase 3:

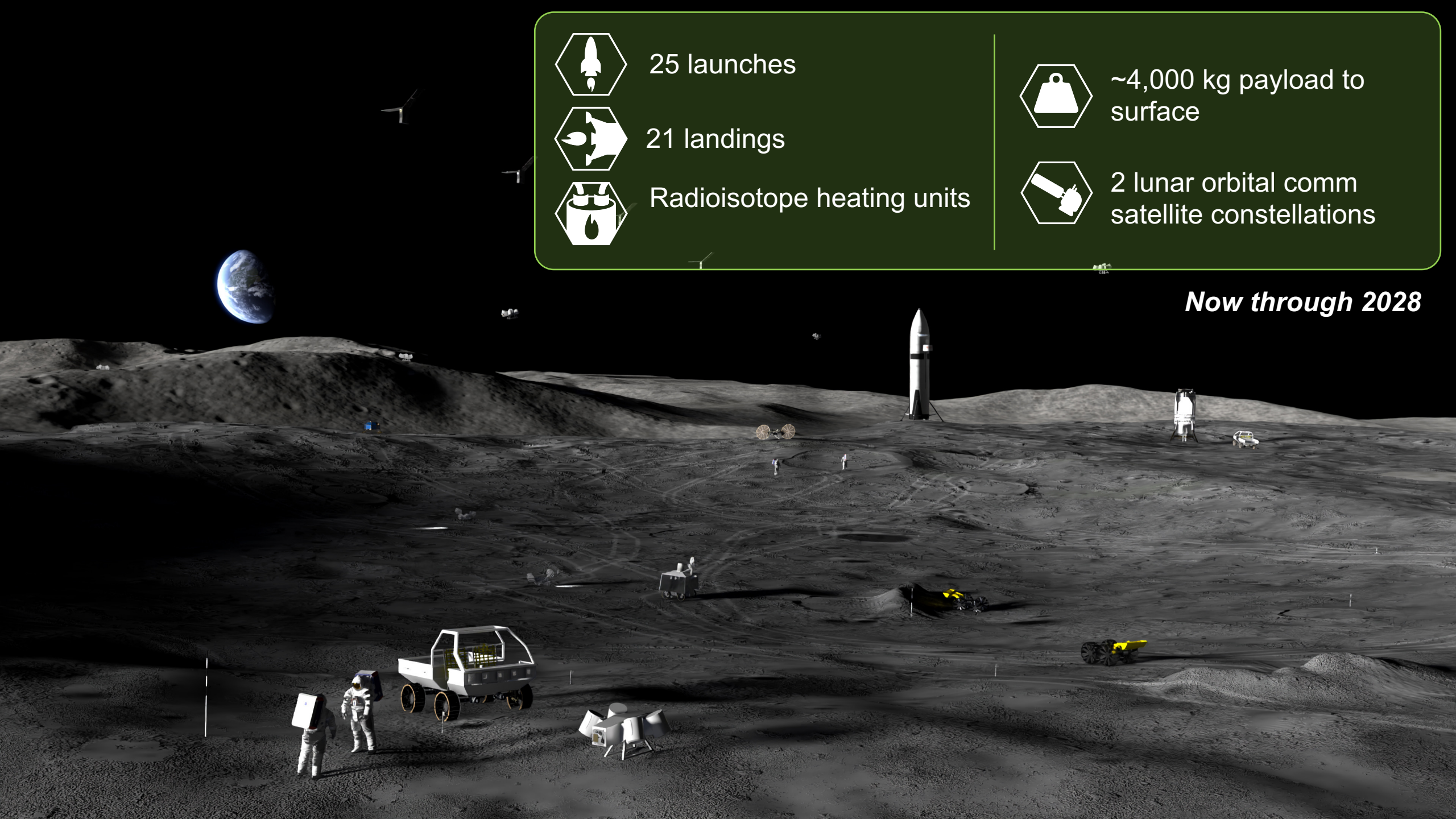
Achieve semi-permanent crew presence

Starts 2032



PHASE ONE

- Achieve high-rate, reliable surface access
- Establish ground truth for Moon Base landing sites
- Experiment and test capabilities
- Complete first crewed Moon Base mission


25 launches
21 landings
Radioisotope heating units
~4,000 kg payload to surface
2 lunar orbital comm satellite constellations
Now through 2028


Navigation Capability
Orbital Comm Relays
Observation Satellites
MoonFall Drone
CLPS
Human Landing System
VIPER
Uncrewed LTV
RHU Survive the Night
Crewed LTV

KEY MISSION

Lunar Terrain Vehicles

Initial deployment of lunar crewed and uncrewed Lunar Terrain Vehicles (LTVs)

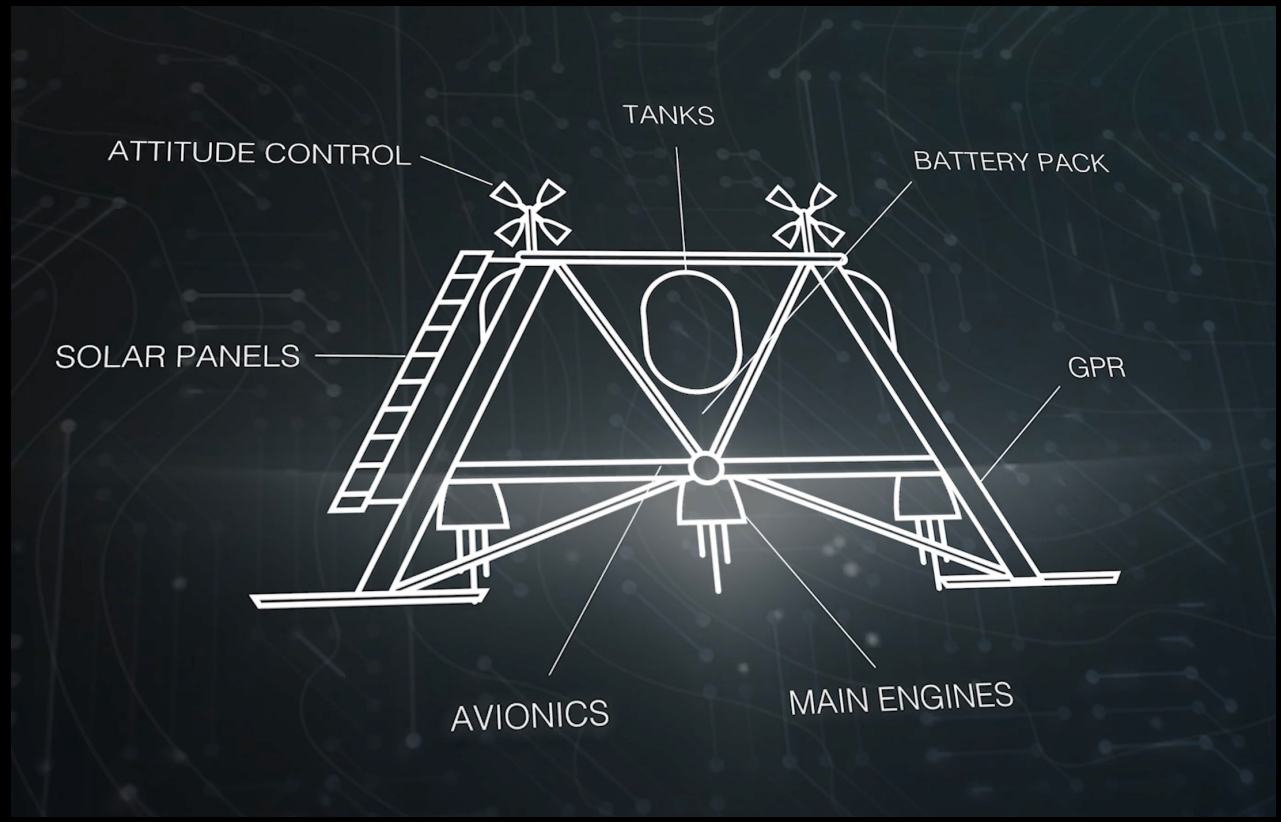
- Crewed vehicle to extend EVA traverse distances
- Uncrewed vehicle for exploration and technology demonstration
- 2m x 1.7m x 1.9m (height)
- 500 kg maximum rover mass
- Traverse slopes up to +/- 20 degrees
- Survives up to 150 hours in shadow
- Max speed 10 km/hr

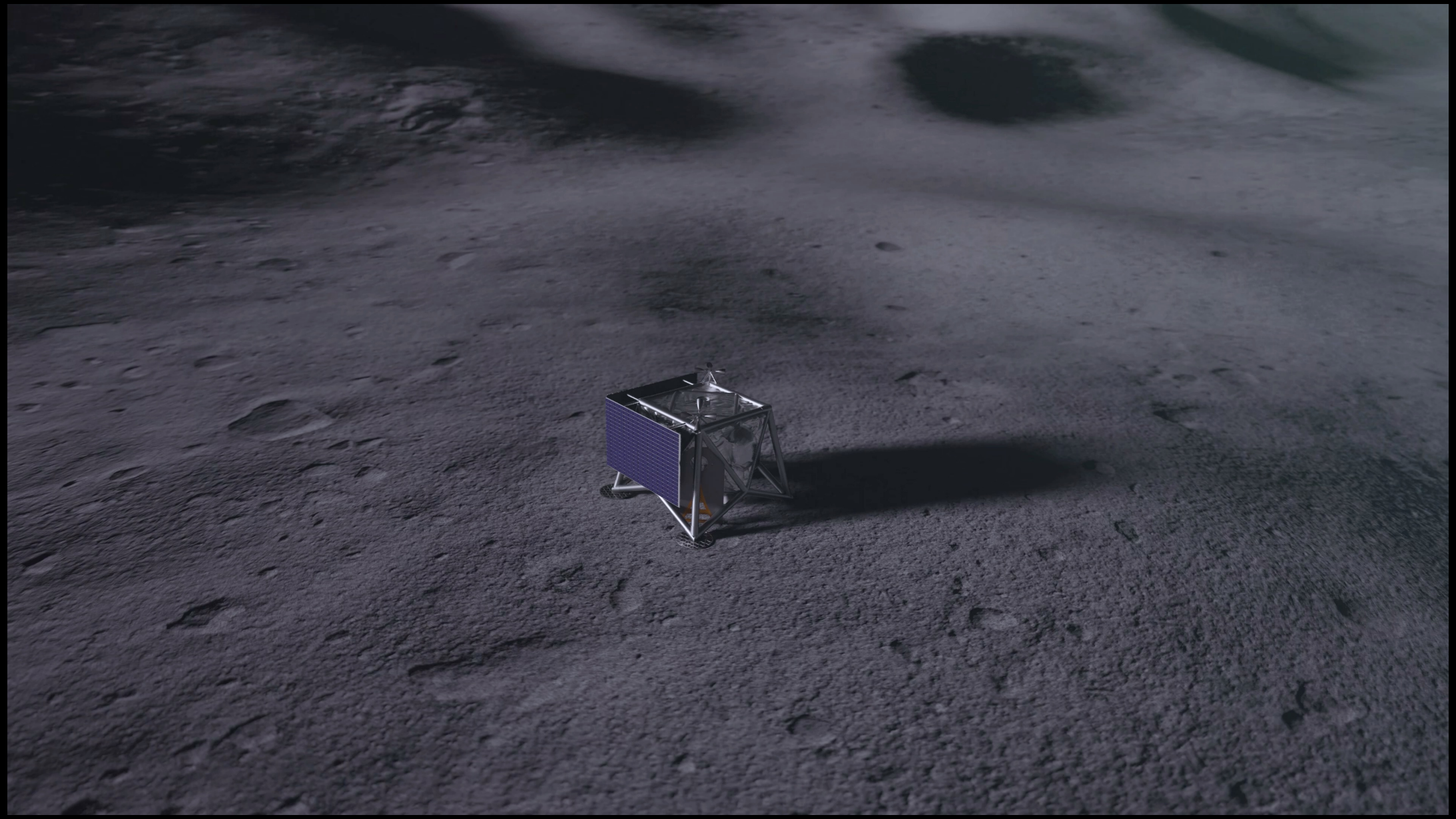
KEY MISSION

MoonFall Drones

Site surveillance and terrain surveying

- Deploy highly mobile drones over the lunar South Pole in a single launch architecture
  - Drones land themselves and are independent spacecraft
  - Ability to survey harder-to-reach terrain
  - Each drone capable of several propulsive hops covering up to 50km each in total
  - 150 seconds launch to landing with a maximum altitude of 1km
- Hosts multiple payloads:
  - Optical camera(s)
  - Survive the night avionics demonstrations



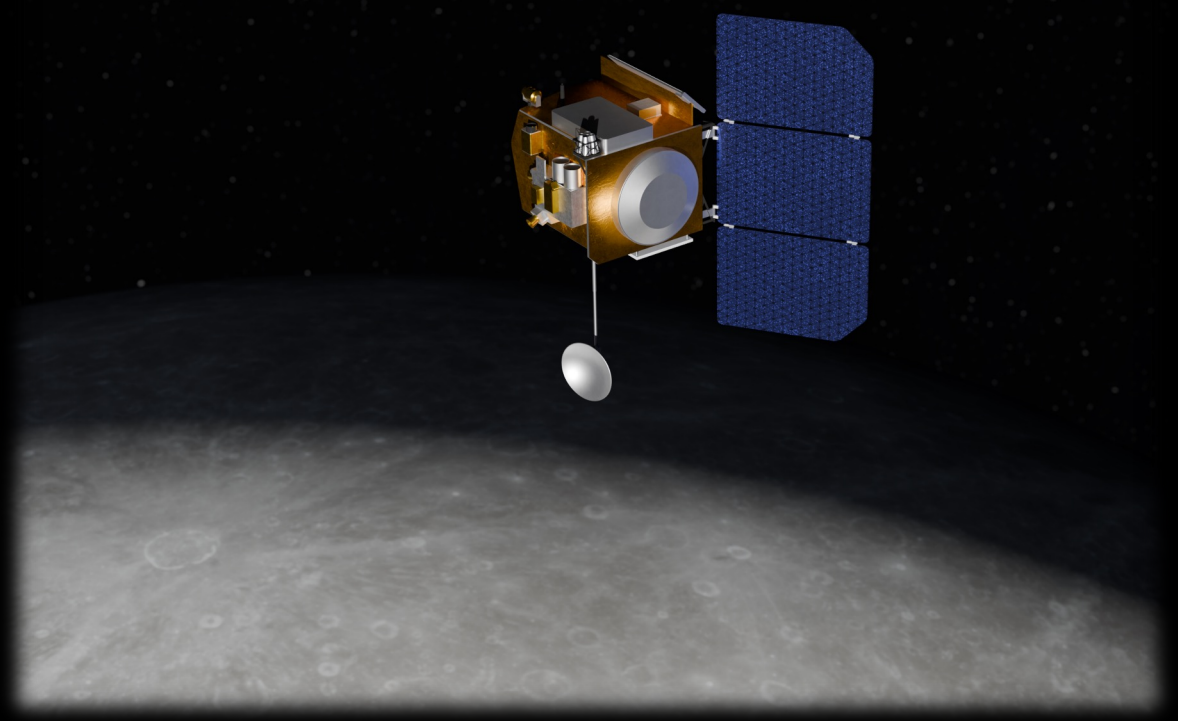


KEY MISSION

Communications and Observation Satellites

Taking the world along as we establish and grow lunar surface operations at Moon Base

- Increase throughput to/from Earth to cislunar space >500 Mbps
- Increase the number of available surface to orbit links
- Increase throughput to/from the lunar surface
- Test initial LunaNET interoperability standards



KEY MISSION

VIPER

Mapping of water and volatiles for lunar resource prospecting

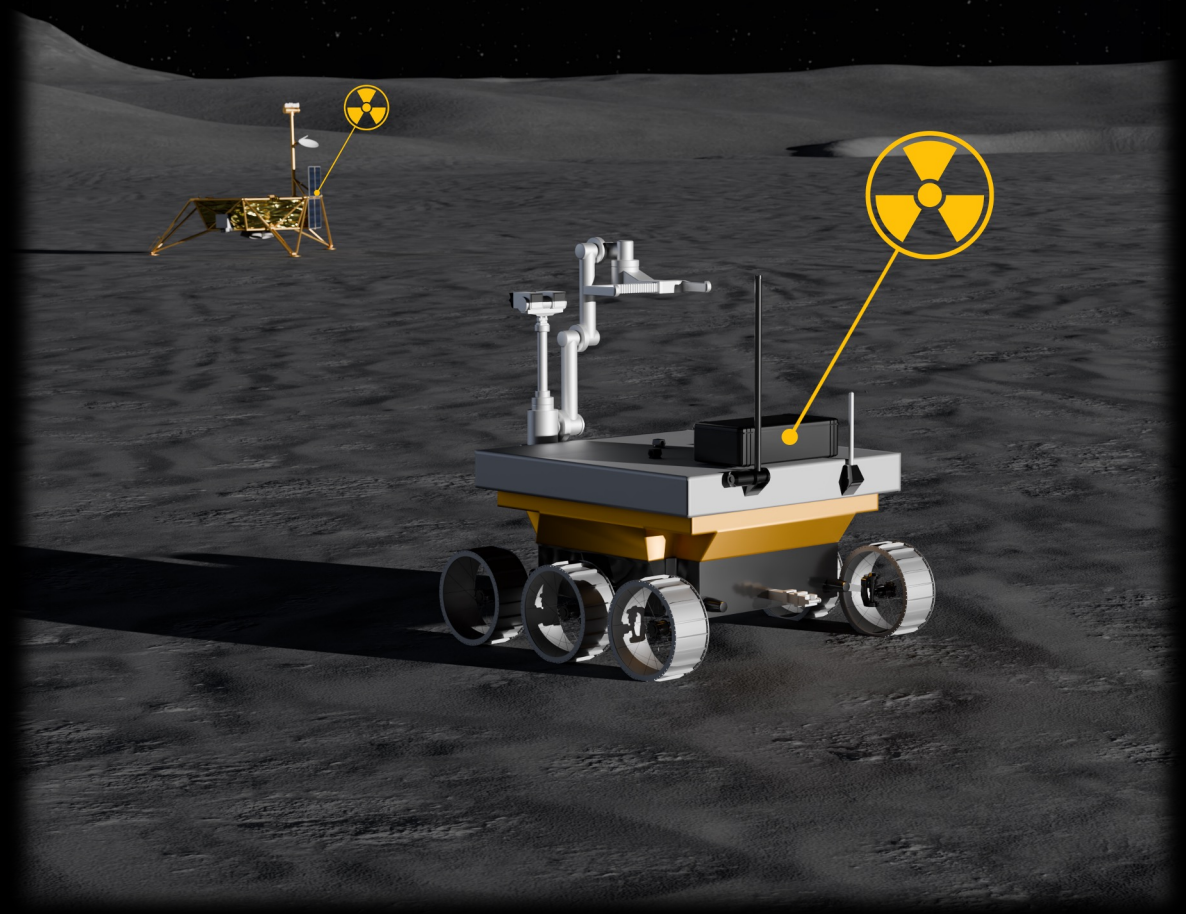
- 1.7m x 1.7m x 2.5m
- 450 kg rover mass
- 100+ day mission traversing 30+ km
- Survives up to 50 hours in shadow
- Three spectrometers & one drill

KEY CAPABILITY

Radioisotope Demos

Radioisotope heater units (RHUs) provide heat, allowing for survive the night capability during lunar surface operations

- Test updated nuclear fuel sources for increased reliability and safety for commercial use
- Initial lander demonstrations will survive 120+ continuous hours of darkness and send a signal back to Earth
- Enable future lunar assets to survive 354+ hours of local darkness



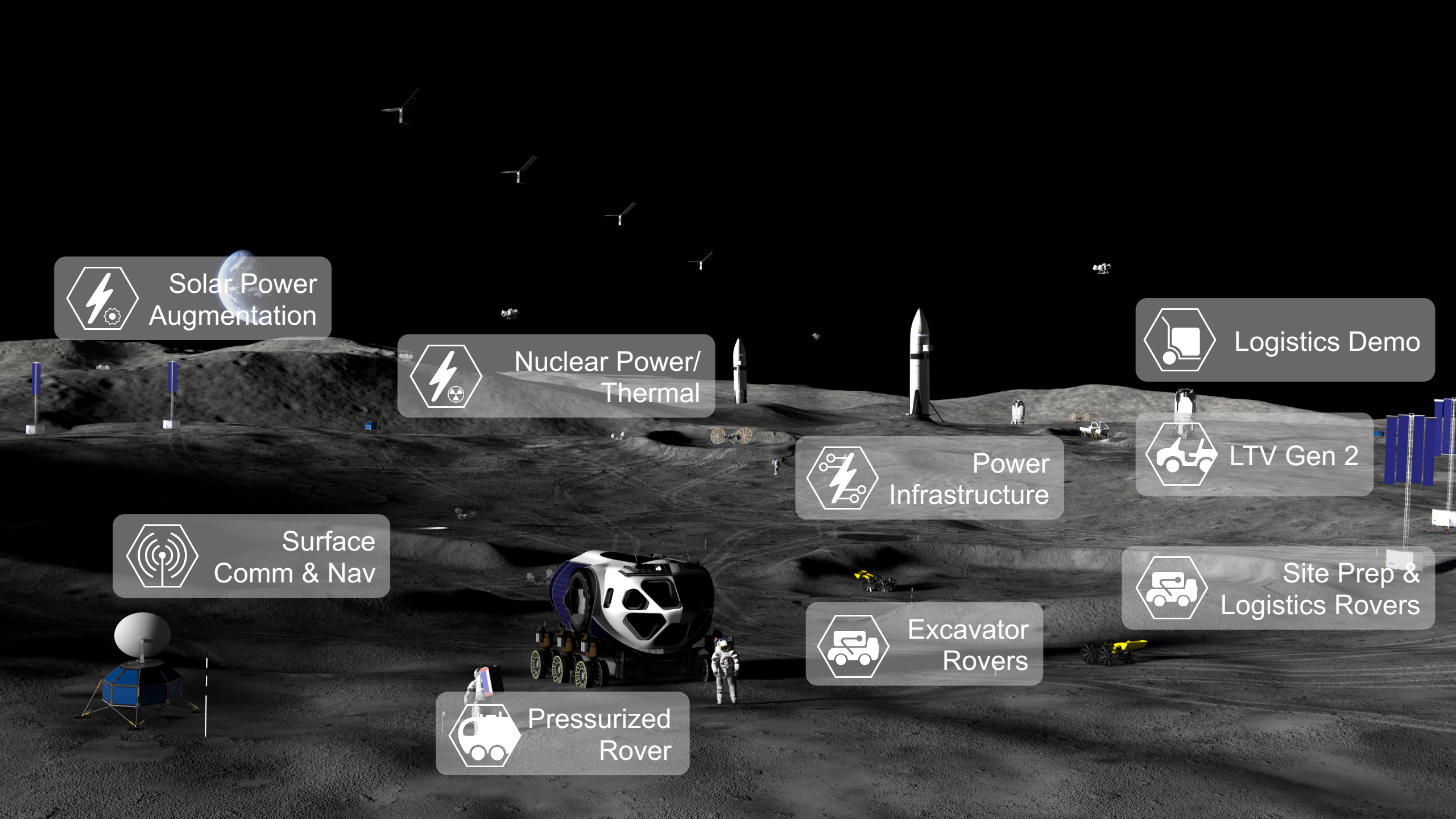
MOON BASE: PHASE 01

	2026	2027	2028
YEAR			
INVESTMENT	$10 BILLION		
SURFACE & ORBITAL ASSETS	x 1	x 2, x 5	x 1, x 5, x 4, x 3
LANDERS	x 1, x 1	x 8, x 1	x 3, x 3, x 4
LAUNCHES	x 2	x 10	x 12

PHASE TWO

- Secure initial site(s)
- Establish initial lunar infrastructure
- Increase CLPS lander payload mass capability to 5 MT
- Technology demonstrations to enable lunar permanence
- Semi-annual crewed missions


27 launches
24 landings
7 rovers
~60,000 kg payload to surface:
Pressurized Rover, MoonFall drones, solar power stations, nuclear power demos, surface comm, science
2029–2033


Solar Power Augmentation
Nuclear Power/ Thermal
Logistics Demo
Power Infrastructure
LTV Gen 2
Surface Comm & Nav
Site Prep & Logistics Rovers
Excavator Rovers
Pressurized Rover

KEY MISSION

Pressurized Rover

In partnership with NASA, the Japanese Aerospace Exploration Agency (JAXA) Pressurized Rover contribution

- Mobile habitat to extend human exploration range
- Supports two crew in shirt sleeve environment while also enabling surface EVAs
- 10-year design life
- 15,000 kg rover mass
- Cargo mass 3,000 kg
- Traverse slopes up to +/- 15 degrees
- Survives up to 150 hours in shadow
- Max speed 3.5 km/hr

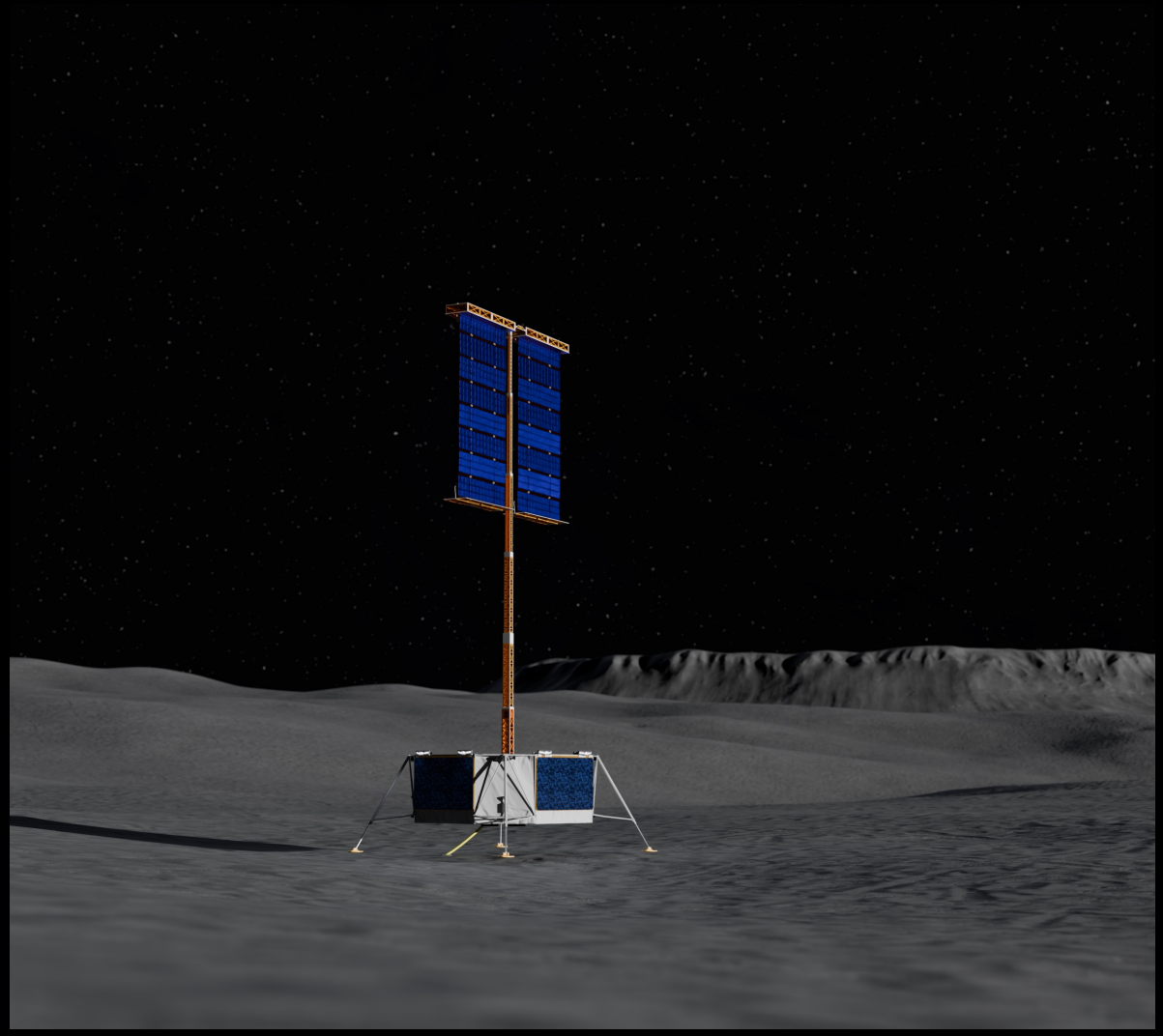
Credit: JAXA/Toyota

KEY MISSION

Solar Power Augmentation

Demonstrate and deploy solar power augmentation systems with energy storage and distribution

- Early demonstration of solar array deployment, battery systems, & power distribution hub
- Deploy solar array stations for permanent infrastructure
  - 10 kW+ during illumination
  - 360 kWh during shadow

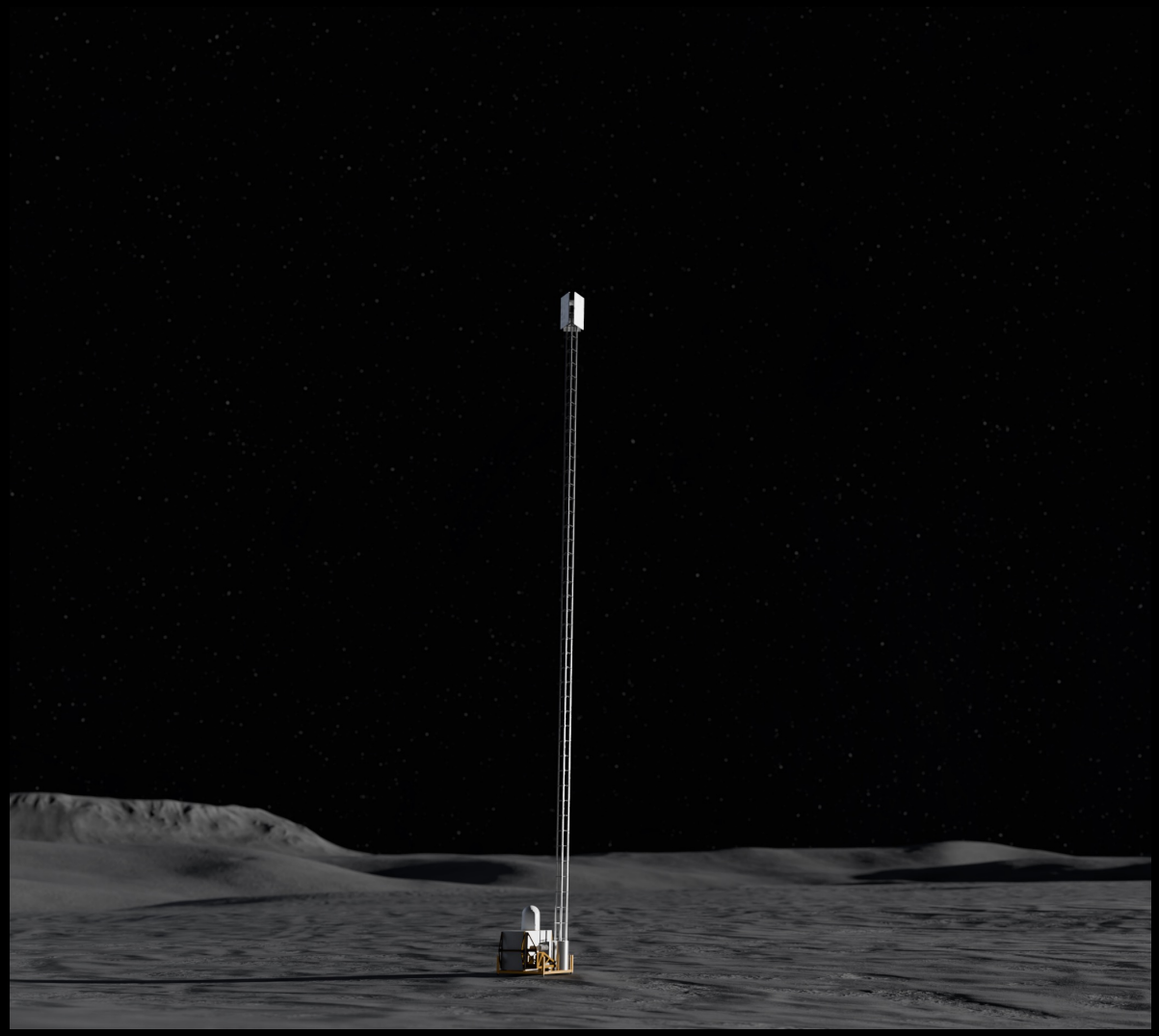


KEY MISSION

Surface Communications

Establish and expand surface network to enable more throughput and connections

- Deploy dedicated surface-to-orbital communication stations
  - Integrate/aggregate comm for other assets
- Deploy surface communication system to enable direct communication across lunar surface
  - Enables asset-to-asset communication
  - ~10km range

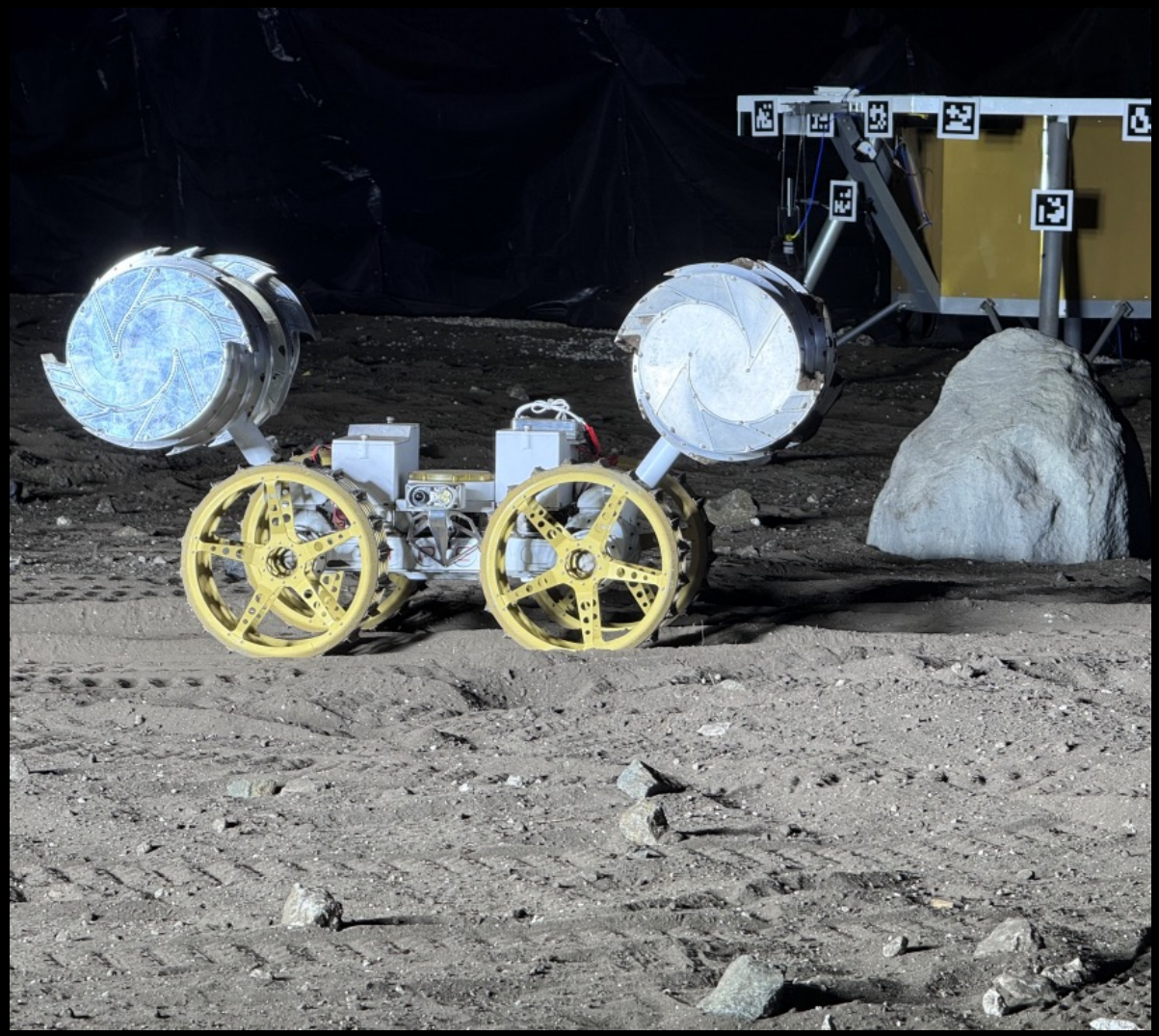


KEY MISSION

Site Preparation and Logistics Rovers

Rovers deployed to enable site preparation, regolith manipulation, and initial logistics capabilities

- NASA LTV Gen 2
- Other industry and international rovers for:
  - Logistics & cargo
  - Site preparation
  - Excavation & compaction



KEY CAPABILITY

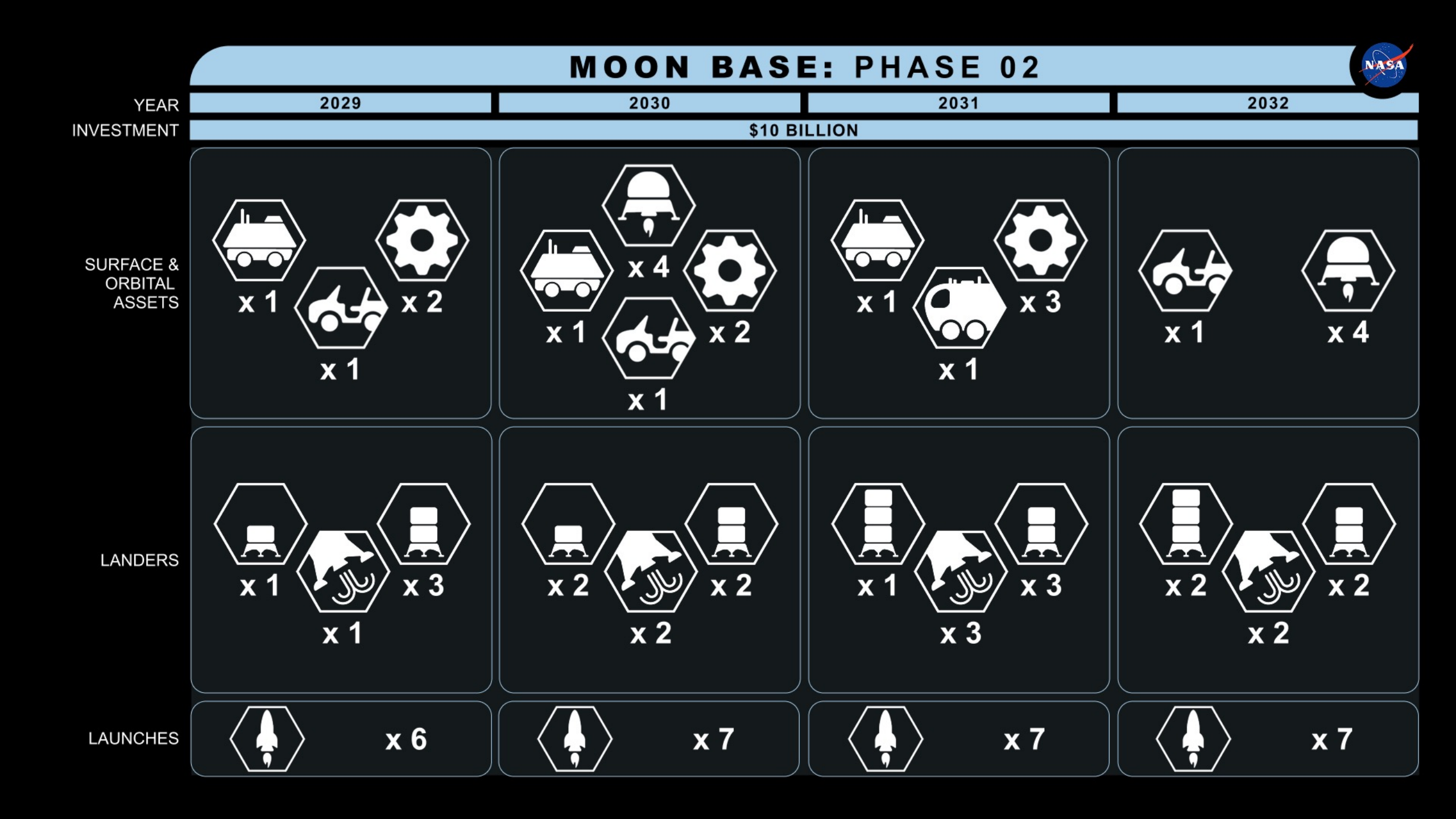
Nuclear Surface Power Capability

Demonstrate nuclear surface power capabilities

- Demonstrate technologies, processes, and operations for future larger scale nuclear power/propulsion
- Demonstrate thermal management concepts and methods for larger scale future applications
- Used as power generation stations
- Used within assets to enable night survival and permanently shadowed region exploration
- Demonstrate reactor surface power

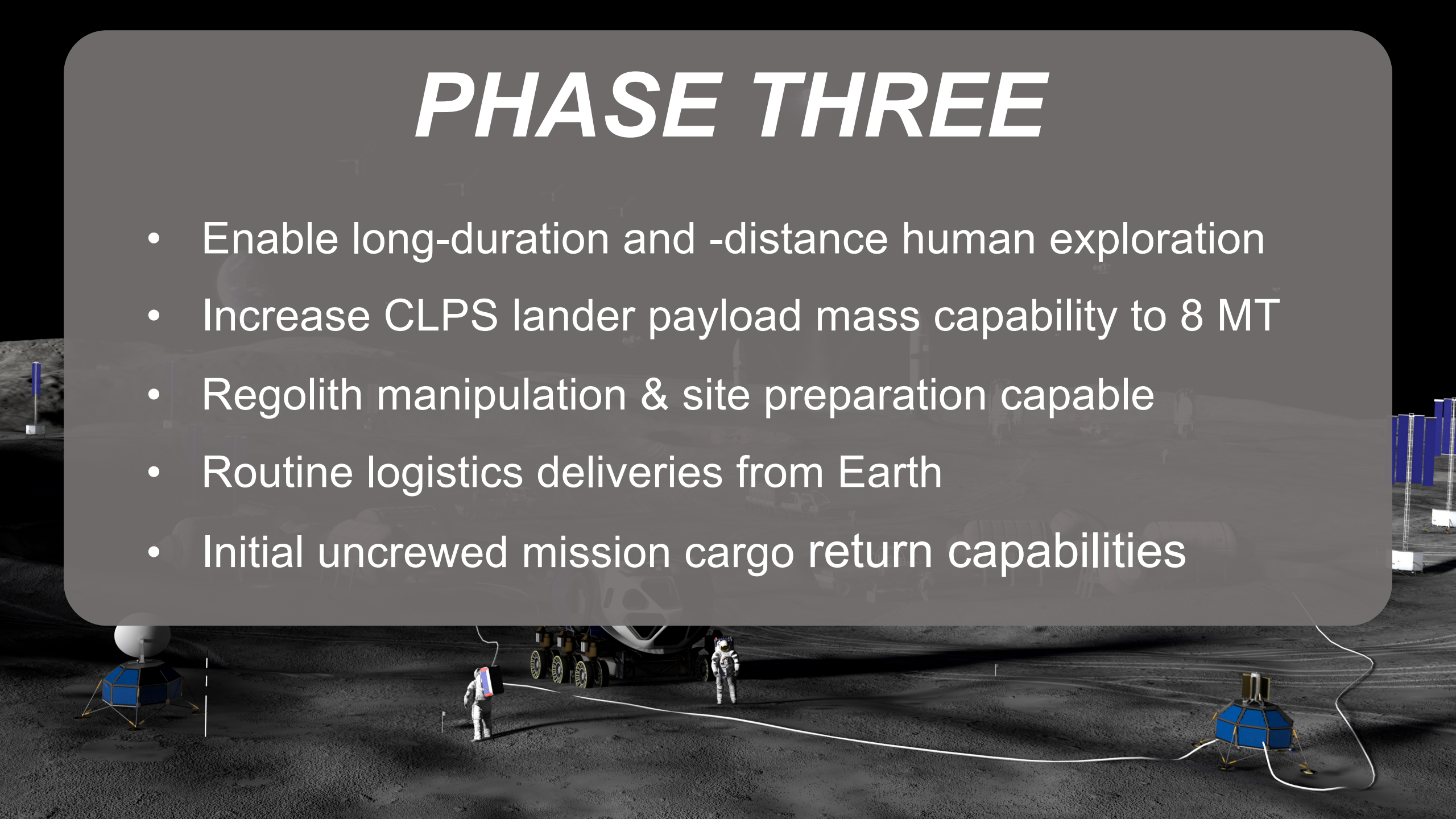
MOON BASE: PHASE 02

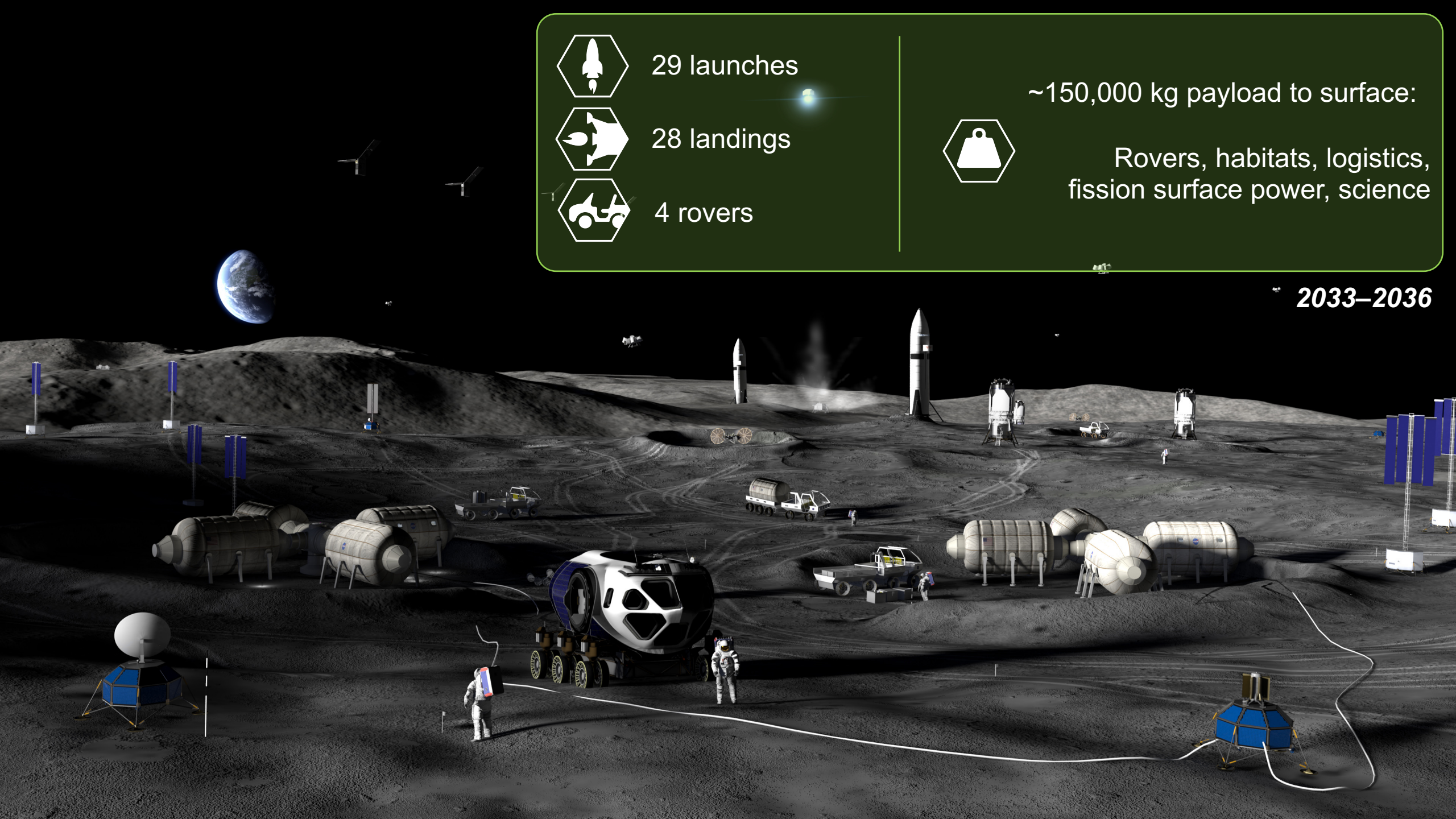
	2029	2030	2031	2032
YEAR				
INVESTMENT	$10 BILLION			
SURFACE & ORBITAL ASSETS	x 1, x 1, x 2	x 1, x 4, x 1, x 2	x 1, x 1, x 3	x 1, x 4
LANDERS	x 1, x 1, x 3	x 2, x 2, x 2	x 1, x 3, x 3	x 2, x 2, x 2
LAUNCHES	x 6	x 7	x 7	x 7



PHASE THREE

- Enable long-duration and -distance human exploration
- Increase CLPS lander payload mass capability to 8 MT
- Regolith manipulation & site preparation capable
- Routine logistics deliveries from Earth
- Initial uncrewed mission cargo return capabilities




29 launches
28 landings
4 rovers
~150,000 kg payload to surface:
Rovers, habitats, logistics,
fission surface power, science
2033–2036


Cargo Return
Fission Surface Power
Logistics
ISRU
Habitats
Habitats
Power Distribution

KEY MISSION

Logistics

End-to-end logistics services in support of crewed operations

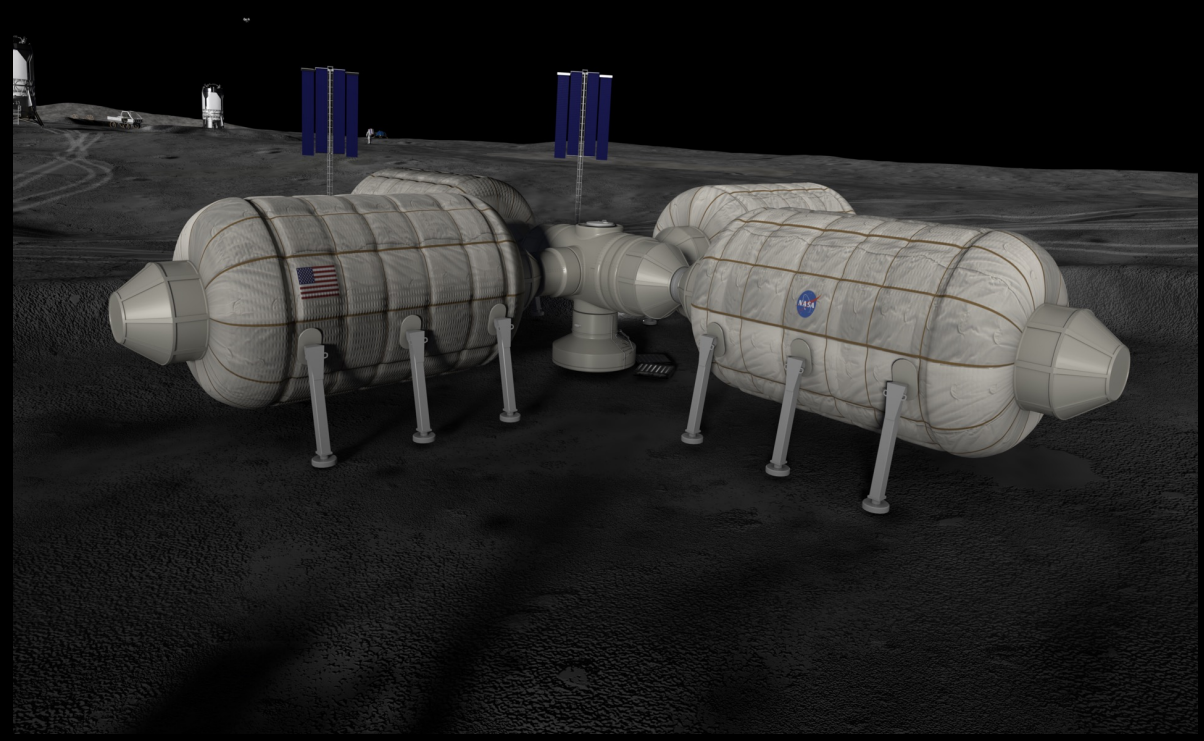
- Deployment, operation, and disposal of systems needed to deliver, transfer, sustain, utilize, and dispose of logistics items needed to support crew on the lunar surface
- Example of mass needed: ~8,000 kg of carriers, consumables, and other items to support a 4-crew, 28-day mission.

KEY MISSION

Habitats

Enable a continuous human presence with increased habitable volume and floor space

- Multiple habitable volumes across multiple site locations
- Various capabilities and needs, including:
  - ECLSS
  - Surface mating
  - Airlocks
- Expands surface science and utilization capabilities
- Increase Earth-independent operations



KEY MISSION

Cargo Return

Return cargo from the lunar surface

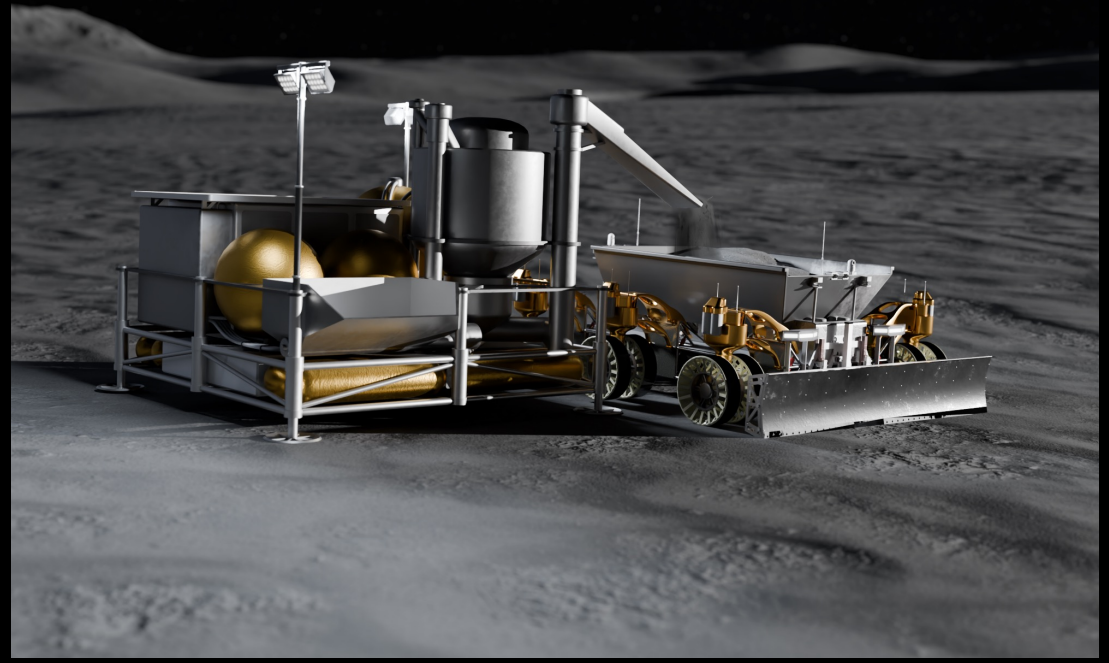
- Initial demo in Phase 2
- Phase 3: implement capability with mass goal of 500 kg
- Uncrewed cargo return missions:
  - Science returns
  - Critical hardware
  - Inspiration

KEY MISSION

In-situ Resource Utilization

In-situ Resource Utilization (ISRU) technology and implementation

- Phase 1 & 2 experiment & demo
- Phase 3 continue demo and begin implementation
- Enabling use of lunar commodities could enable reductions in launch mass, cost, and risk to human exploration
  - Key commodities from regolith:
    - Oxygen, water, rare Earth elements, hydrogen
- Converting regolith into durable and sustainable materials with techniques such as
  - Corbelling, 3D printing, sintering

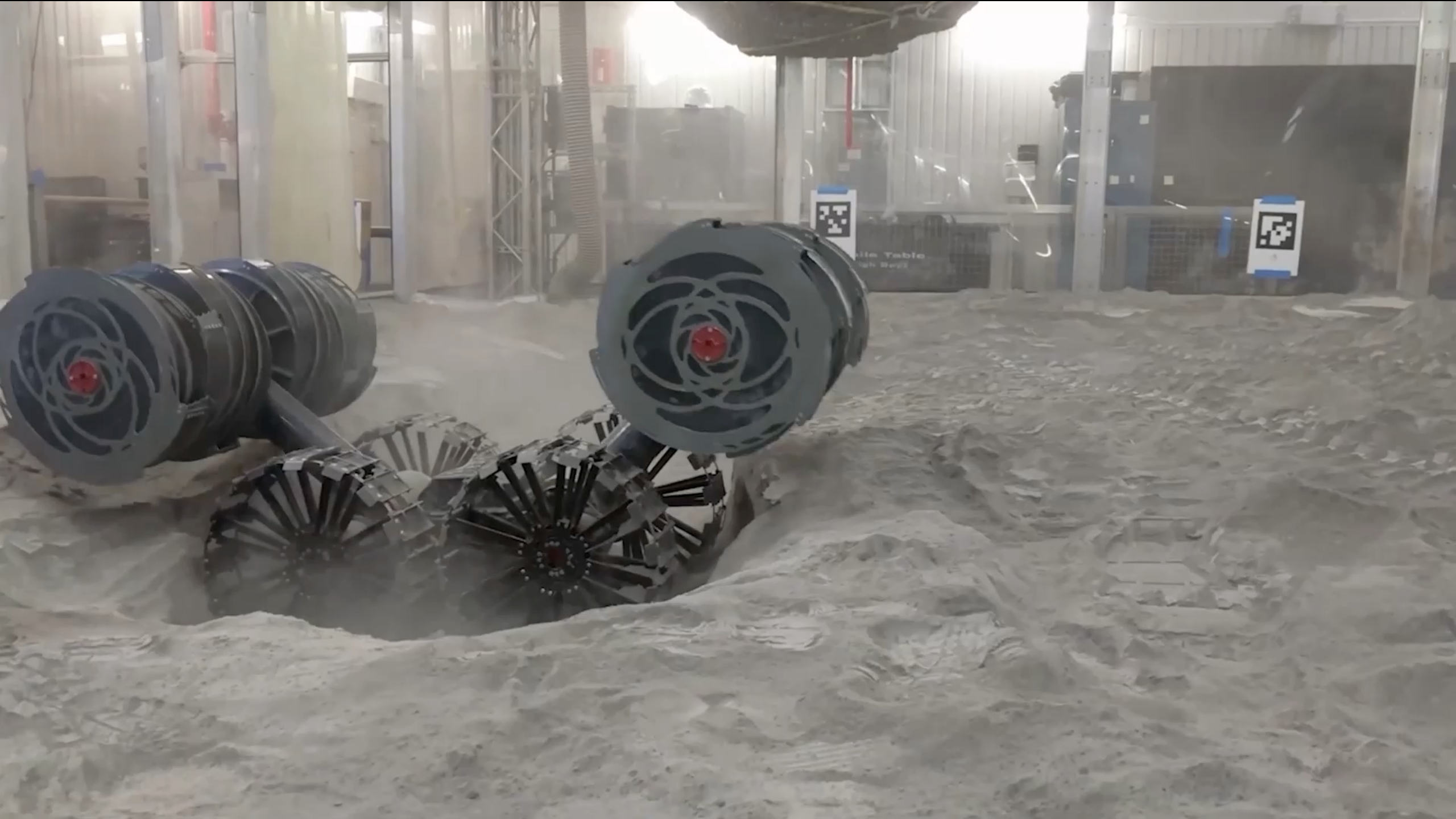


MOON BASE: PHASE 03

	2033	2034	2035	2036
INVESTMENT	$10 BILLION +			
SURFACE & ORBITAL ASSETS	x 1, x 2	x 1, x 1	x 1, x 1	x 1, x 1, x 1
LANDERS	x 3, x 1, x 2	x 2, x 2, x 3	x 2, x 2, x 3	x 2, x 2, x 4
LAUNCHES	x 7	x 7	x 7	x 8

MOON BASE

	PHASE 01			PHASE 02				PHASE 03			
YEAR	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
INVESTMENT	$10 BILLION			$10 BILLION				$10 BILLION +			
SURFACE & ORBITAL ASSETS	x 1	x 2 x 5	x 1 x 5 x 4 x 3	x 1 x 1 x 2	x 1 x 4 x 2 x 1	x 1 x 1 x 3	x 1 x 4	x 1 x 2	x 1 x 1	x 1 x 1	x 1 x 1 x 1
LANDERS	x 1 x 1	x 8 x 1	x 3 x 3 x 4	x 1 x 3 x 1	x 2 x 2 x 2	x 3 x 1 x 3	x 2 x 2 x 2	x 1 x 3 x 2	x 2 x 2 x 3	x 2 x 2 x 3	x 2 x 2 x 4
LAUNCHES	x 2	x 10	x 12	x 6	x 7	x 7	x 7	x 7	x 7	x 7	x 7



LIVE

Video Feed

Moon Base Operations

WATCH

COMING UP
Explore Live Events

DISCOVER NEW THINGS
Explore by Topic

DIVE DEEP IN A SHOW
Explore by Series

Rising to the Challenge

To achieve the near-impossible, we are driving to a high volume of complex missions with challenging execution timelines.

There are known current limitations that will challenge us…

- Supply chain
- Reliable access to capable test facilities
- Manufacturing capability and capacity
- Technology maturation

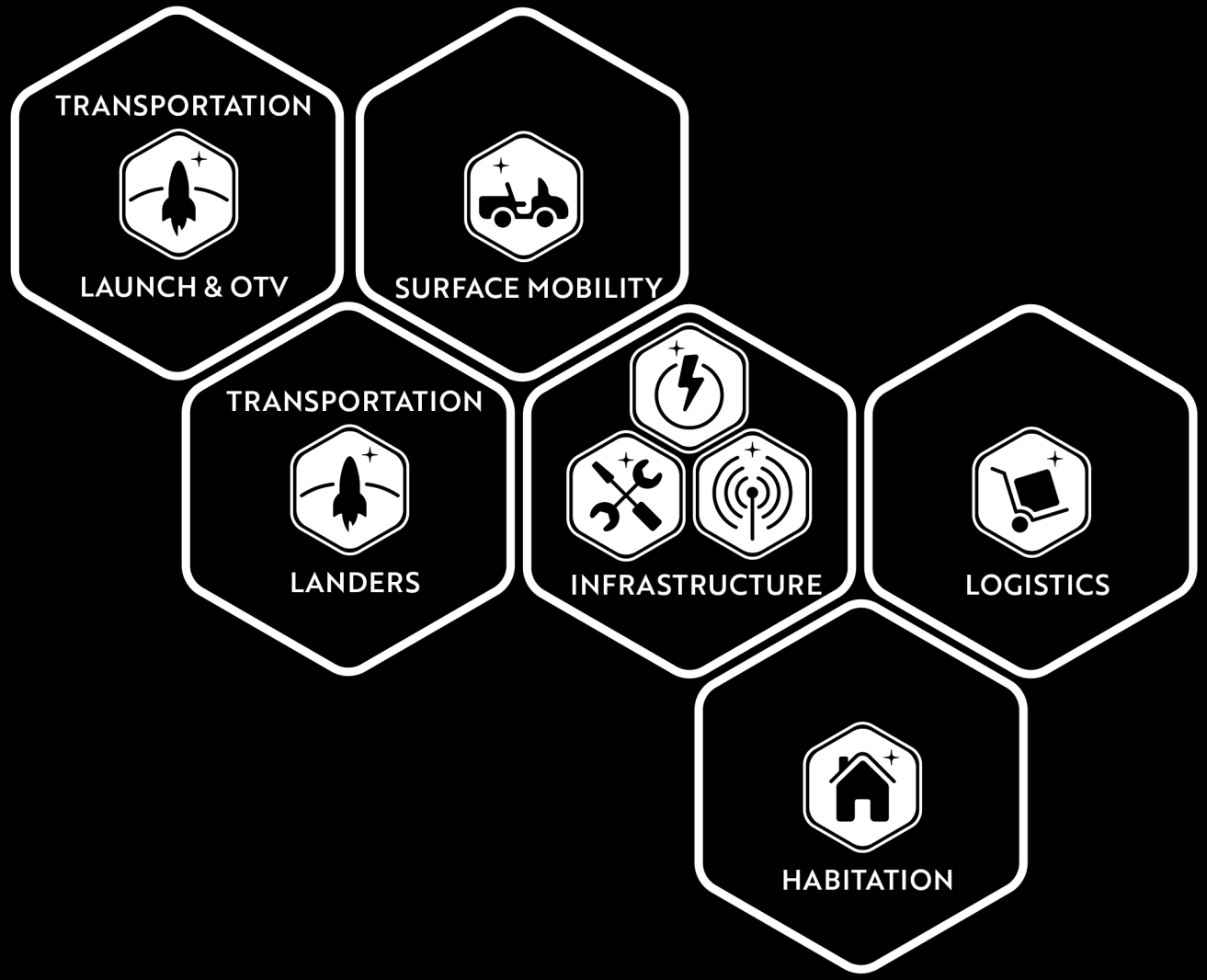
NASA will actively participate to help overcome challenges…

- Leverage highly capable NASA facilities (environmental testing, propulsion testing, etc.)
- Leverage core NASA expertise to provide collaboration, in-line support and lessons learned – this starts now on existing projects
- Leverage previous development experience, and relationships, to assist with supply chain issues

We need your ideas — requests for information soliciting inputs are ***posted to sam.gov today!***

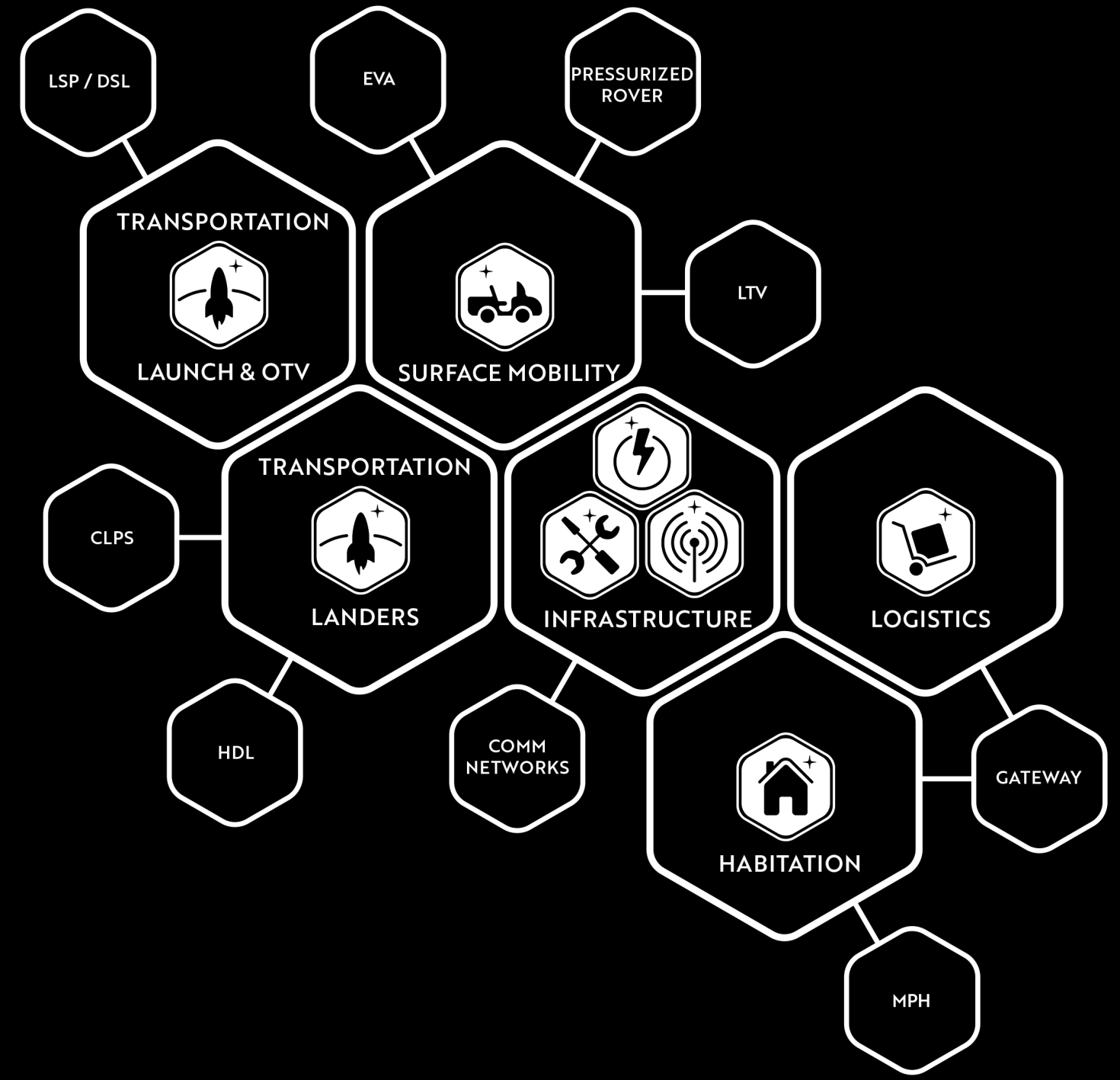
CAPABILITIES

How We're Building the Moon Base



CAPABILITIES

Every Asset, Every Kilogram, and All Lunar Exploration Resources Focused On Building the Moon Base



CAPABILITIES

Transportation: Launch & In-Space Transit

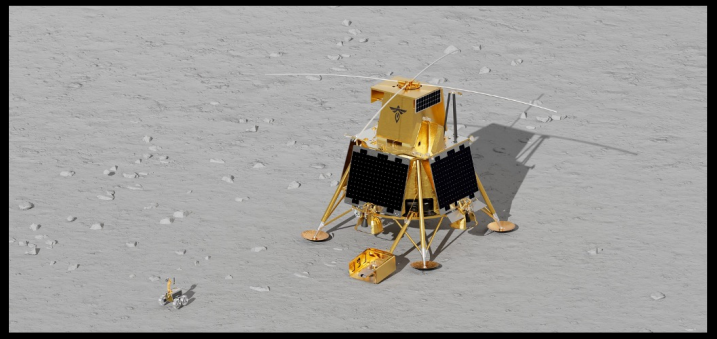
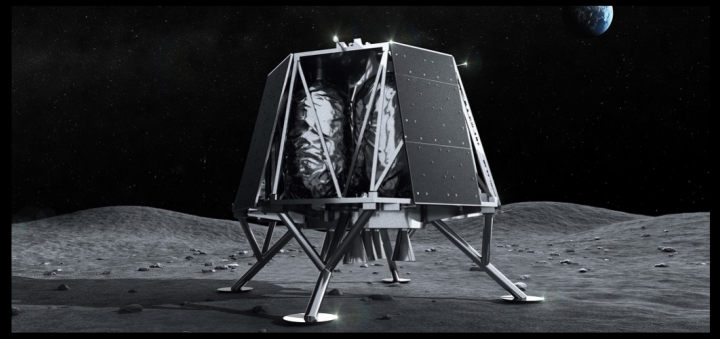
CAPABILITIES

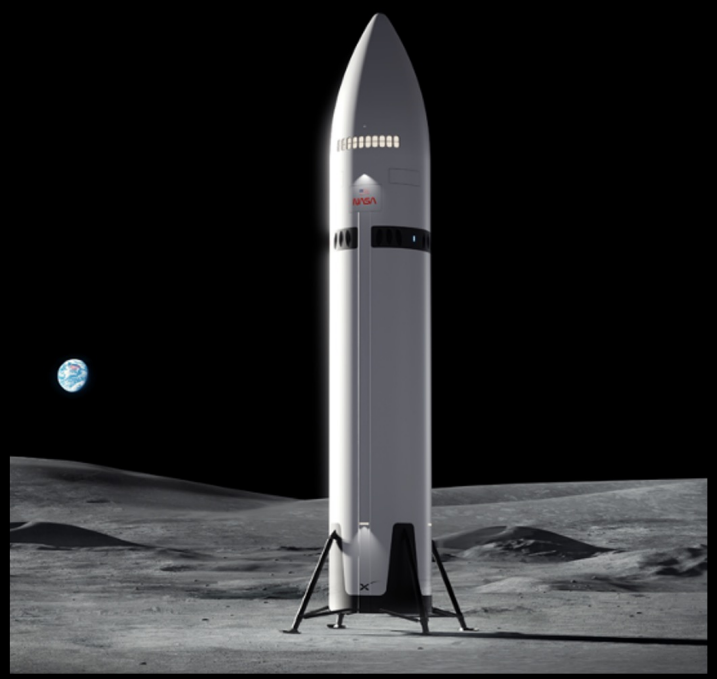
Launch Services Program & Deep Space Logistics

Leveraging the agency's Launch Services Program & Deep Space Logistics Project provides commercial end-to-end contract management and mission integration expertise to ***enable lunar access and logistics deliveries through a mixed fleet approach,*** *enabling* unique mission support and block buys for standardized delivery capabilities.

This enables both existing and emerging domestic launch & in-space transit capabilities to assure reliable access to the Moon, across all levels of capability.

This experience base will help us accelerate access to cislunar space through the purchase of an abundance of launch & transit capacity to serve NASA and our partnering organizations' needs (academia, international partners, and other government agencies).




CAPABILITIES

Transportation: Landers

CAPABILITIES

Commercial Lunar Payload Services

CLPS was set up to:

- Enable low cost (more risk tolerant) lunar payload delivery opportunities
- Incubate a new US-led industry base

With the Moon Base directive, the CLPS approach will evolve to increase:

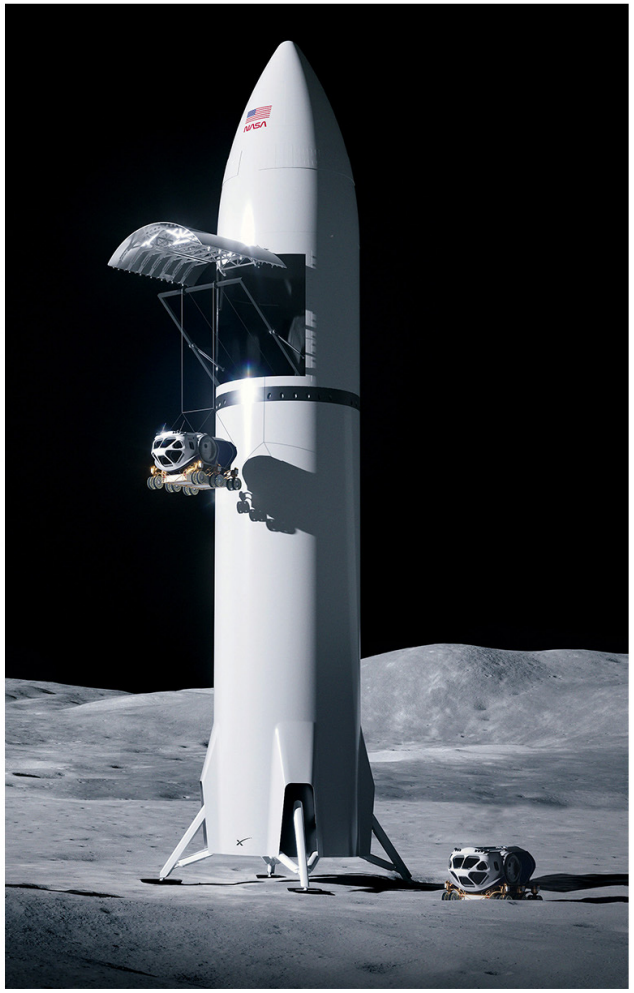
- Lander payload delivery capability through Phase 3 and beyond
- Mission reliability
- Increased mission quantity and cadence

To achieve this goal, NASA will immediately:

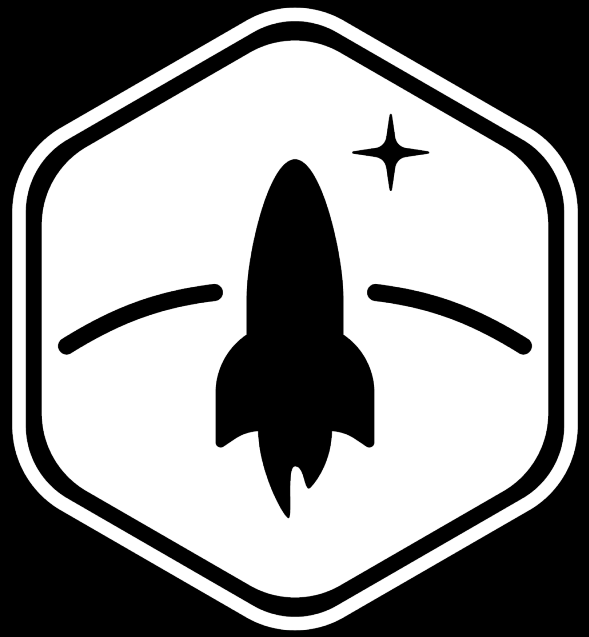
- Release two new Requests for Task Order Proposals (RFTPs) to support Phase 1
- Infuse NASA's core competencies to increase mission reliability
- Release a follow-on CLPS solicitation to support Phase 2 & 3

Large Cargo Landers

Drawing on the Human Landing System for cargo with **Human-class Delivery Landers**



Transportation Procurements



Launch Opportunities
NASA Launch Services task orders issued starting in CY 2027

Lander Opportunities
New Commercial Lunar Payload Services (CLPS) Opportunities:

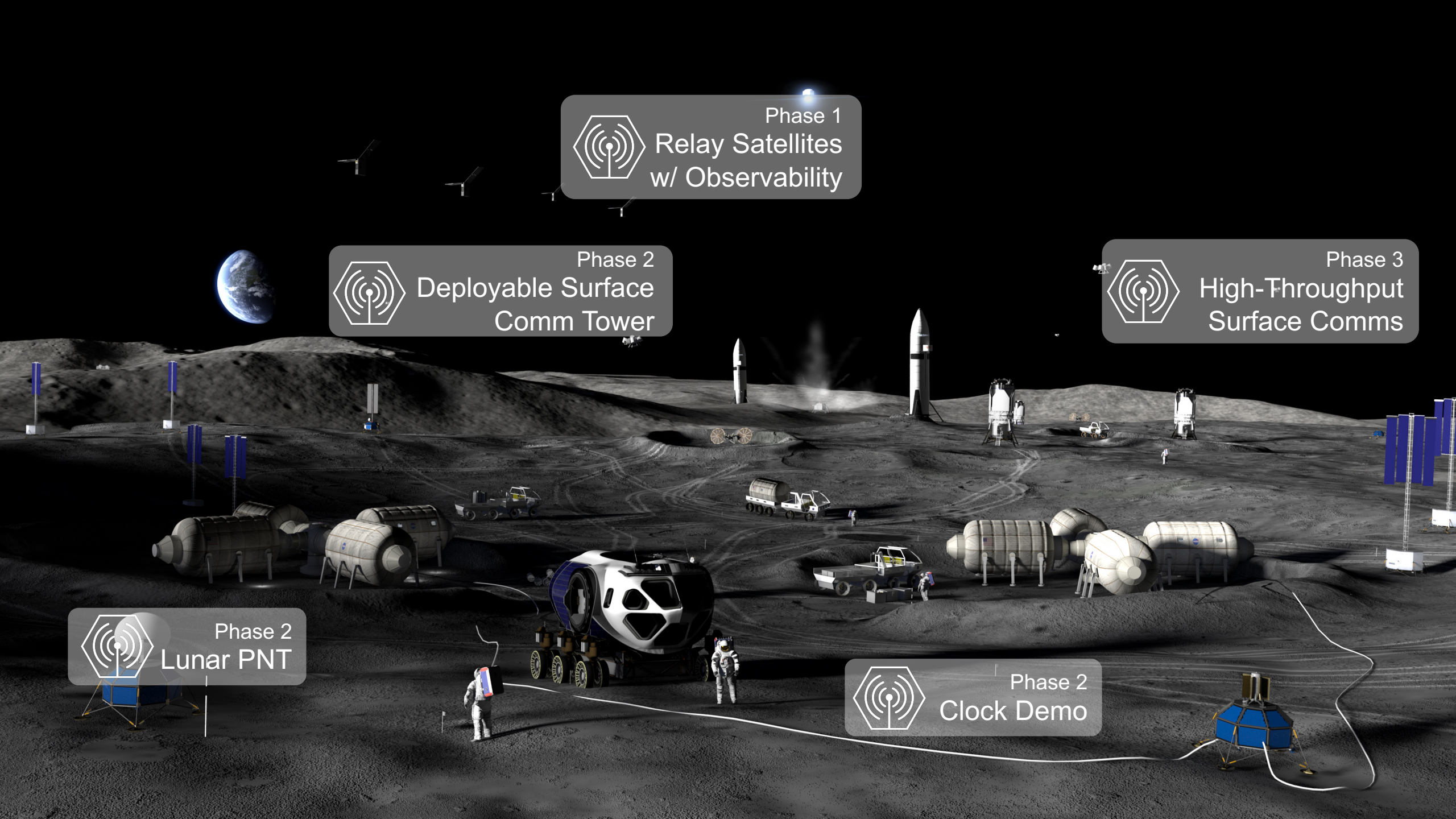
- CLPS 1.0 Draft RFTPs ***issued today*** for large payloads (500 kg) & smaller science payloads (<100 kg)
  - Task Order awards within 90 days
- Follow-on Draft RFTP issued within 50 days
  - Task Order award(s) within 150 days
- CLPS 2.0 Draft Request for Proposals issued today
  - New Contract awards by the end of GFY26

Baseline Planned CLPS Opportunities:

- CLPS 1.0 Draft Request for Task Plan to vendors in mid-June for CP-32 DIMPLE Delivery

CAPABILITIES

Infrastructure: Communications & Positioning, Navigation, Tracking, and Observation

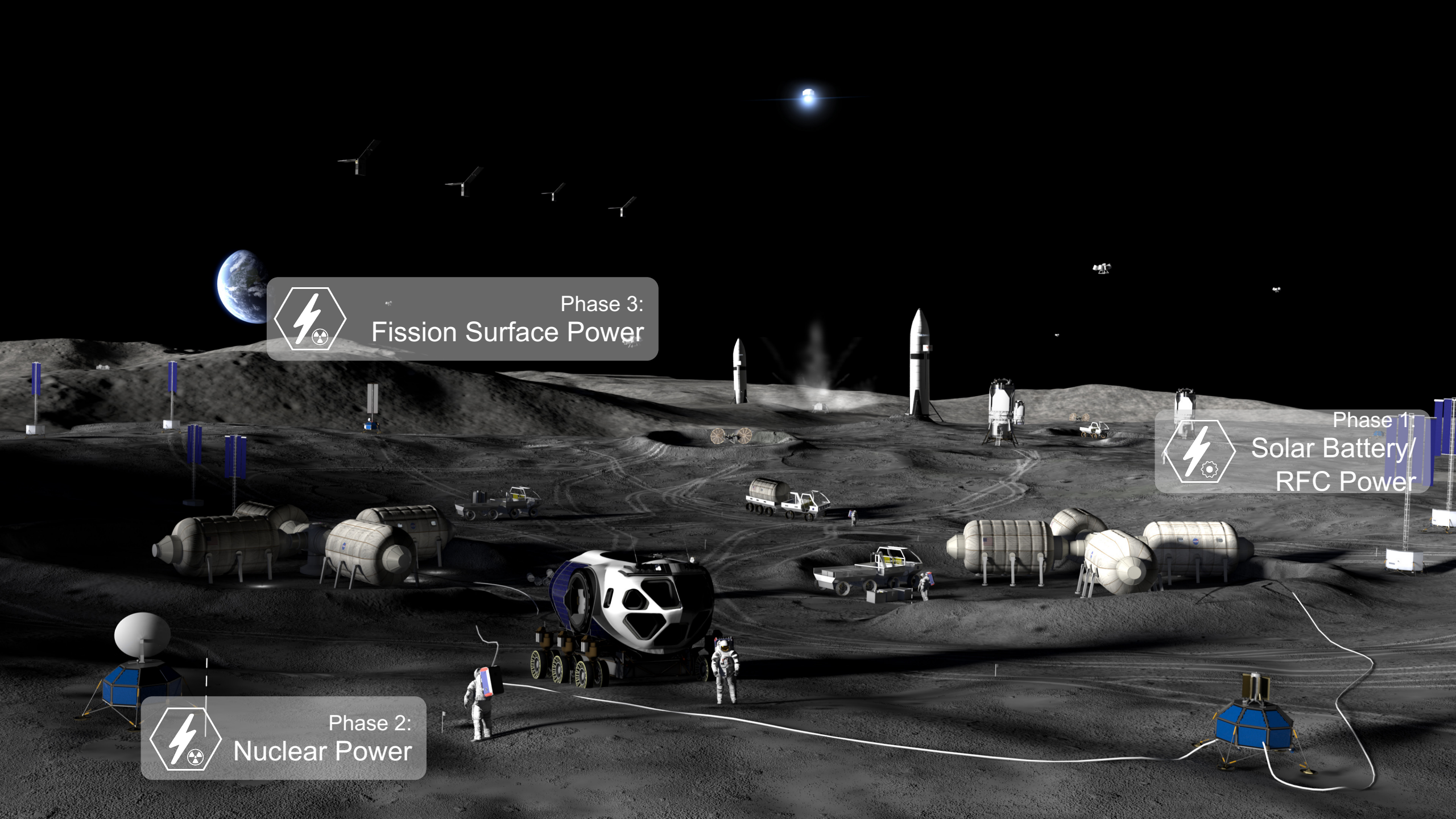

Phase 1
Relay Satellites
w/ Observability
Phase 2
Deployable Surface
Comm Tower
Phase 3
High-Throughput
Surface Comms
Phase 2
Lunar PNT
Phase 2
Clock Demo

Communications, Position, Navigation, Timing

Phase 1	Phase 2	Phase 3
Orbital comm & PNT relay • Deploy initial 5-satellite constellation • Add second provider constellation ***Add observation capability Data and standards*** • Mature interoperability specification baseline across all users and infrastructure - LunaNET	***Surface communications*** • Permanent surface "cell towers" • Simultaneous support for multiple users via integrated surface network terminals ***Navigation infrastructure*** • Clock technology demonstration	***Surface communications*** • Coordinated communication across all assets in support of Moon Base • Scaled network deployment across regions ***Navigation infrastructure*** • Clock ensembles – persistent time broadcast

CAPABILITIES

Infrastructure: Power

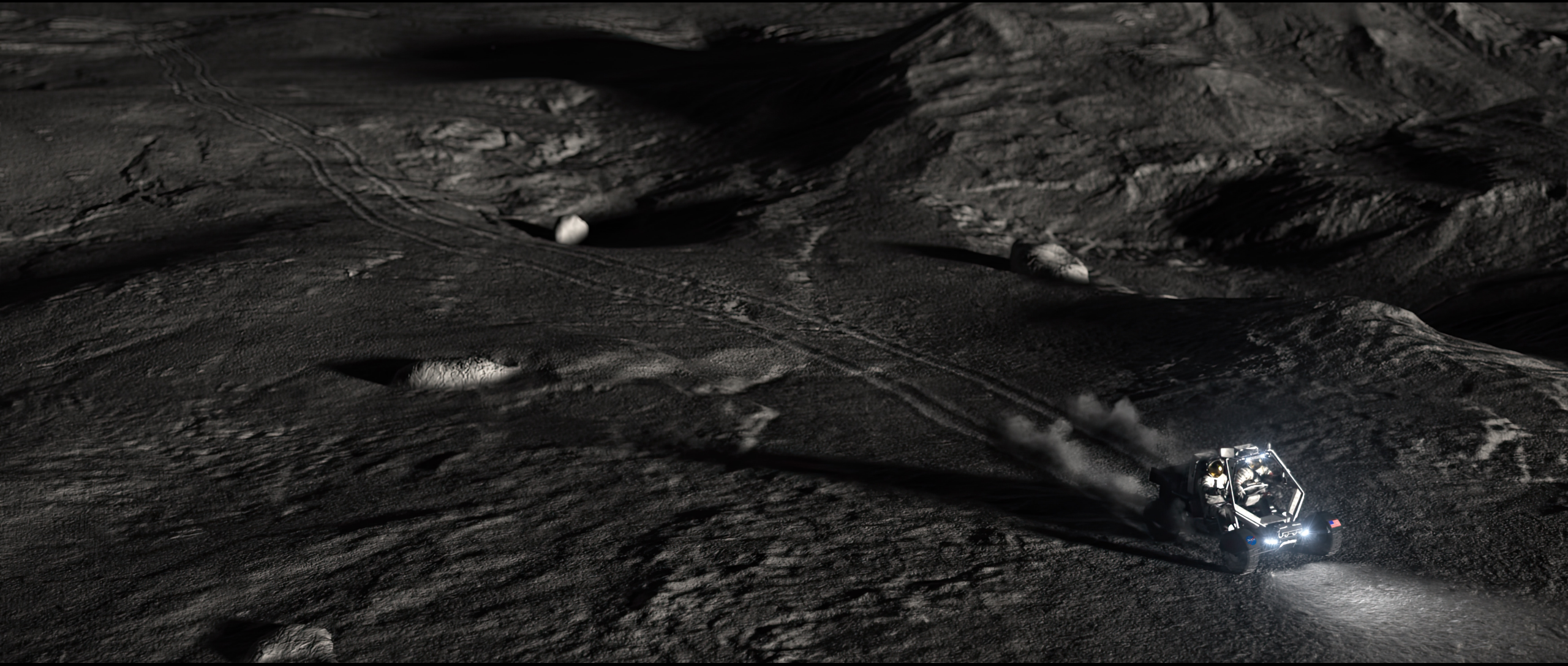

Phase 3:
Fission Surface Power
Phase 1:
Solar Battery/
RFC Power
Phase 2:
Nuclear Power

CAPABILITIES

Power

Phase 1	Phase 2	Phase 3

Initial Power
• Deploy assets responsible for self-supported power generation and survival
• Demo initial hibernation points
• Demo initial Radioisotope Heater Units (RHUs)
	Deploying Power Infrastructure
	• Deploy Solar Arrays Power Stations
	• Deploy Radioisotope Thermal Generator (RTG) Power Stations
	• Assets begin routinely using RHUs & RTGs to enable night survival and additional night operational capability
	• Demonstrate wireless charging for Rovers
	• Demonstrate dust tolerant electrical connectors
	• Demonstrate electrical cable deployment
	• Demonstrate reactor surface power
		Enabling Power Distribution
		• Fission Surface Power
		• Power distribution deployed to support habitats and surface assets
		  • Wireless charging
		  • Dust tolerant electrical connectors
		  • Electrical cable deployment
		• Permanently Shadowed Region exploration



CAPABILITIES

Mobility


Phase 2+
Advanced
LTV
Phase 1
LTV
Phase 2+
International
Partner Rovers
Phase 1+
Science
Rovers
Phase 2
Pressurized
Rover
Phase 1
Site Preparation
& Logistics

CAPABILITIES

Mobility

Phase 1

CLPS 1.0 Science Rovers

- NASA - VIPER
- Astrolab - FLIP
- UAE Rover – Rashid

MoonFall Drones

- Science, overnight survival tech demo, surface communication

Lunar Terrain Vehicle Phase 1

- Less complicated rovers, one-year design life & NASA as the only user
- Simplified crewed rover(s)
- Autonomous rover(s) capable of site surveying, site preparation demonstration, & logistics mobility

Phase 2

Lunar Terrain Vehicle

- Increased reliability of crewed & uncrewed rovers (NASA as the only user)
- Increase logistics and science payload carrying capability
- Regolith manipulation demo(s)

Partner Rover

JAXA - Human Pressurized Exploration Rover

Partner Potentials

- Science rovers
- Landing & habitation site prep rover demo(s)
- Power cable deployment rover demo(s)
- Initial logistics transfer rovers
- Increase robotic manipulation capabilities

Phase 3

Lunar Terrain Vehicle

- Crewed & uncrewed rovers 10-year design life requirement (NASA & commercial users)
- Full logistics transfer capabilities
- Robotic manipulation capabilities
- Permanently shadowed region exploration capable using RHU & RTG
- Regolith manipulation

Partner Potential Rovers

- Landing & habitation site prep rovers
- Power cable deployment rovers
- Large logistics/utility rovers
- Robotic manipulation capabilities

CAPABILITY EVOLUTION

Lunar Terrain Vehicles

LTV contract was set up to:

- Deliver a “fully capable” crewed rover to survive for 10 years
- Per current schedule, delivery to the lunar surface by 2030
- Cost, technical complexity, and schedule puts NASA in a “no fail” solution space

With the Moon Base directive, LTV must adapt to:

- Gain quicker access to crewed and uncrewed lunar surface rover operations
- Increase quantity of rovers on lunar surface
- Add uncrewed rovers that can evolve to serve numerous additional lunar surface needs
- Allow for multiple vendor solutions, de-risking NASA
- De-risk long-term mission success through learning and phased design evolution

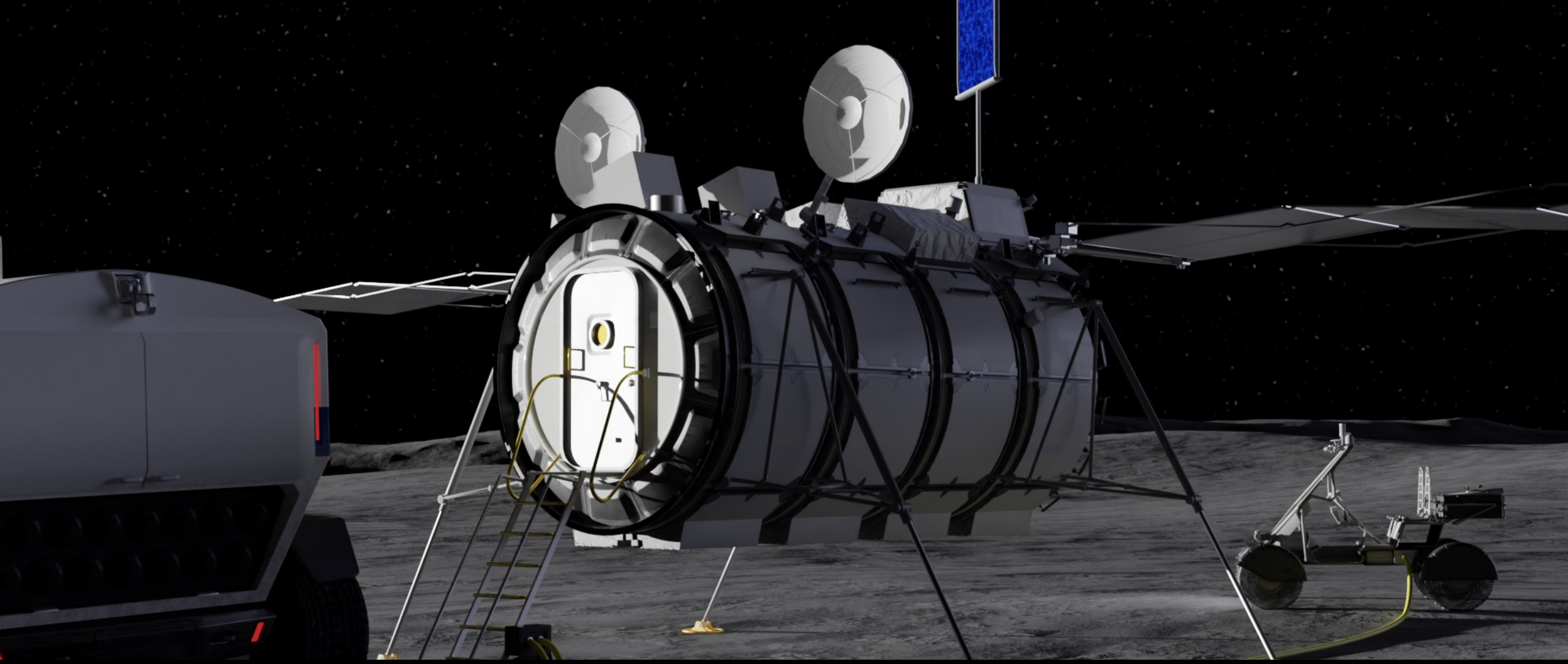
LTV Procurements

LTV Opportunities

LTV draft RFTP ***issued today*** for proposals on a more simplified variant of both crewed and uncrewed rovers.

On-ramp RFP to increase vendor pool for Phase 2 LTVs ***planned for 2027***.

Foresee Task Order competitions ***every 18 to 24 months*** for future rover deliveries as Moon Base capability needs evolve.



CAPABILITIES

Habitation and Logistics

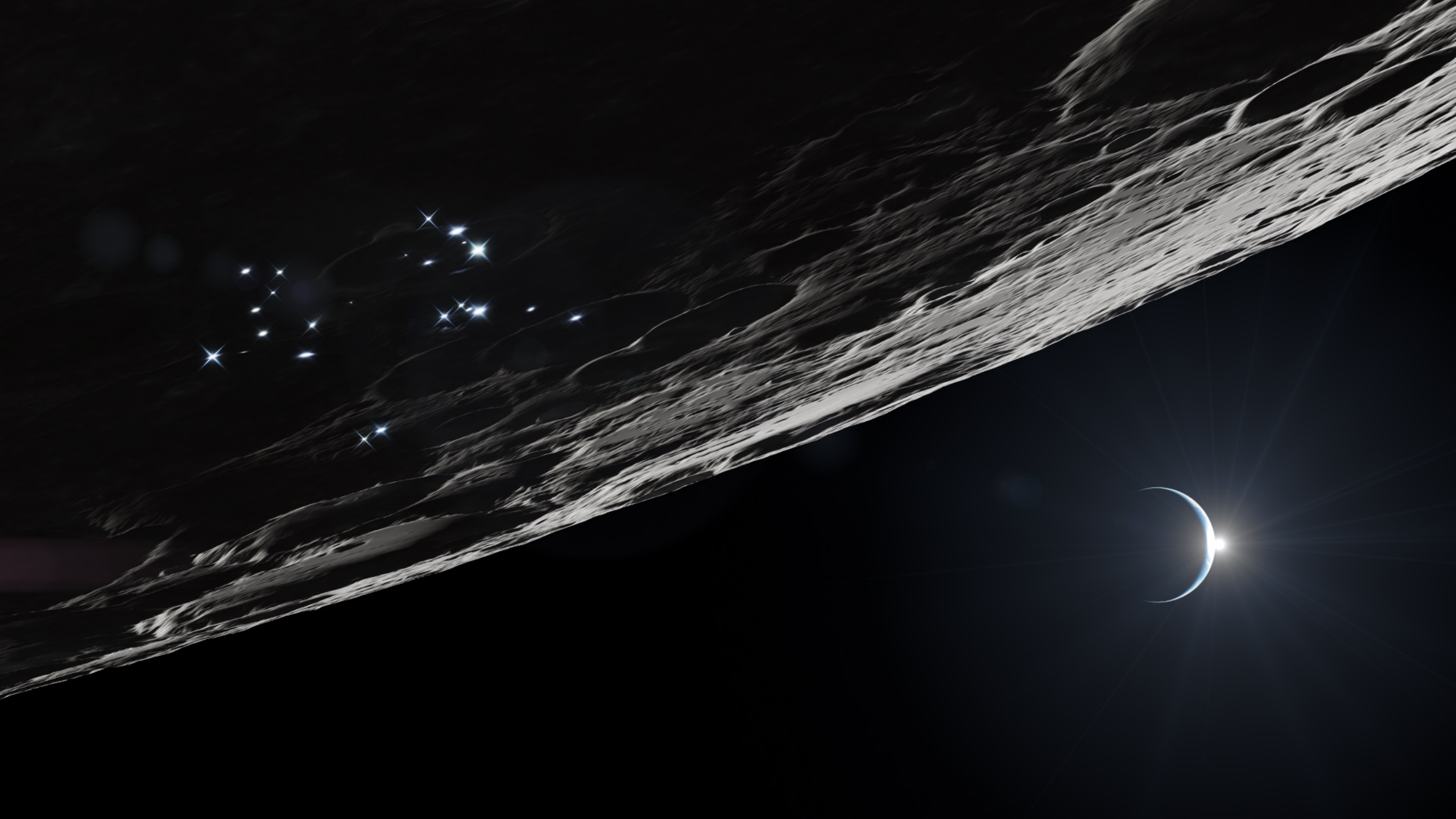

Phase 3
Cargo
Return
Phase 1
Logistics
Deliveries
Phase 3
Habitats

Habitation & Logistics

Phase 2	Phase 3

Early Surface Logistics
• Deploy initial logistics capabilities
  • 0.5 to 1.5 metric tons
  • Initial sustainment
• Demo surface mating
• Demo small cargo return
 	
Demo Habitation
• Establish early human habitation lunar base capability
• Early pressurized module(s) with minimal environmental control and life support systems supported by external power
	Operational Surface Logistics
	• End-to-end logistics capabilities
	  • Up to eight metric tons per 28-day mission
	• Operational surface mating
	• Sustained small cargo return
	• Demo med/large cargo return
	  • Goal: 500 kg
	• Initial surface habitats > 100 m^3
	  • Partner habitats
	  • US habitats
	• Additional elements
	  • Airlocks
	  • Nodes

2026 Procurement Timeline



Exploring the secrets
of the universe for
the benefit of all.

nasa.gov